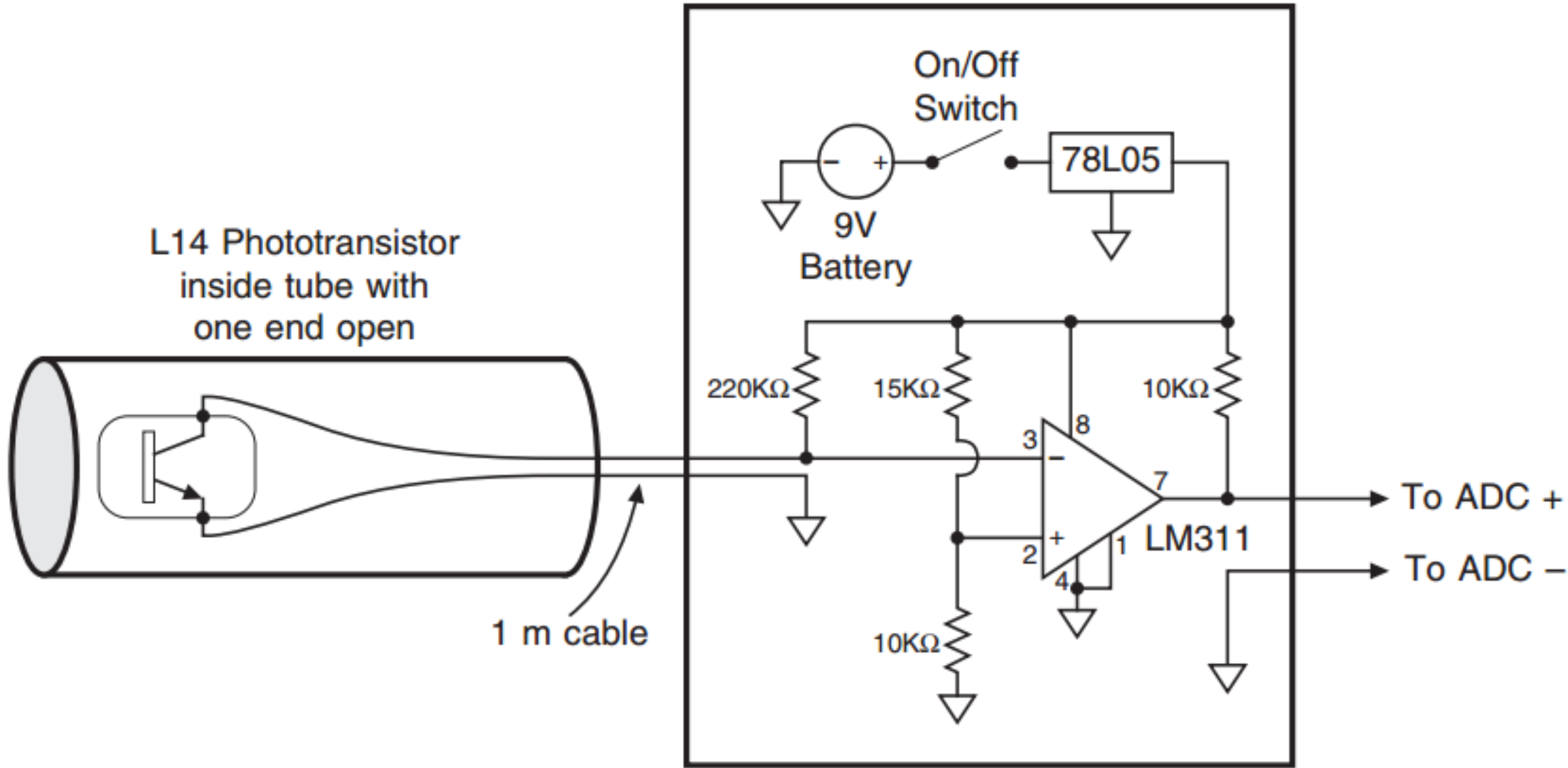
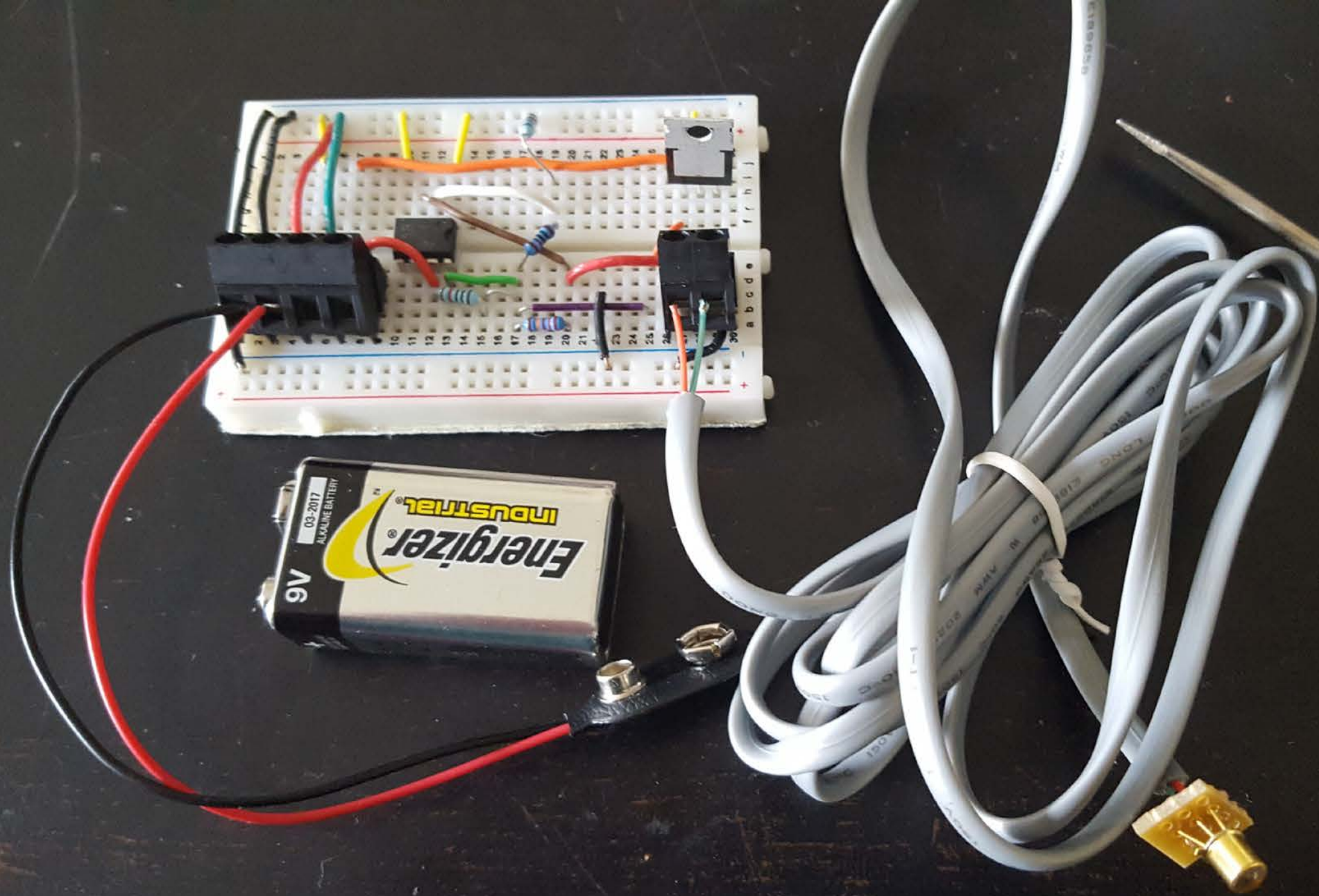


# Lecture 14: Prototyping and Schematics





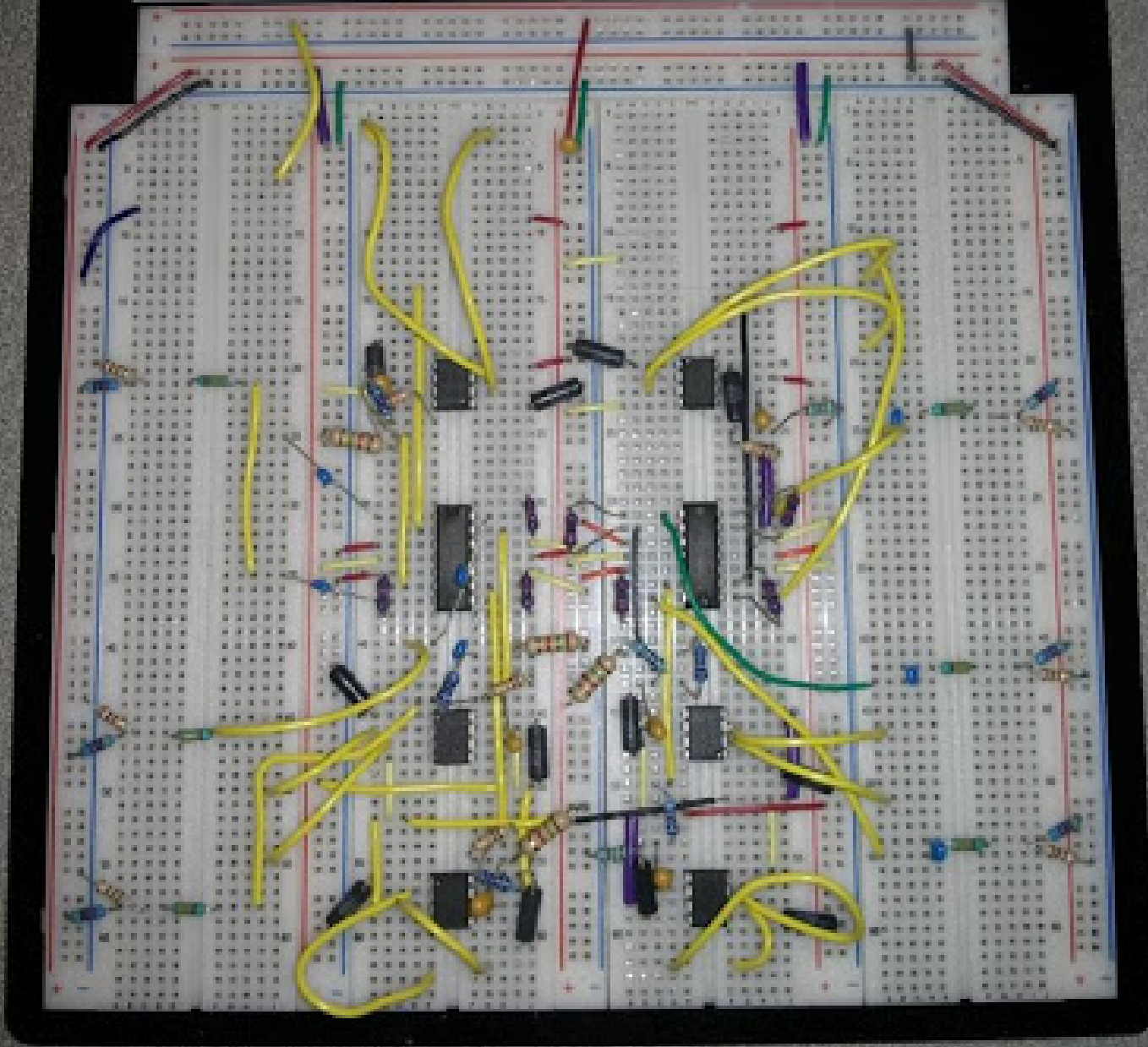
## Breadboards have some limitations

- 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.



HEL  
ELECTRONICS  
PB-3260

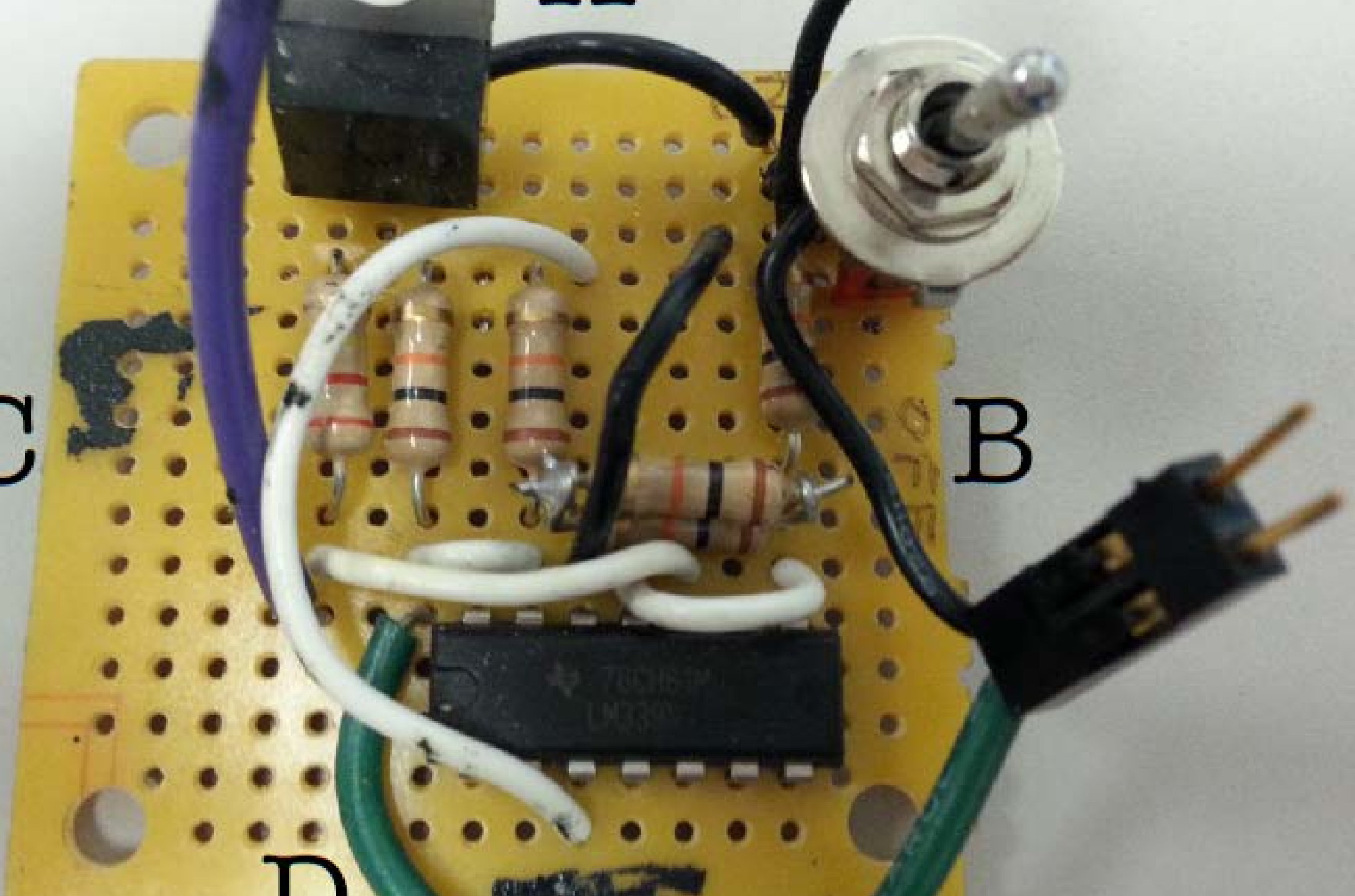
Va Vb Vc  $\perp$

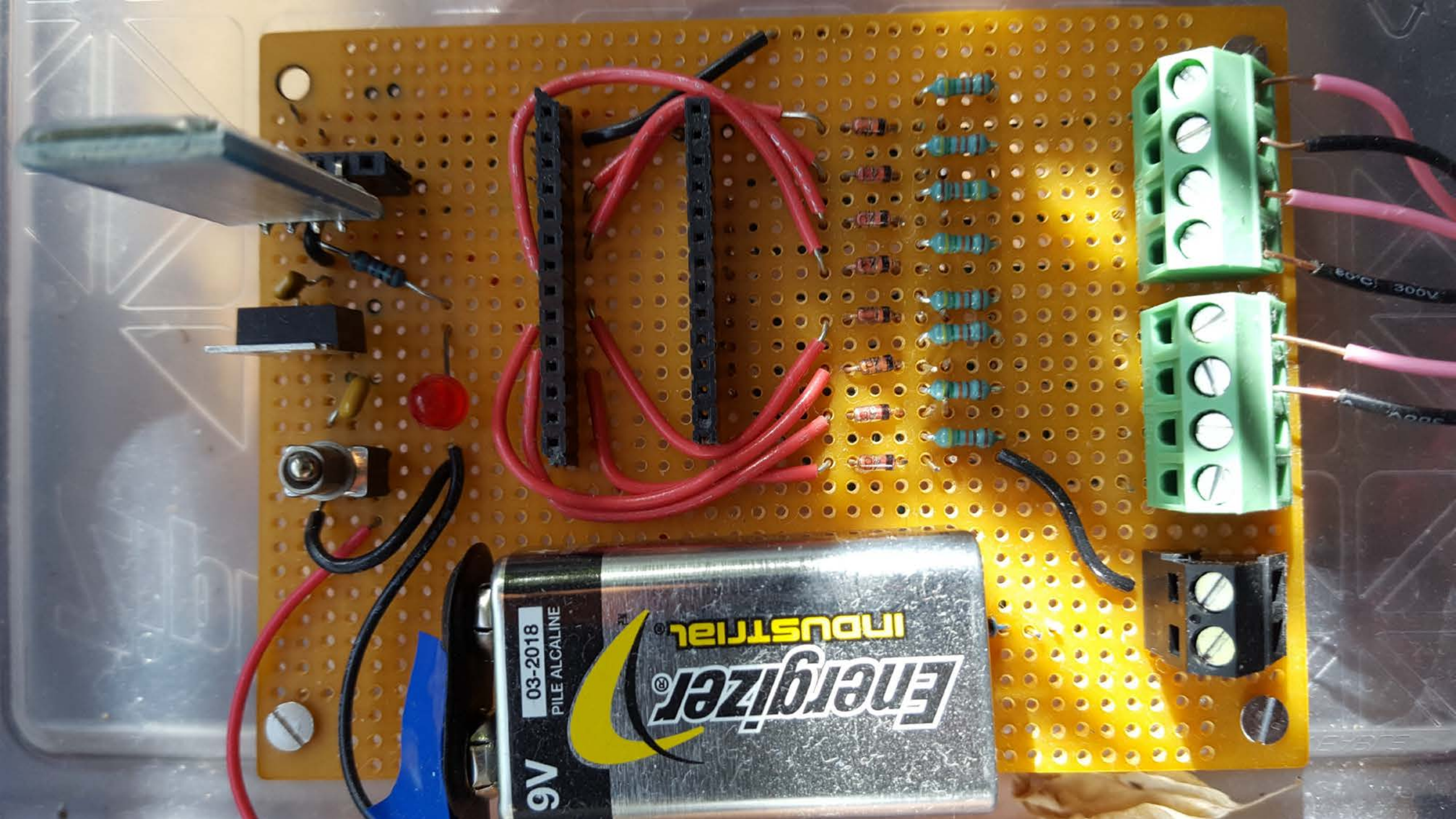


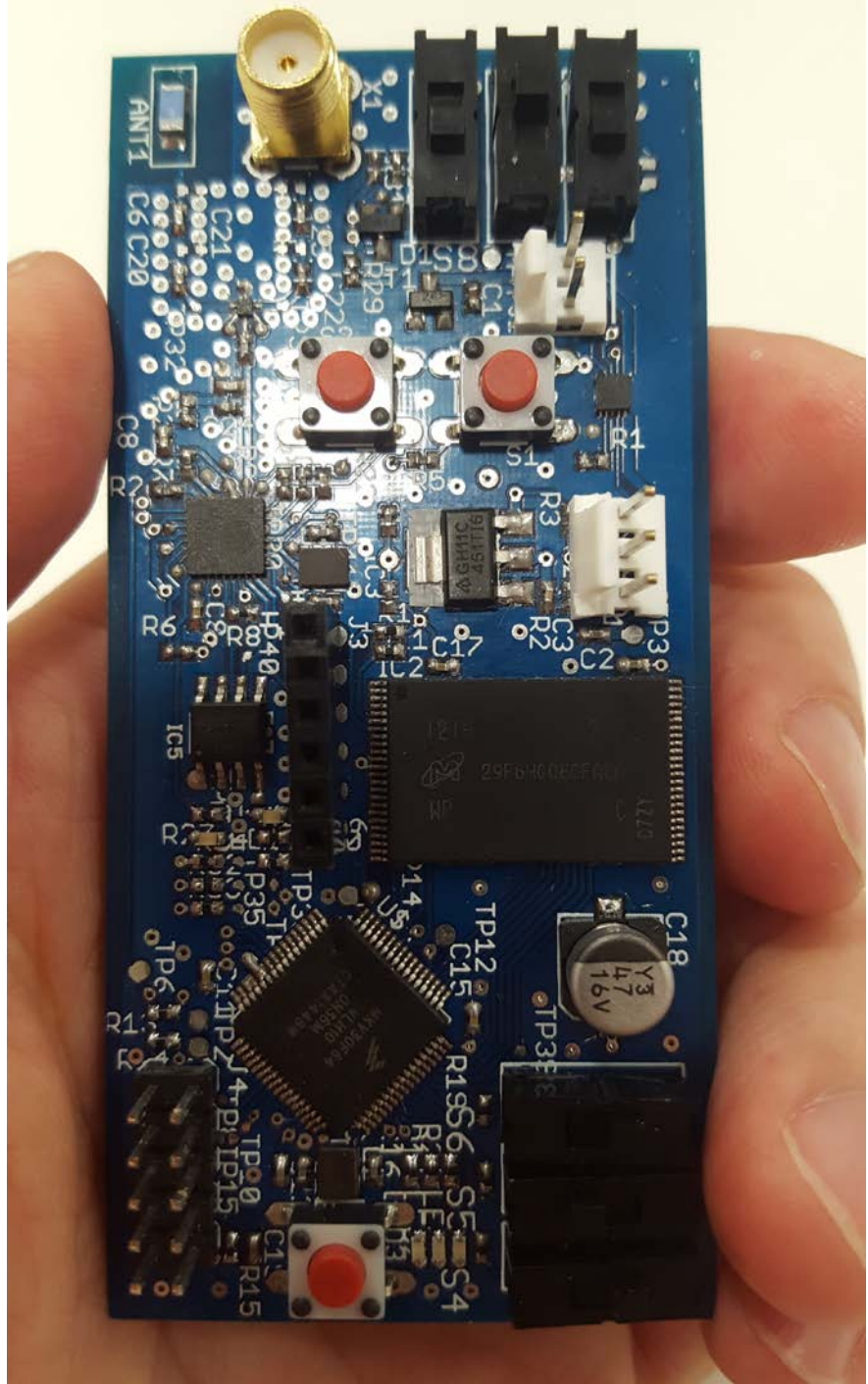
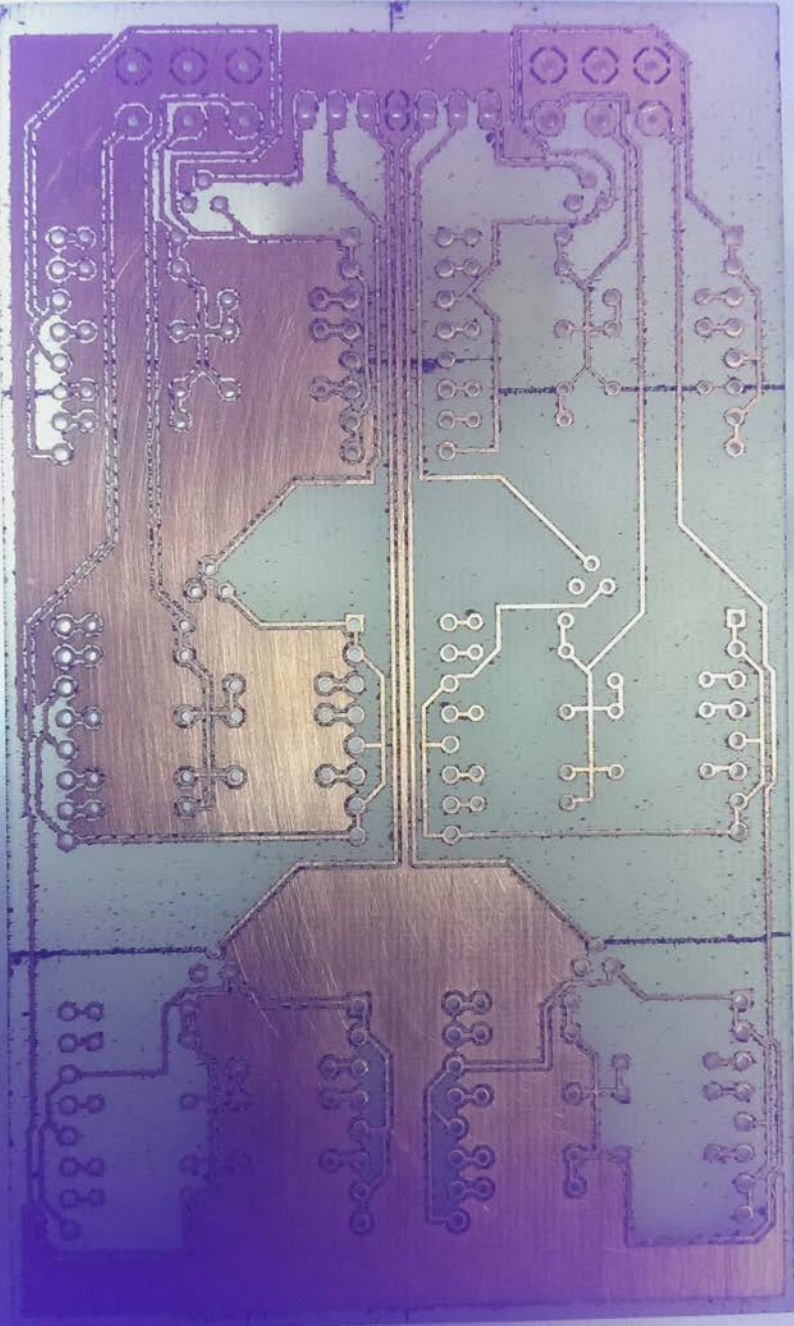
C

B

D





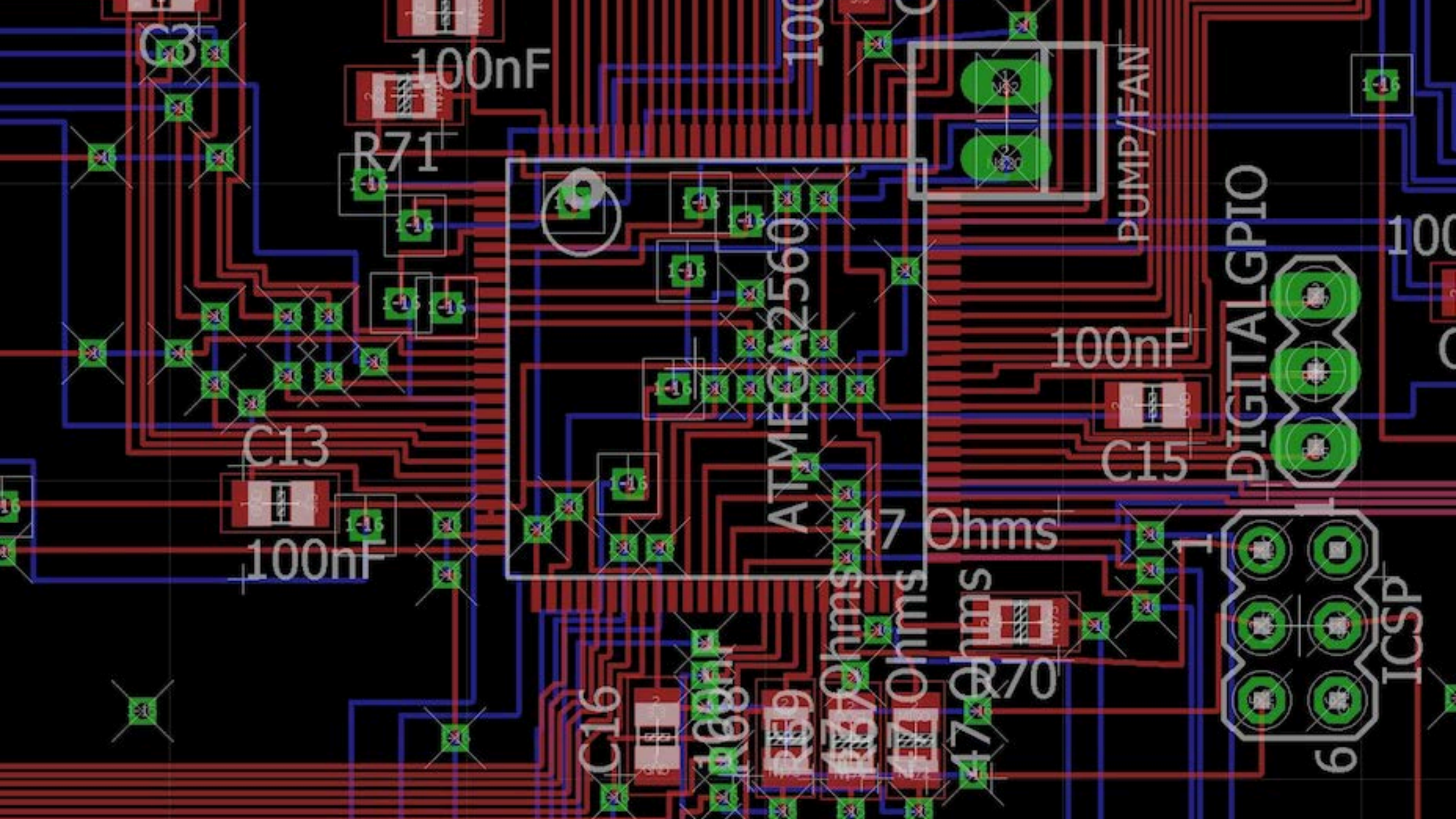




# What will we cover today...

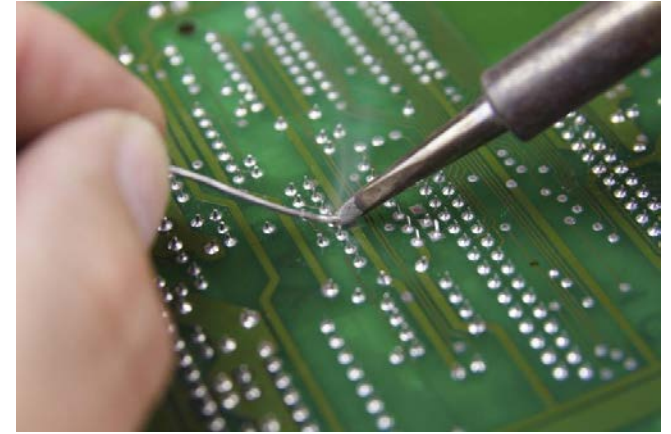
- There are “experts” throughout the room.
  - Goal is to introduce everyone to Eagle
  - Making a new part
  - Creating a schematic
  - Creating board files
  - Exporting for printing (?)
  - Tips
- 
- Most of the slides based on the ECE445 tutorial.

# 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

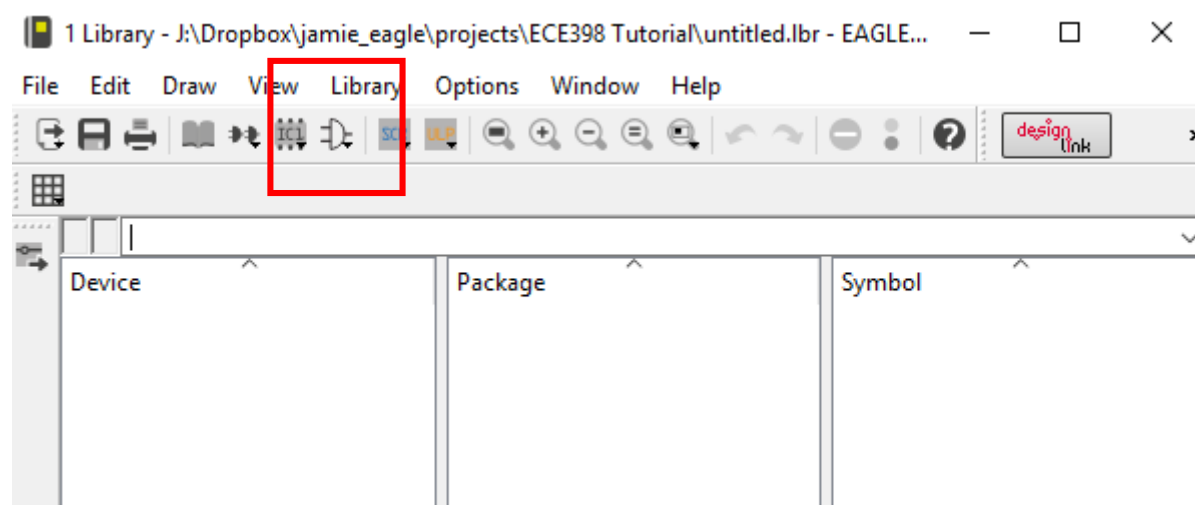


# Creating a new part...

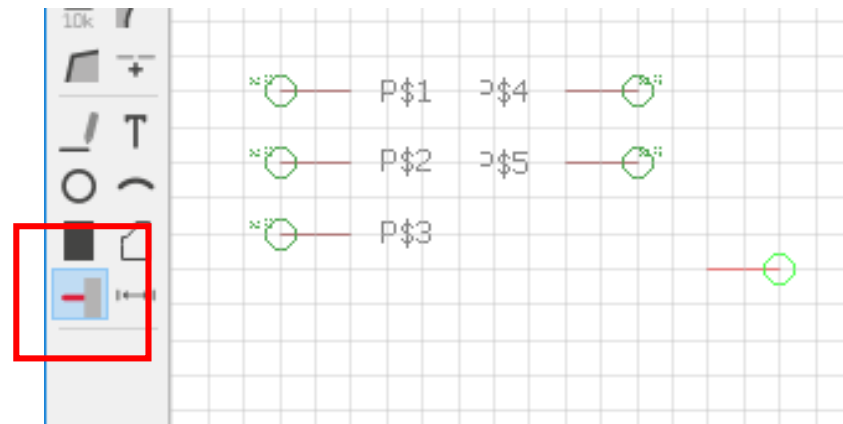
- Using EAGLE 7.7
- You will need the data sheet.
- Find physical dimensions.
  
- EAGLE -> File -> New
- Create new library
- Save library
  
- TPS799 Linear Regulator - <http://www.ti.com/lit/ds/symlink/tps799.pdf>
- Have to create three aspects of the part
  1. Device
  2. Symbol
  3. Package

# Creating the symbol

- Edit symbol

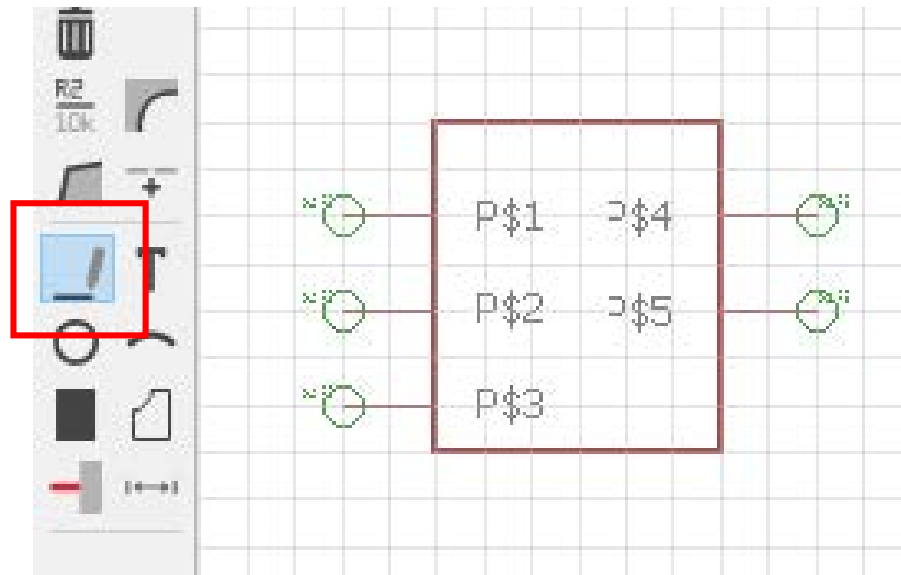


- Add pins

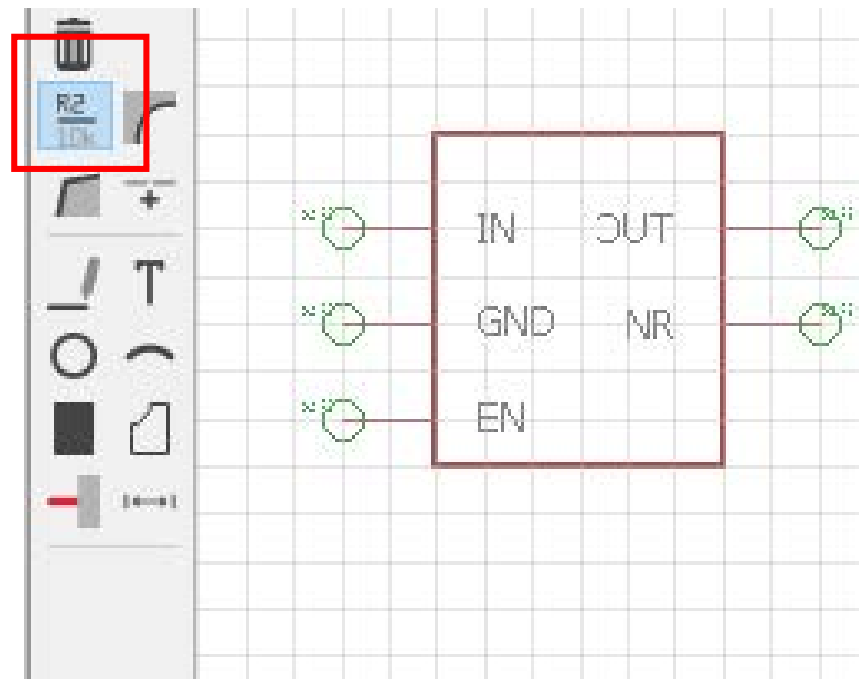


- Add an outline  
'Esc' key to end

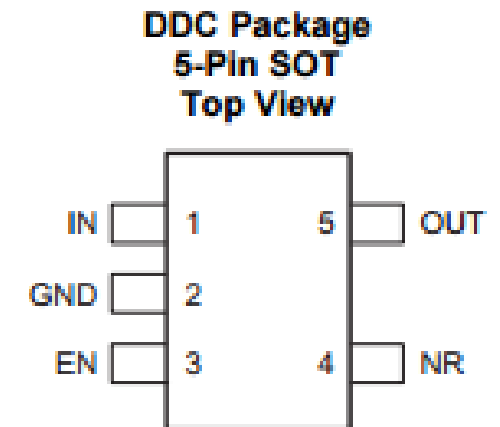
If you need to delete lines, use trash button.



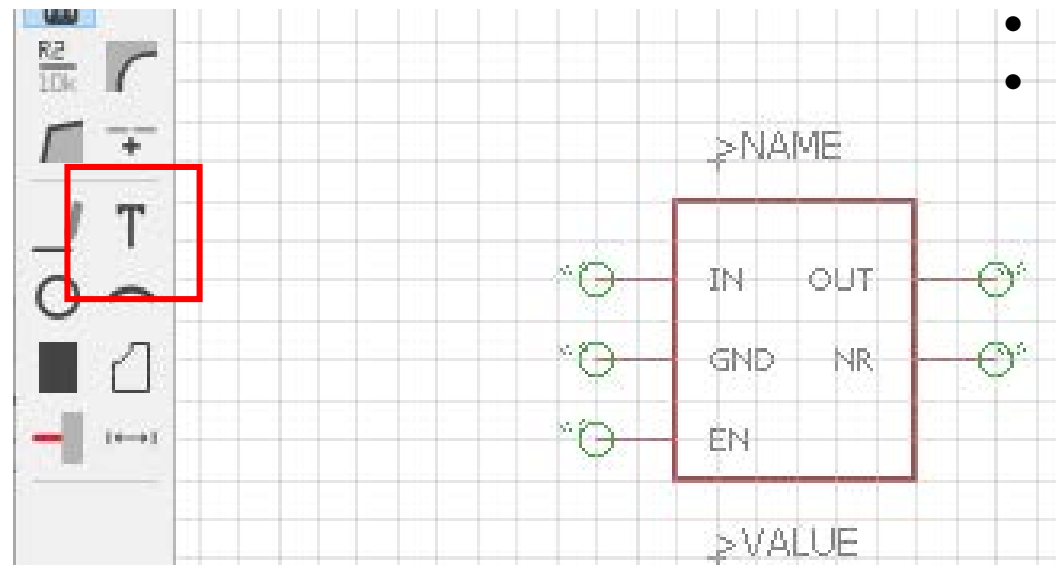
- Name the pins



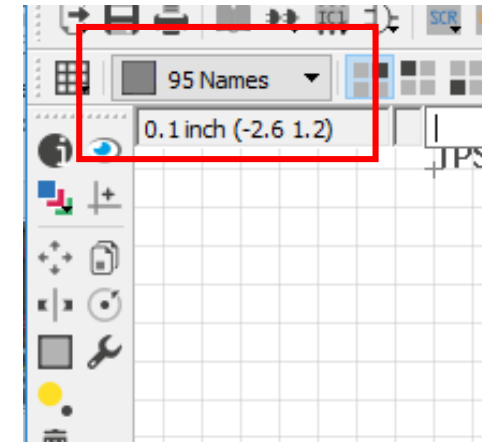
- From the data sheet



- Add labels



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



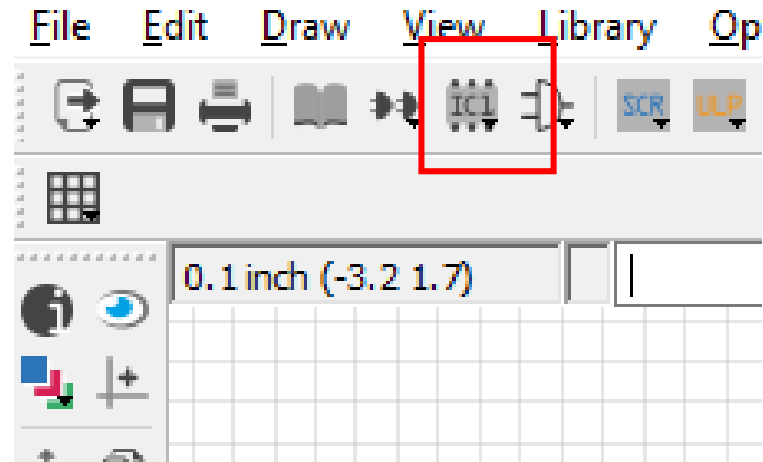
More on layers:

<https://learn.adafruit.com/ktowns-ultimate-creating-parts-in-eagle-tutorial/creating-a-package-outline>

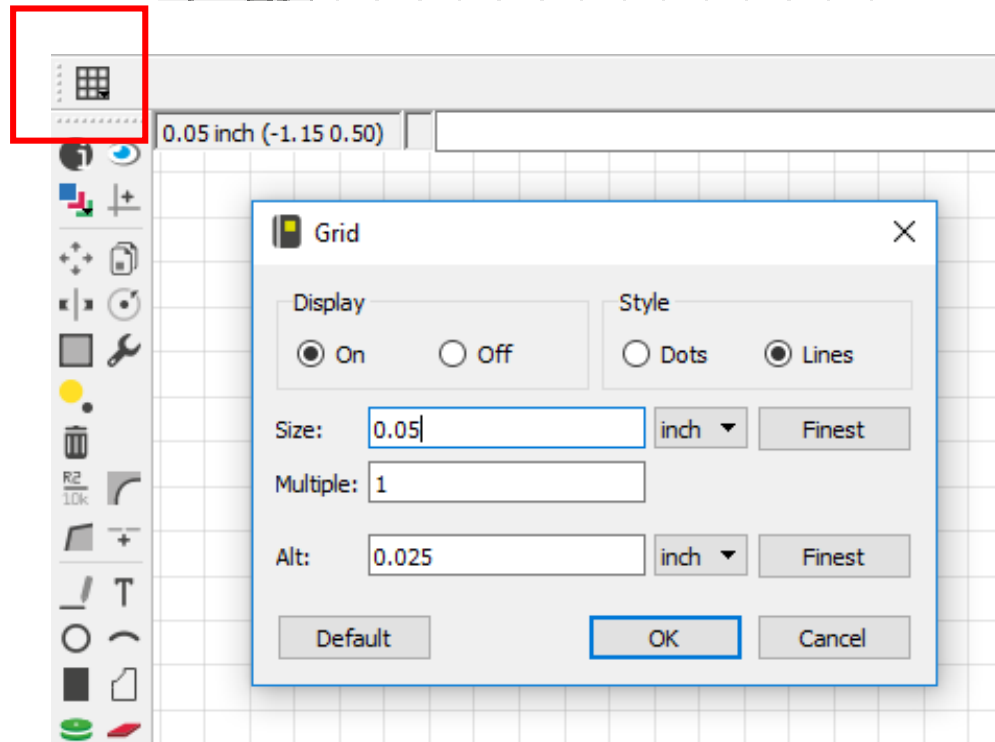


# Creating the package

- Select package



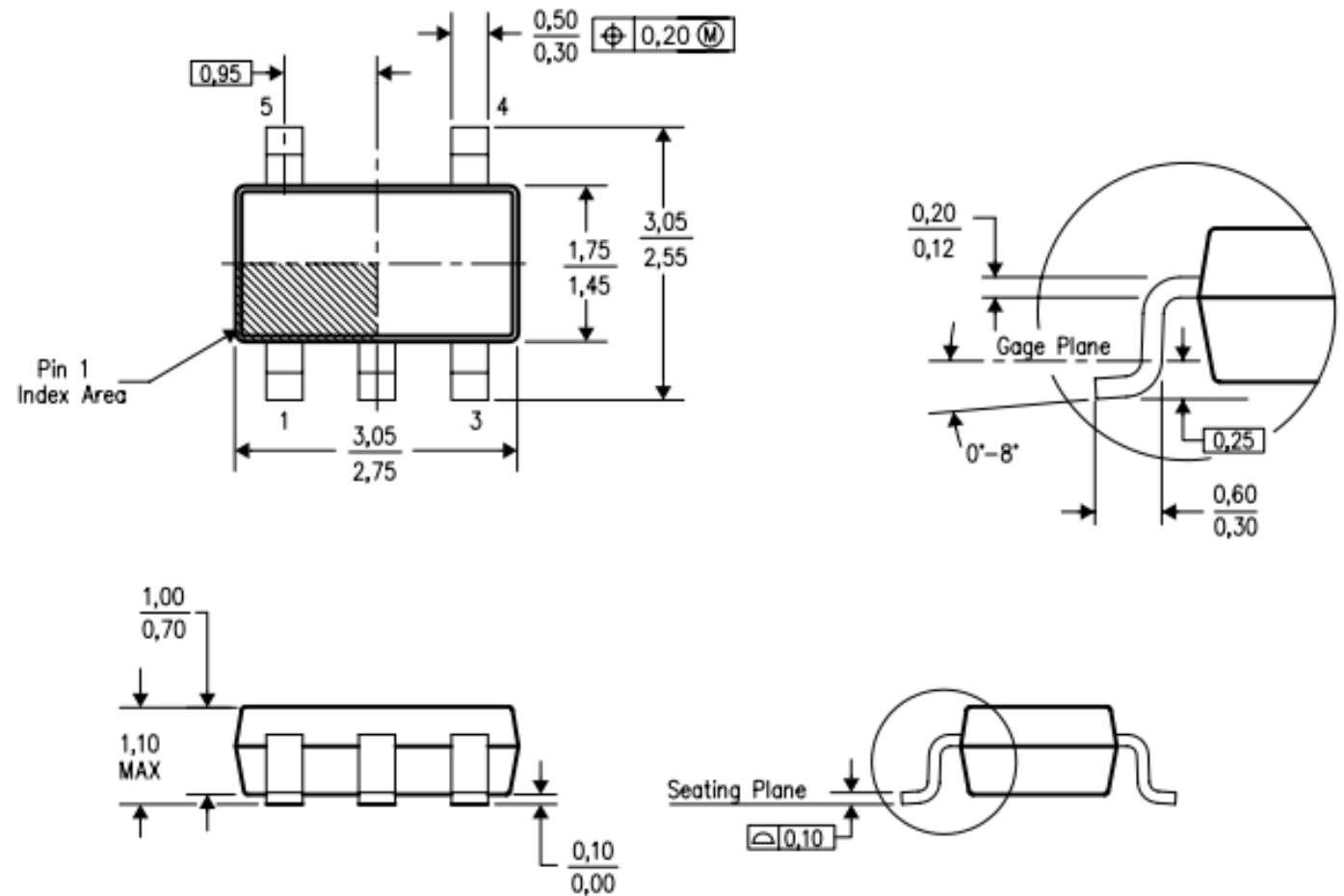
- Note the grid

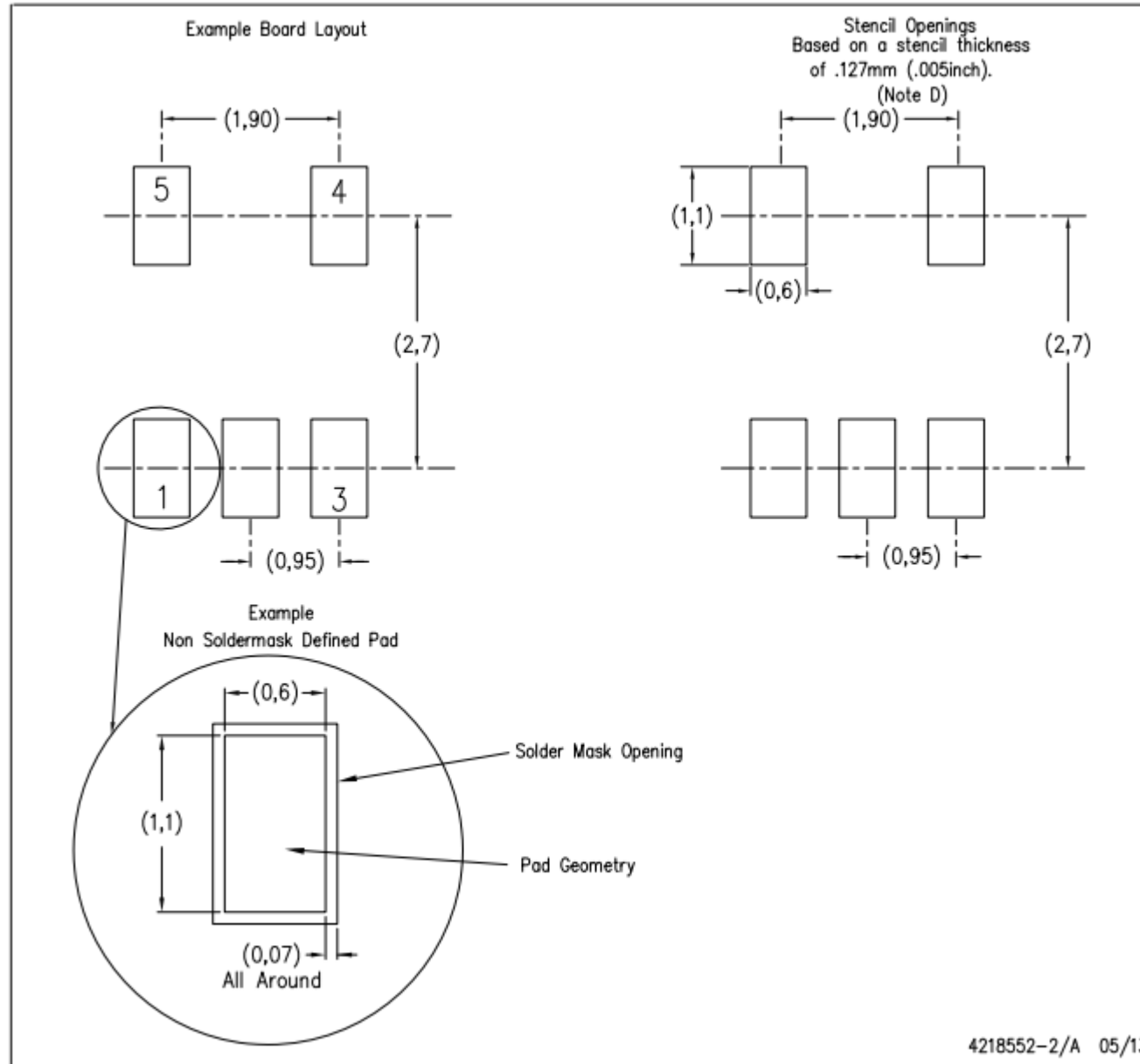


# TPS799

## 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).

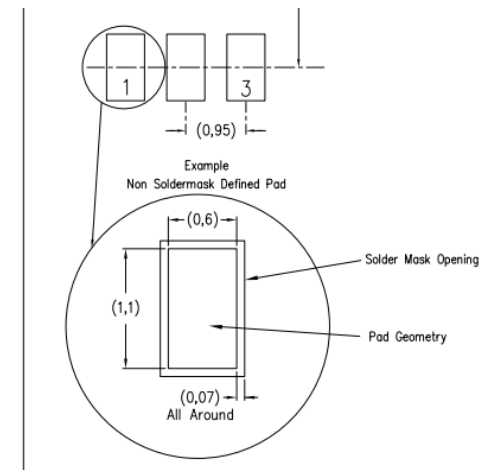
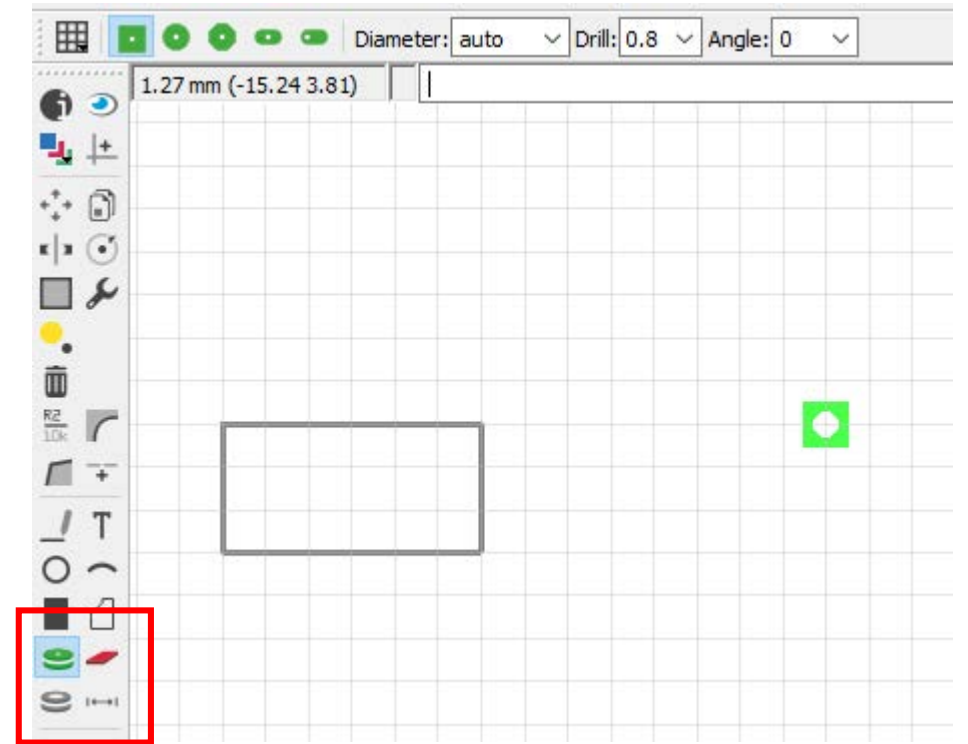
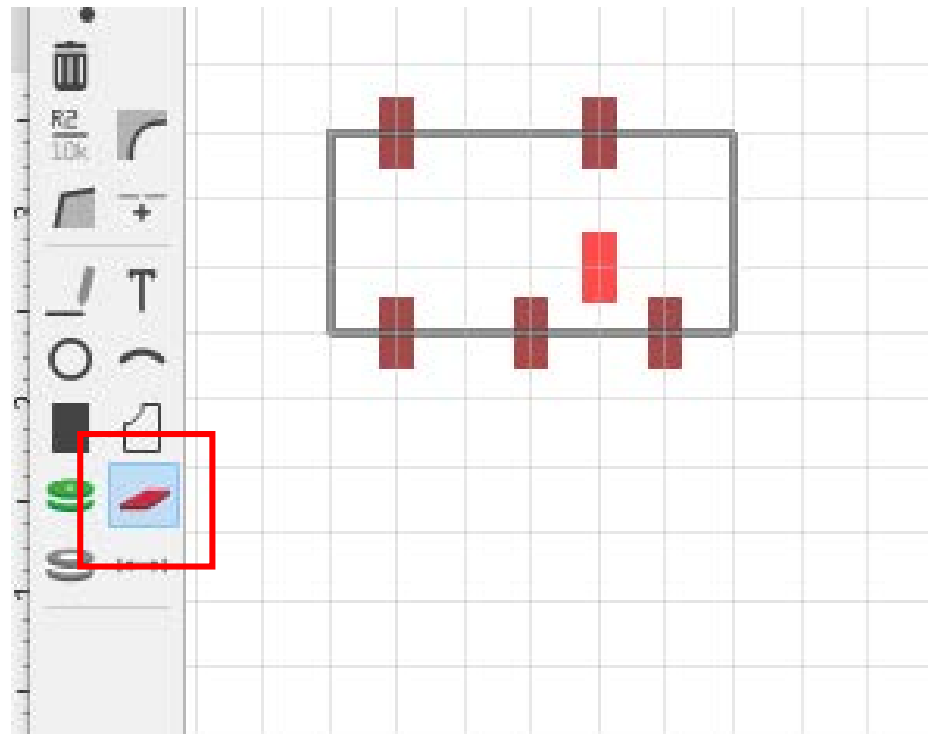




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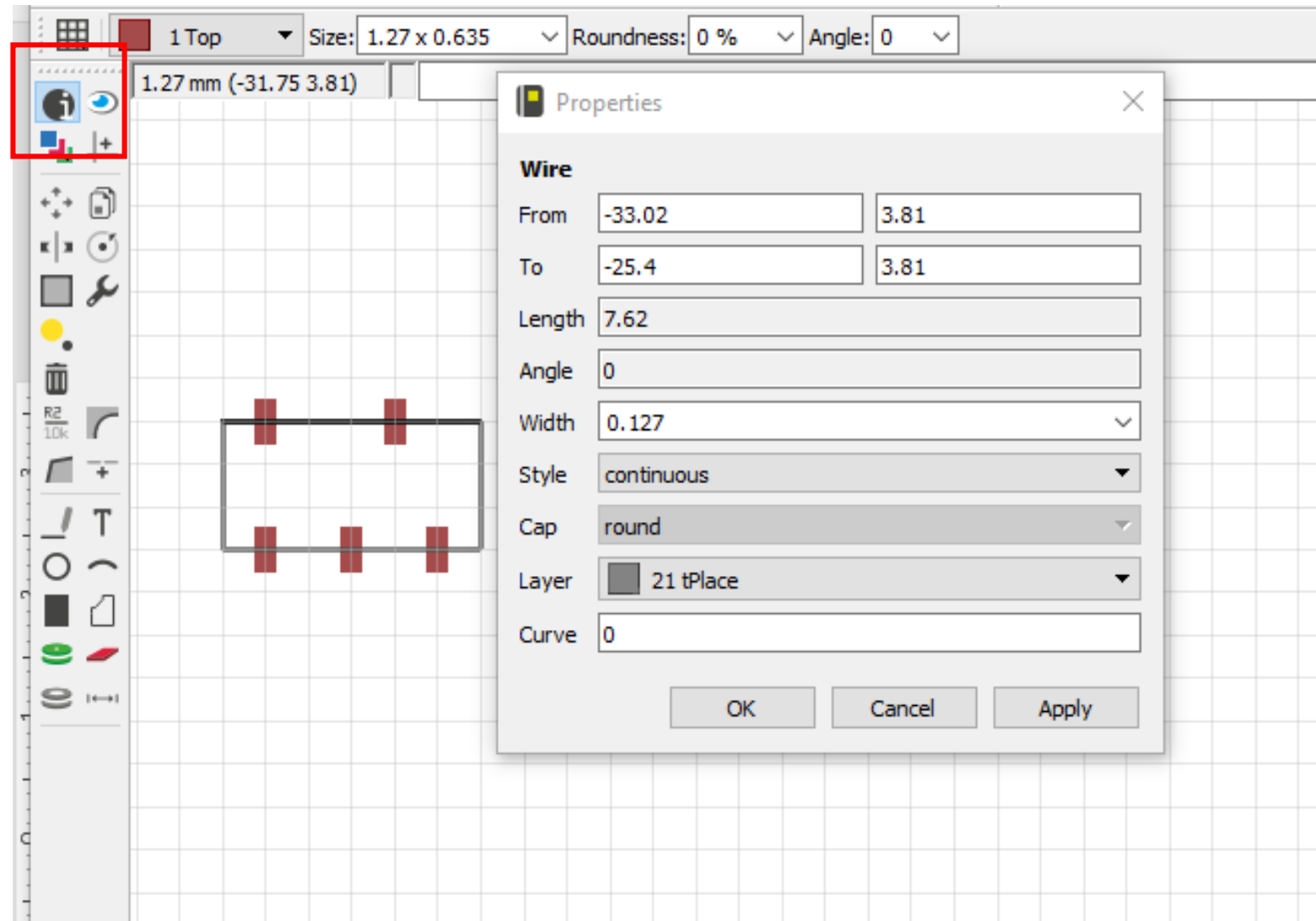
NOTES: A. All linear dimensions are in millimeters.  
 B. This drawing is subject to change without notice.

- Add pads

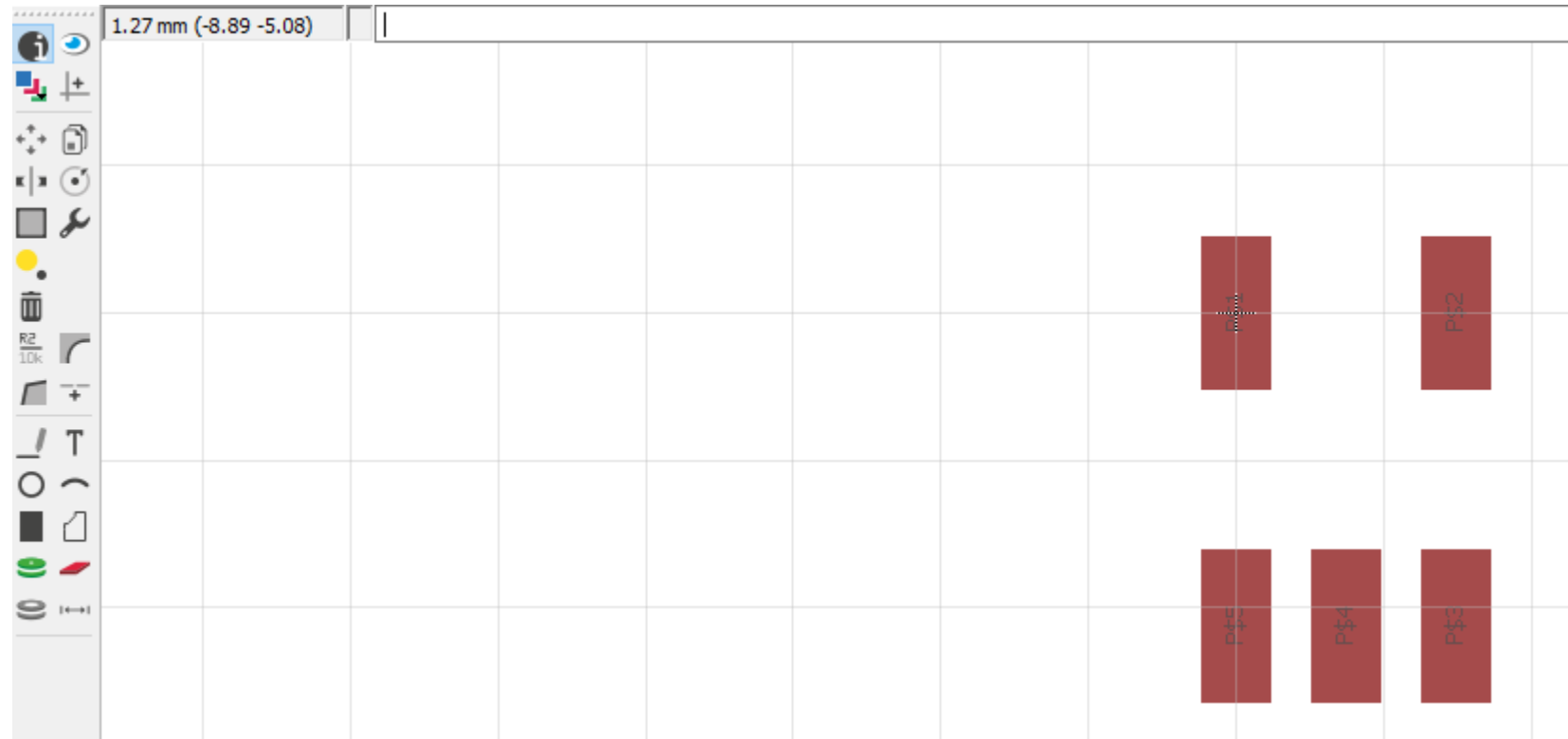


NOTES: A. All linear dimensions are in millimeters.

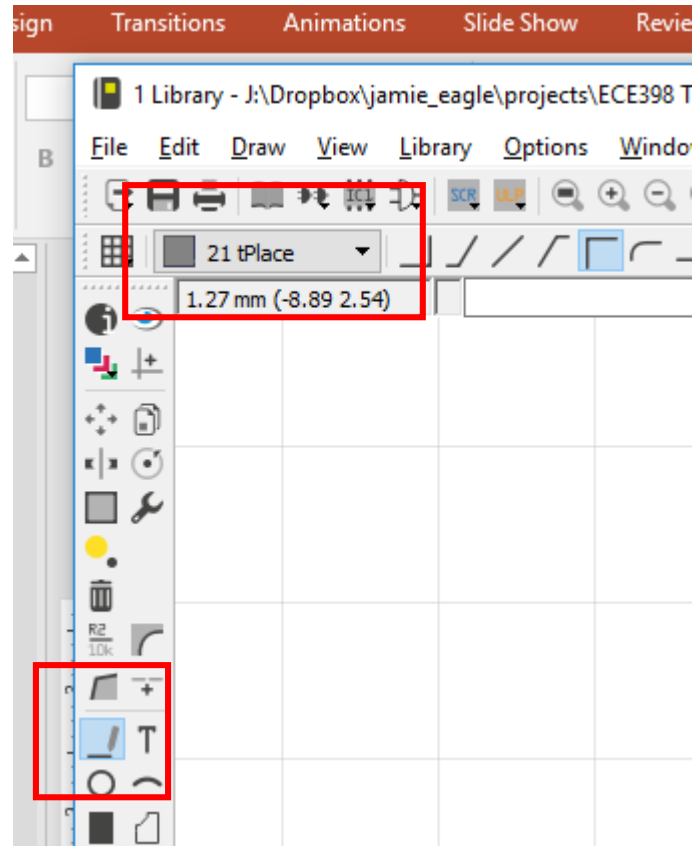
- Use the “i” tool to adjust position.



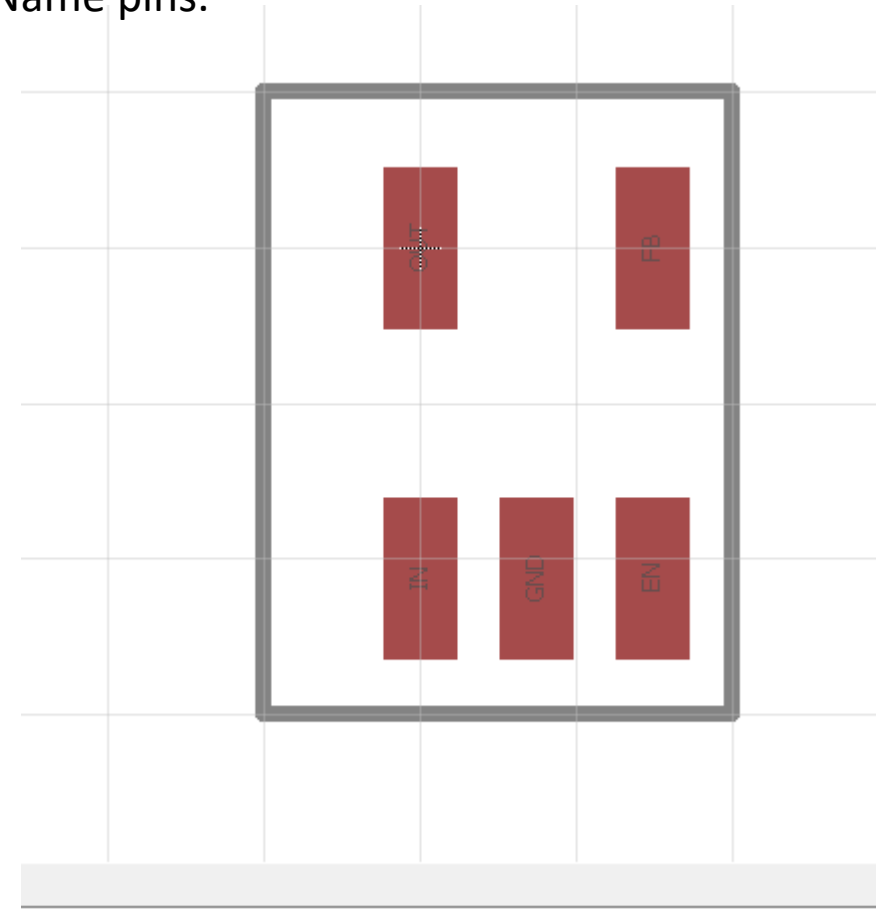
- Use the “i” tool to adjust position.



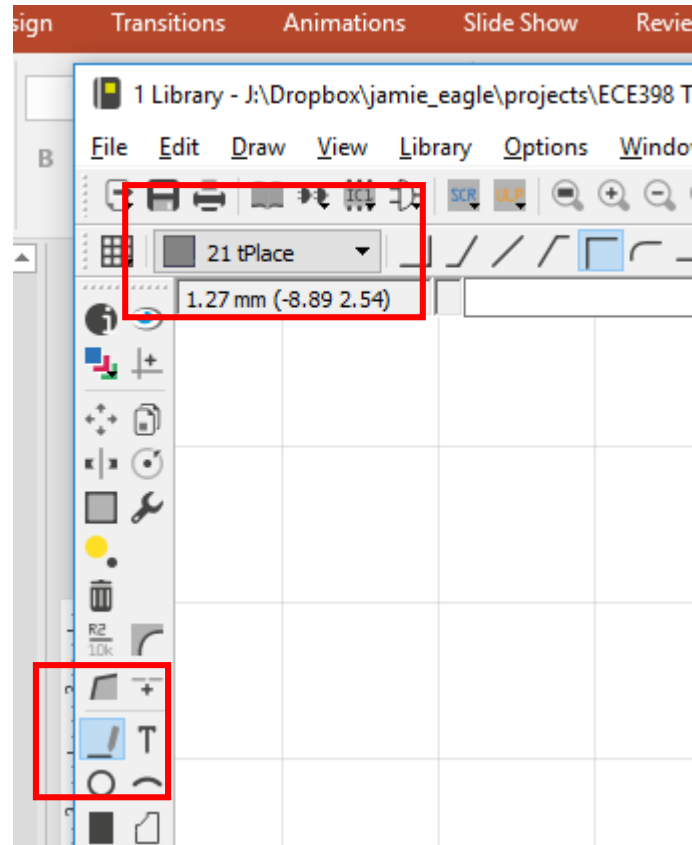
- Add outline.



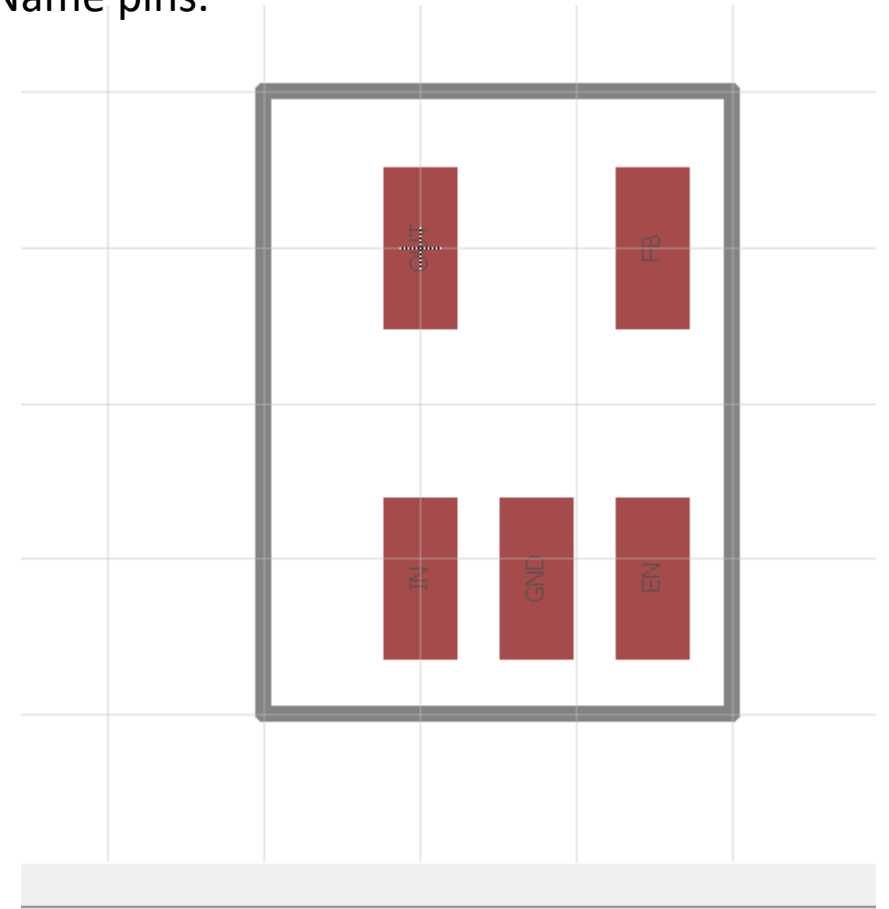
- Name pins.



- Add outline.



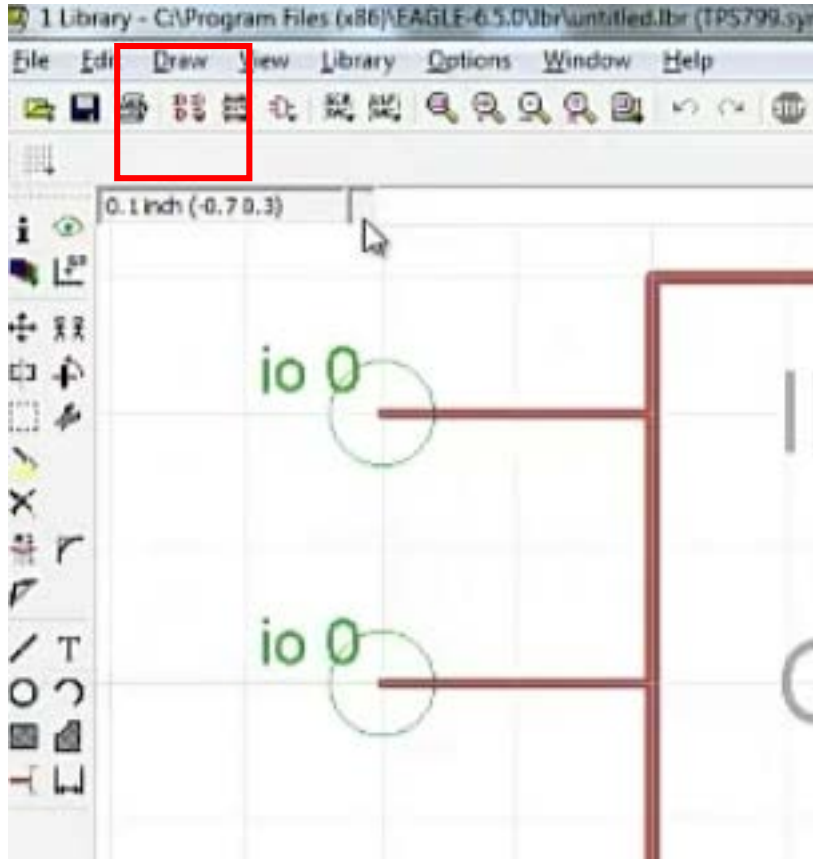
- Name pins.





# Create device

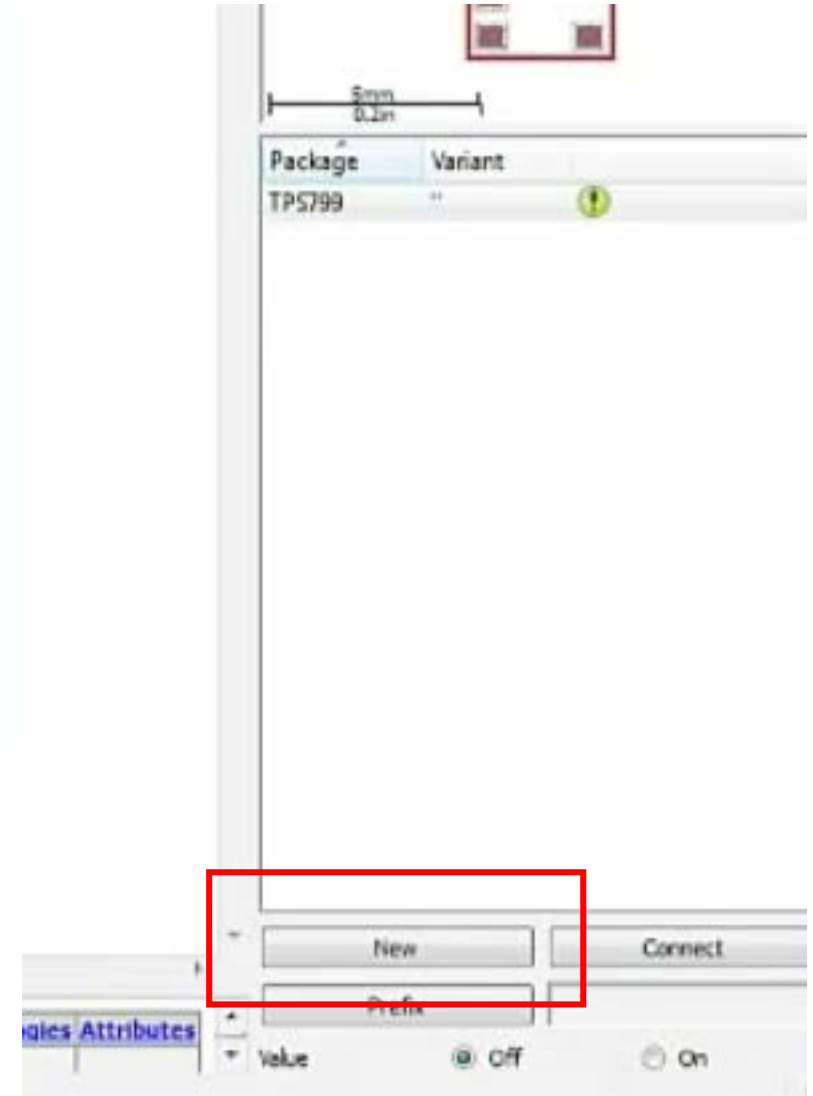
- Device



- Add symbol

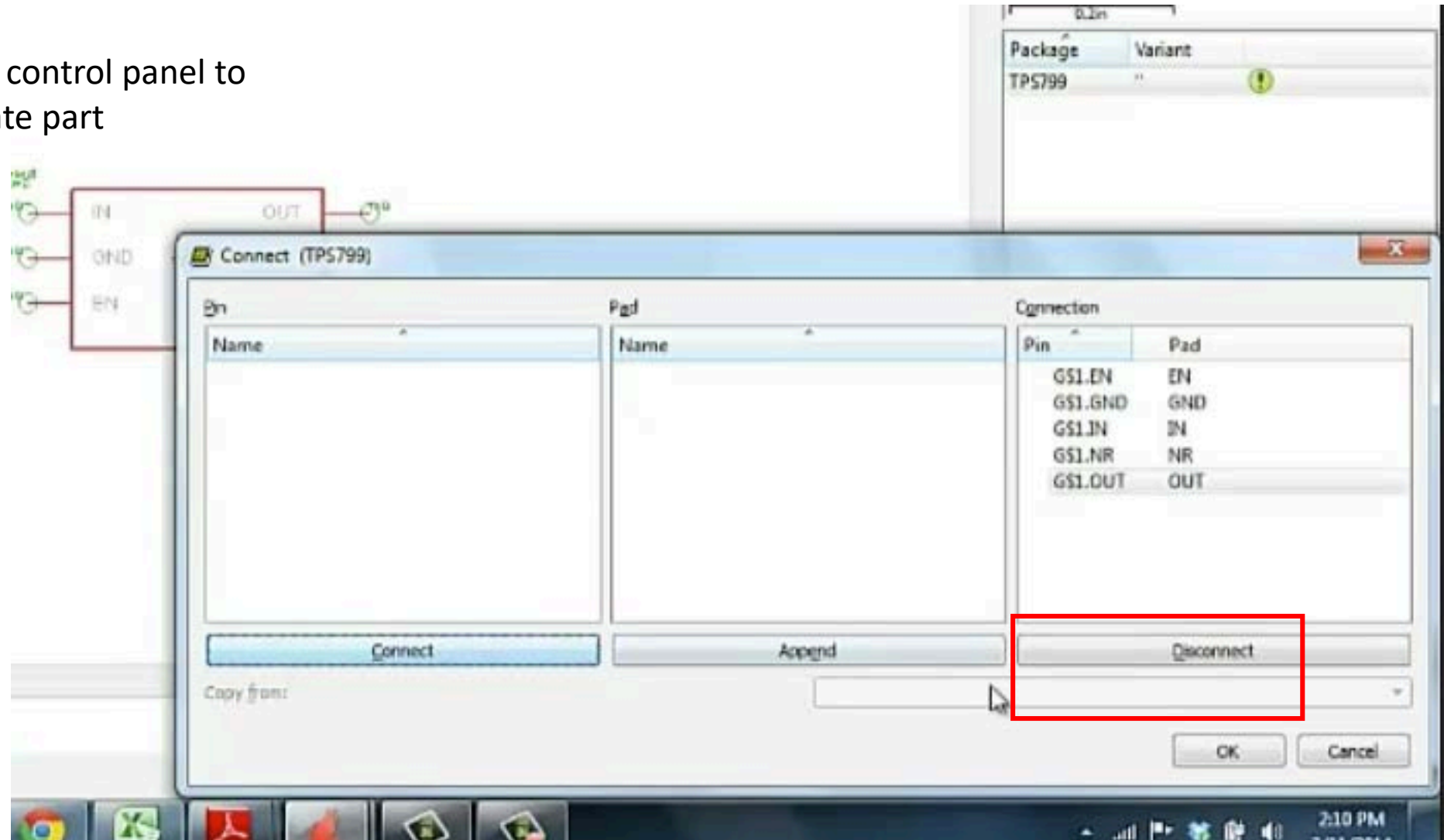


- Package



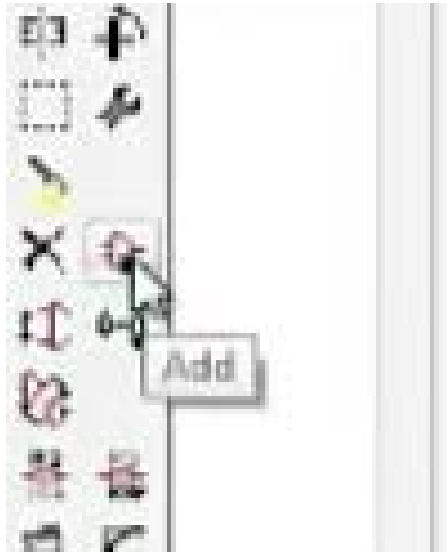
# Create device

- 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 Re
- ▶ rcl Resistors, Capacitors, Inductors
- ▶ recom-int... RECOM POWER SOLUTIONS
- ▶ rectifier Rectifiers
- ▶ relay Relays

# Actual circuit

Unbelievable number of resistors

The image shows a software interface for managing a large number of resistors in a circuit. On the left, a list of resistors is displayed, with the 'R-... 0207/10' entry selected. The list includes various resistor types and values, such as 0204V, 0204/5, 0204/7, 0207/2V, 0207/5V, 0207/7, 0207/10, 0207/12, 0207/15, 0309/10, 0309/12, 0309V, 0411V, 0411/12, 0411/15, and 0411V. Below the list, there are search and attribute filters, and several checkboxes are checked: 'Pads', 'Smgs', 'Descriptor', and 'Preview'.

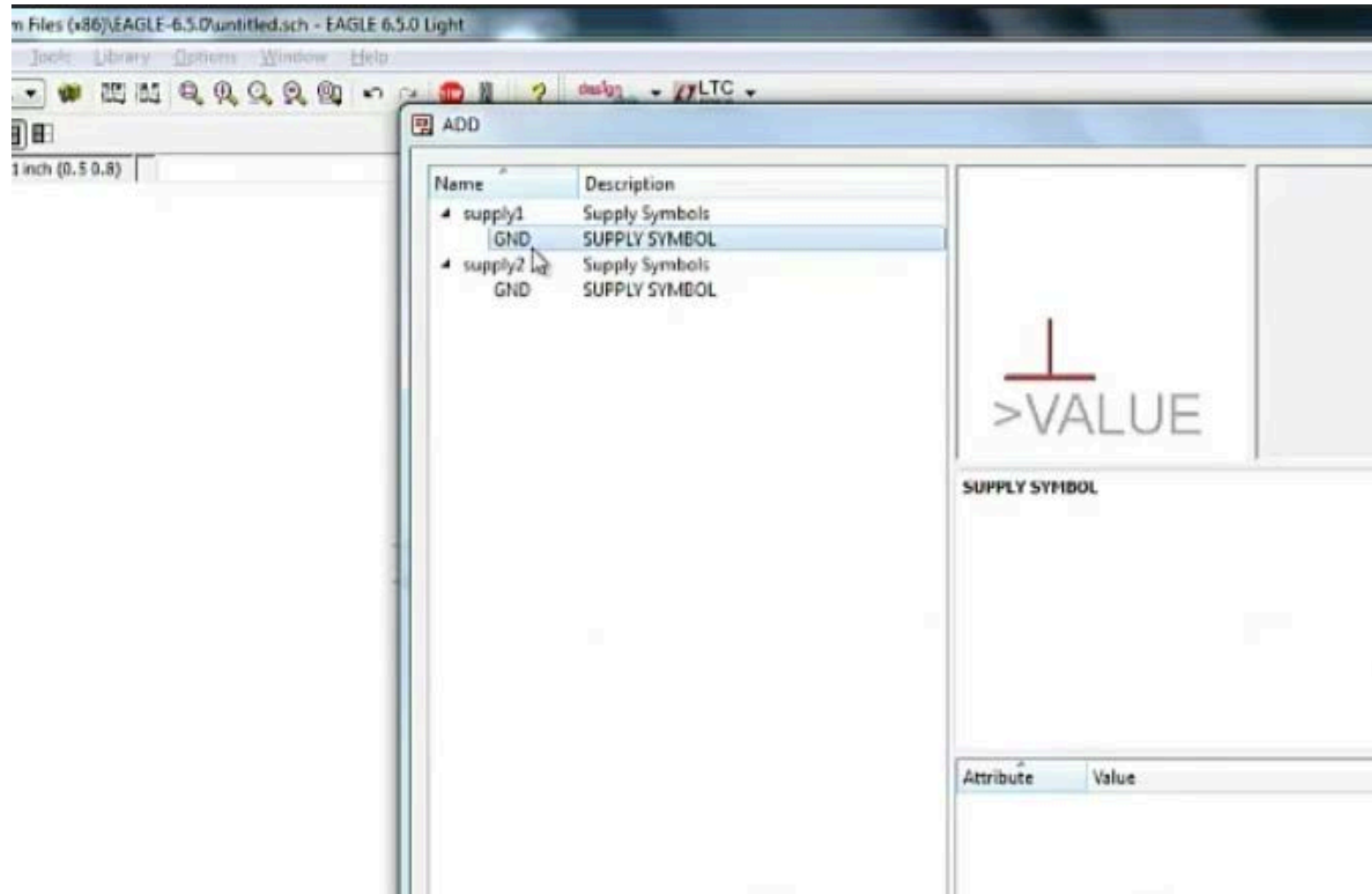
On the right, a preview of the selected resistor is shown. It includes a schematic symbol labeled 'G\$1' and '>VALUE', a physical component model, and a scale bar indicating 5mm (0.2in). Below the preview, the following information is displayed:

- RESISTOR, American symbol**
- Package: 0207/10**
- RESISTOR**
- type 0207, grid 10 mm

At the bottom right, there is a table with columns for 'Attribute' and 'Value'.

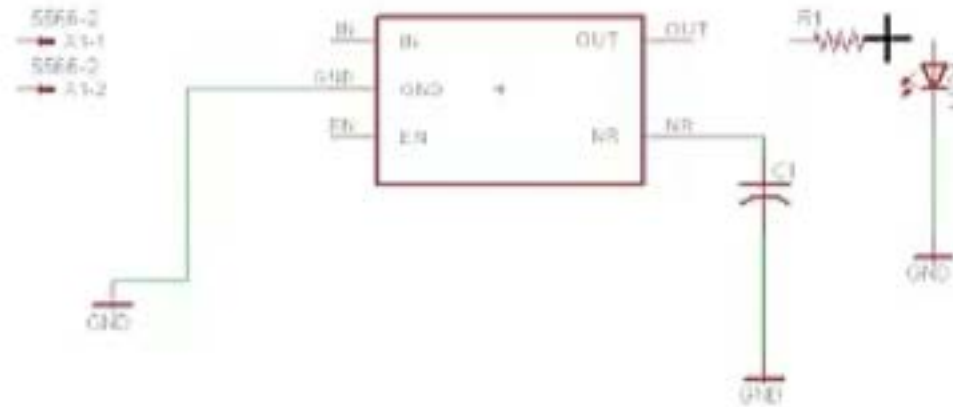
# Actual circuit

Add ground



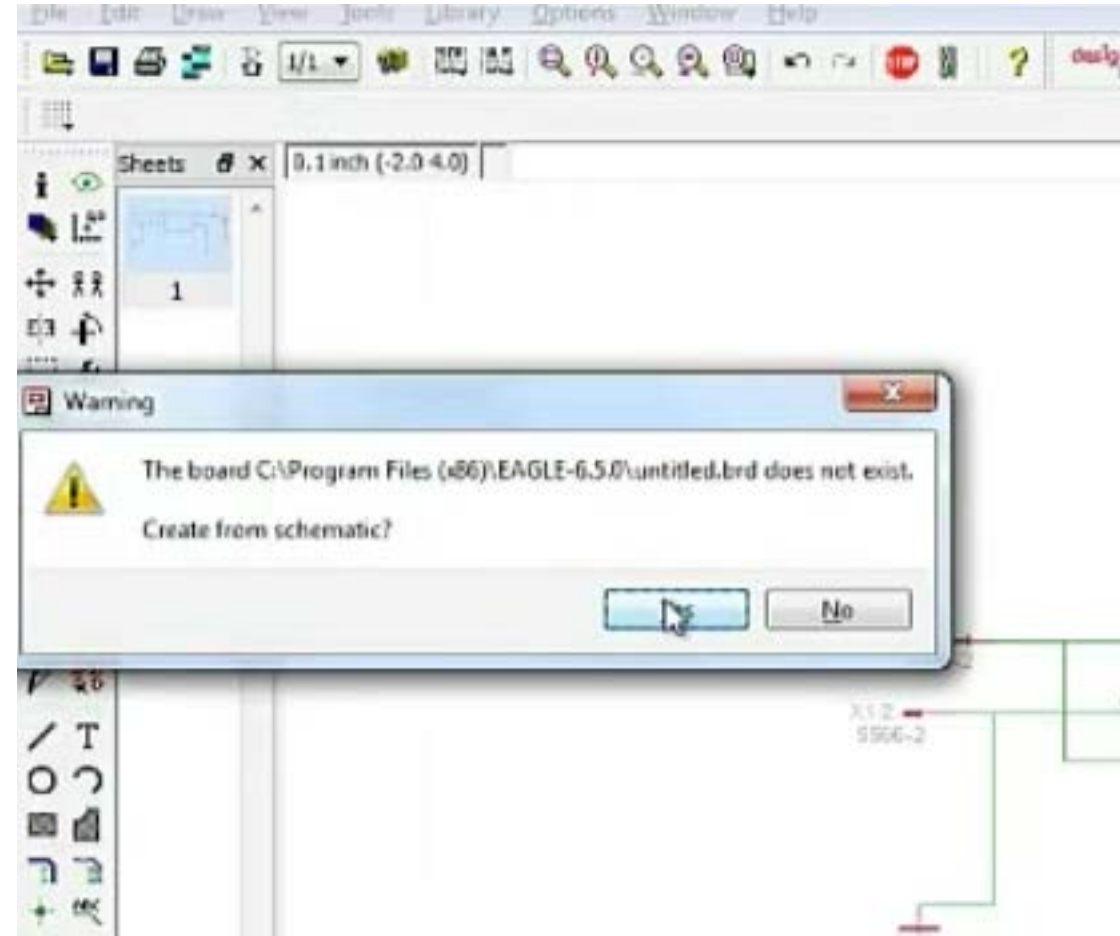
# Actual circuit

Use wire tool to connect everything



# Actual circuit

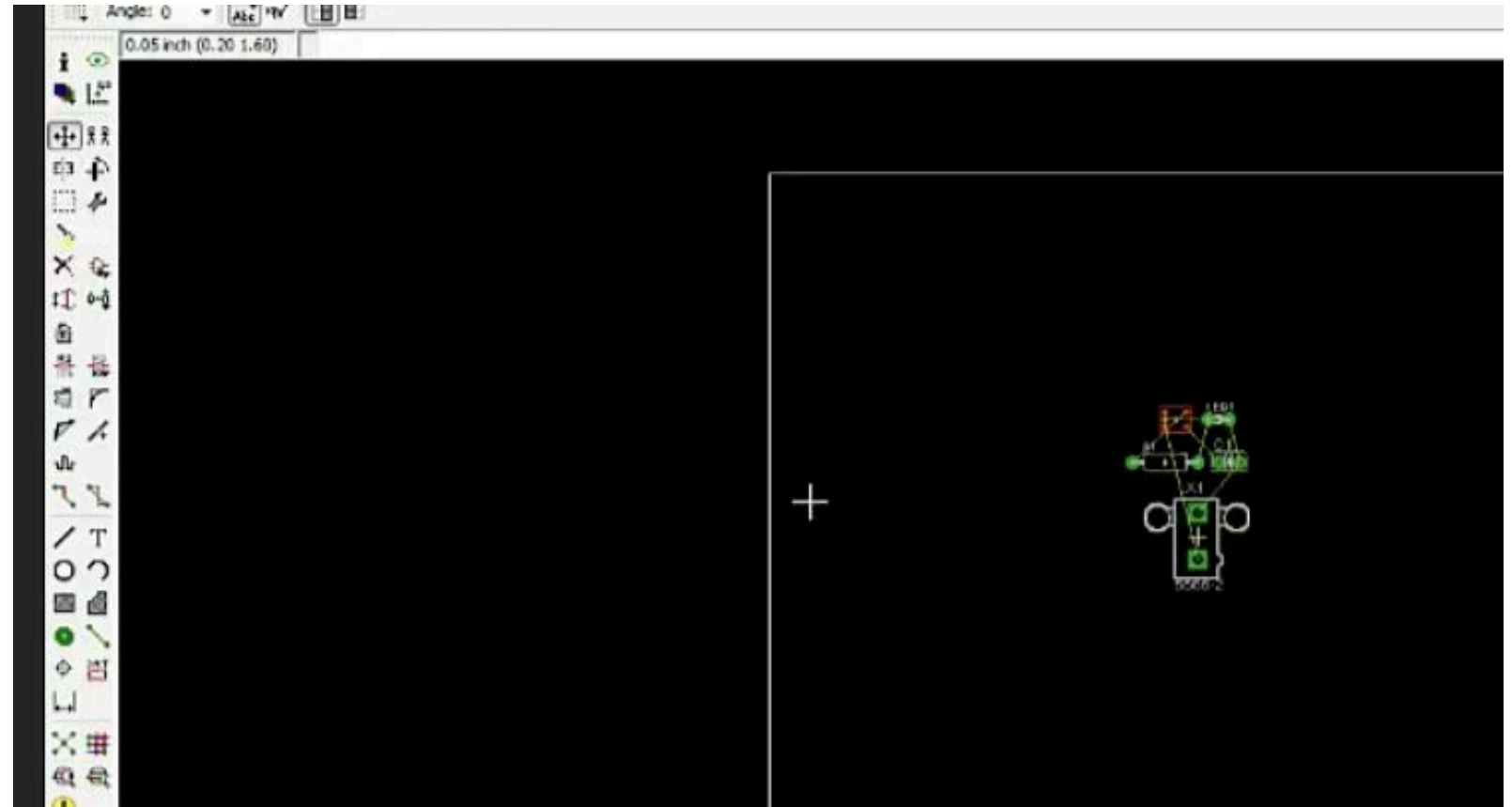
Switch to board



# Actual circuit

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

Change grid to mil



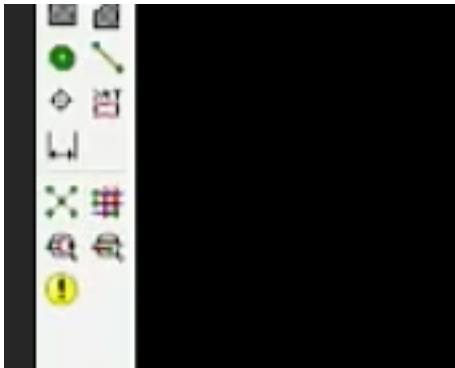


# Actual circuit

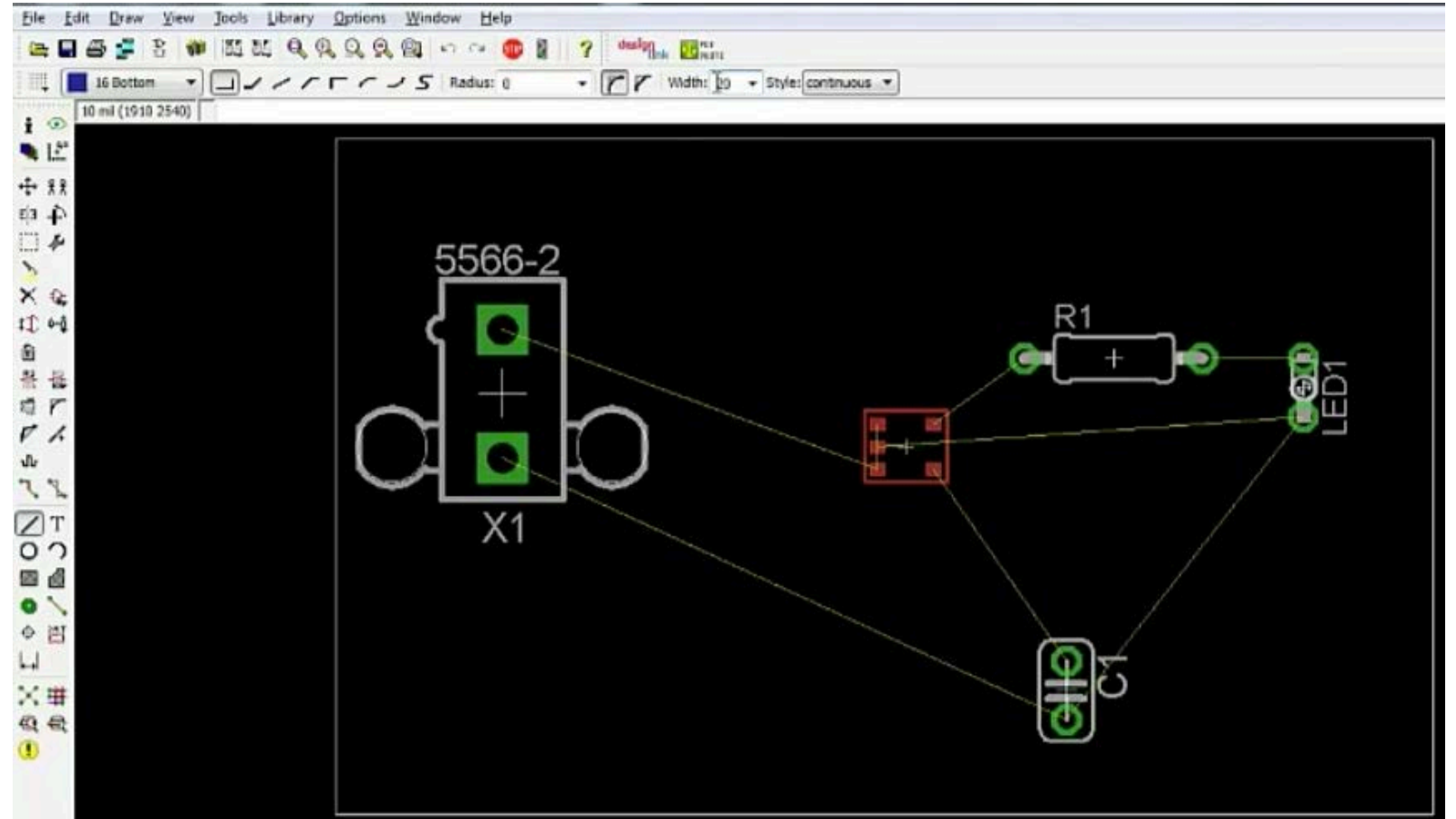
Use wire tool to connect.

Check wire width.

Put on the proper layer.

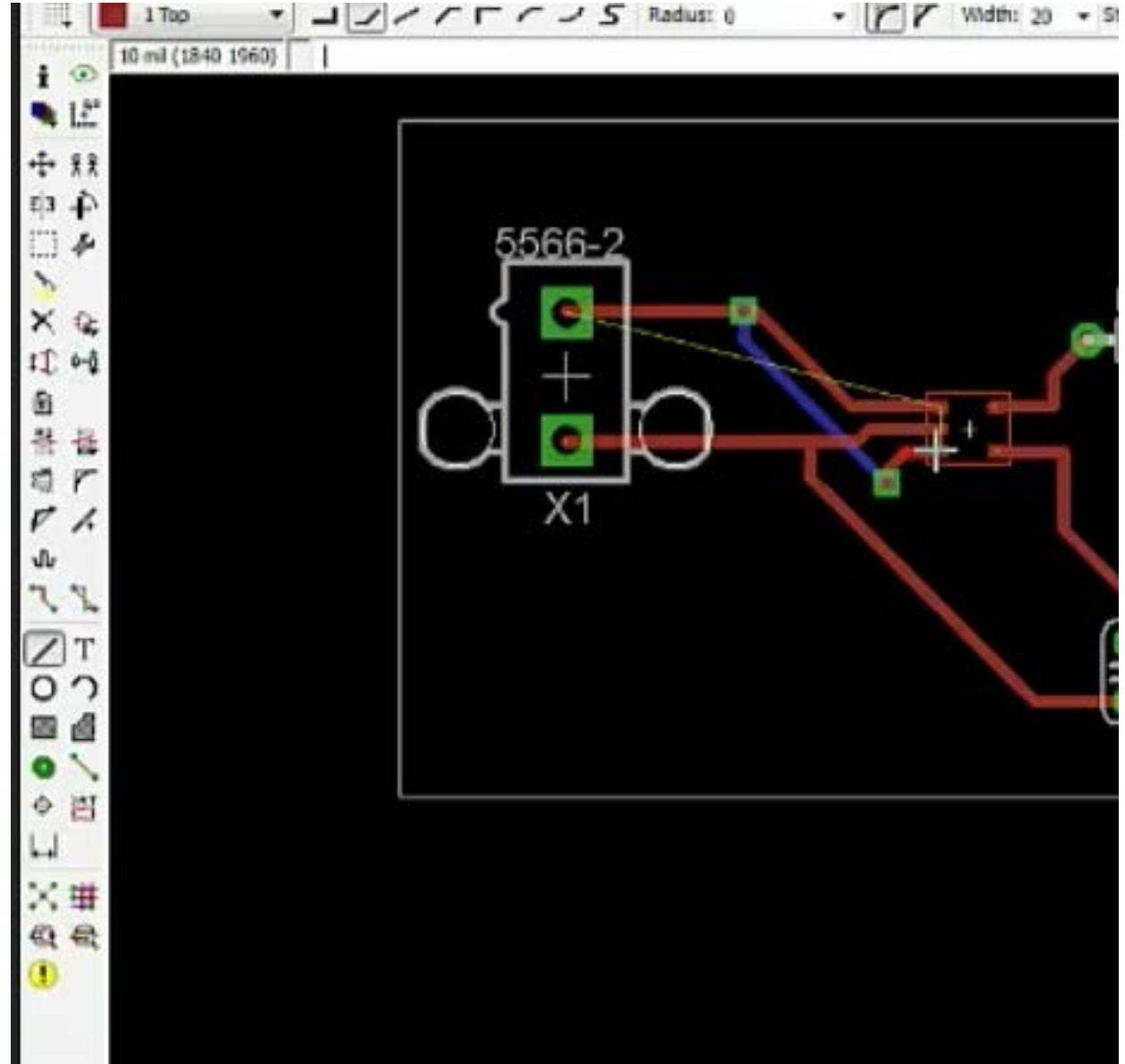


Rats nest to check...



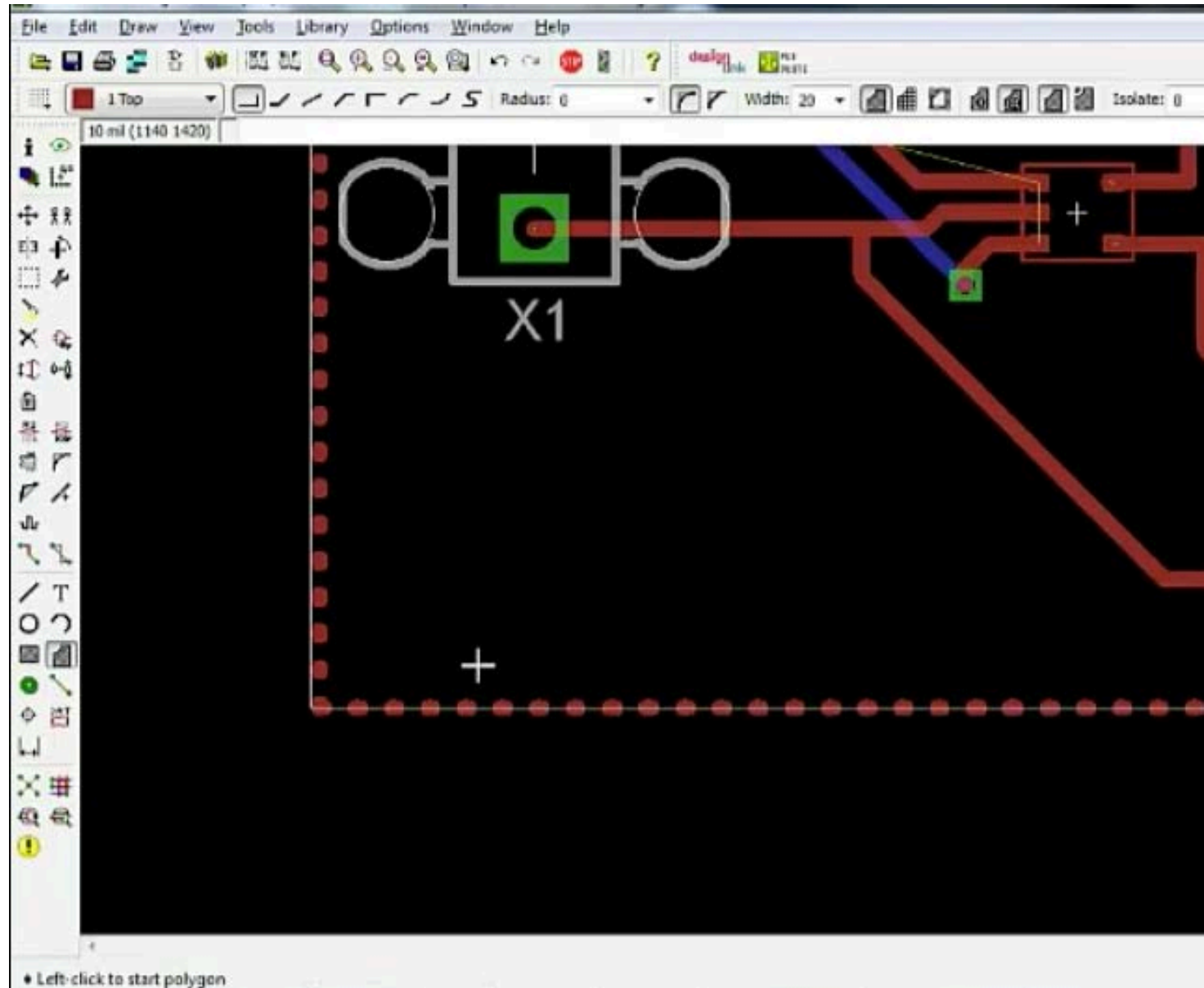
# Actual circuit

Vias



# Actual circuit

- Add ground plane
- Name it ground
- Use rats nest



DRC

Nathan

# Export to Gerber

[https://www.youtube.com/watch?v=B\\_SbQeF83XU](https://www.youtube.com/watch?v=B_SbQeF83XU)

# Tips from Danny

- \* Extending pads, 0.5mm surface mount
- \* put components on on side of 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 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