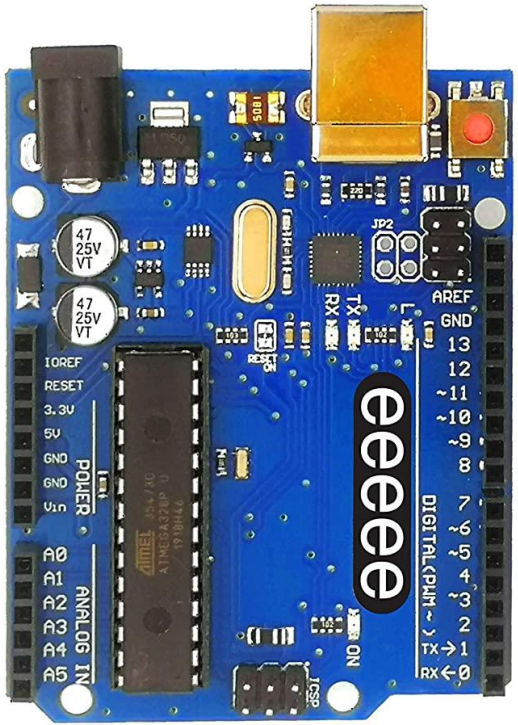
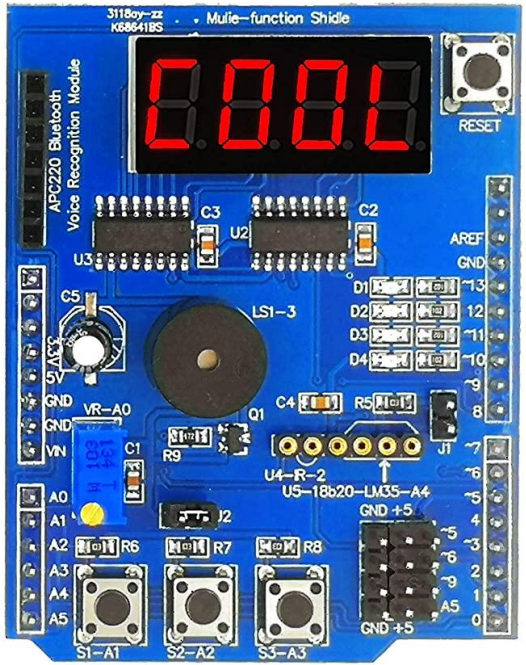
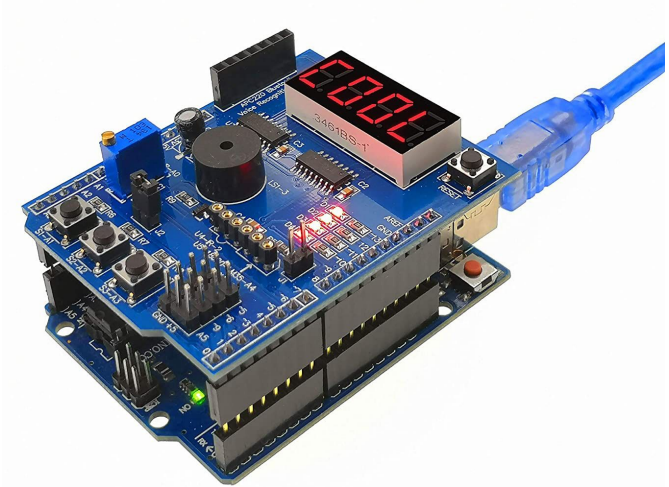
Extending Arduino Functionality via Printed Circuit Board (PCB)

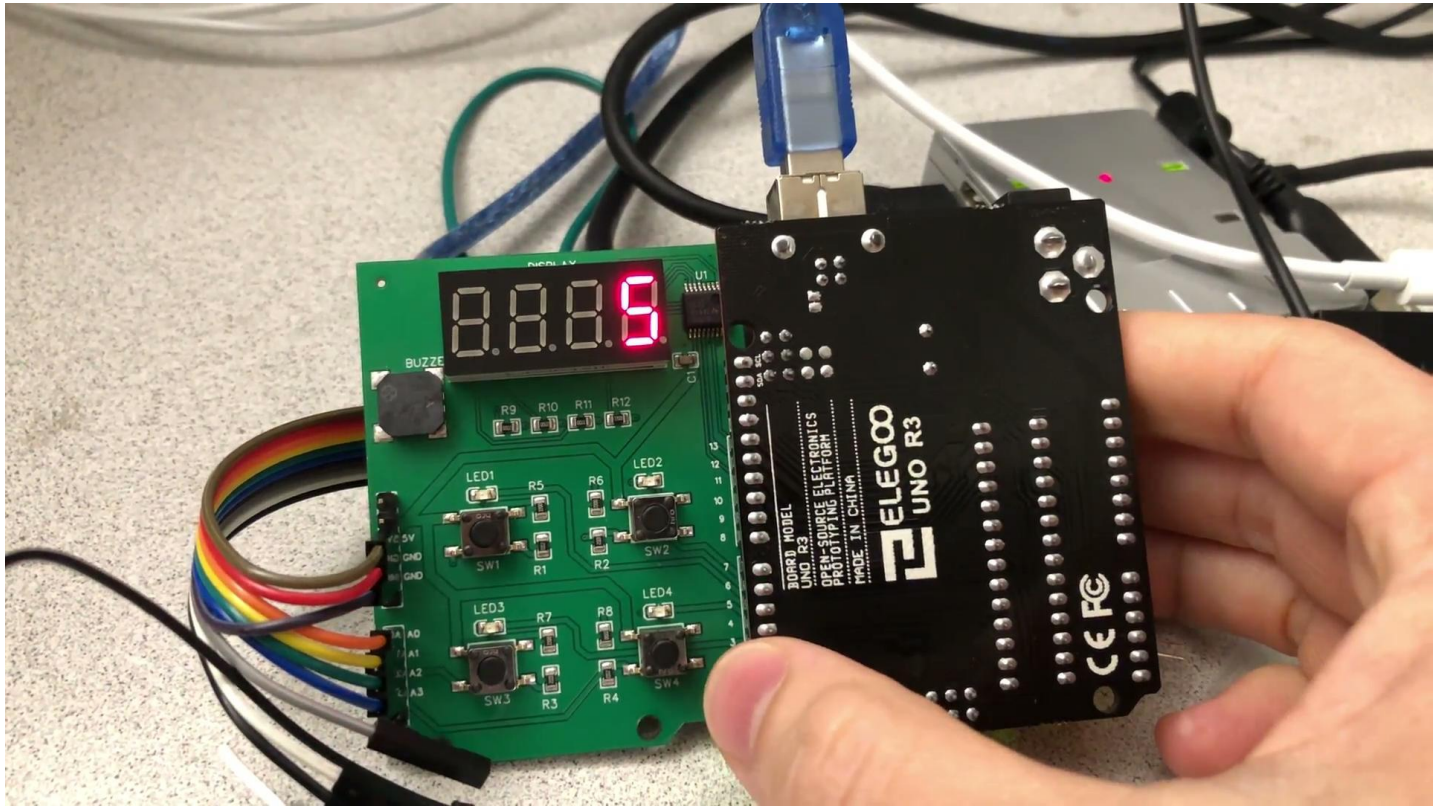






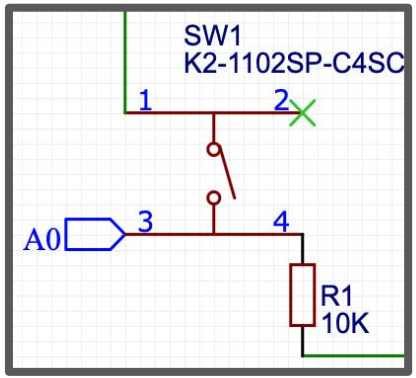
EEEEE UNO R3 &
Multi-Function Shield Starter
kit on Amazon here

Joe’s PCB: Whack-a-mole video

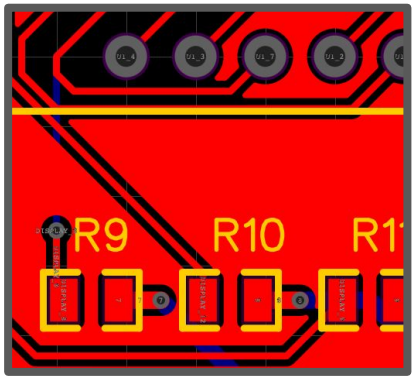


PCB Design Process

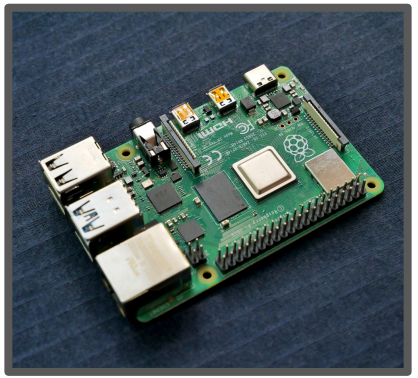
Idea



Schematic



Layout



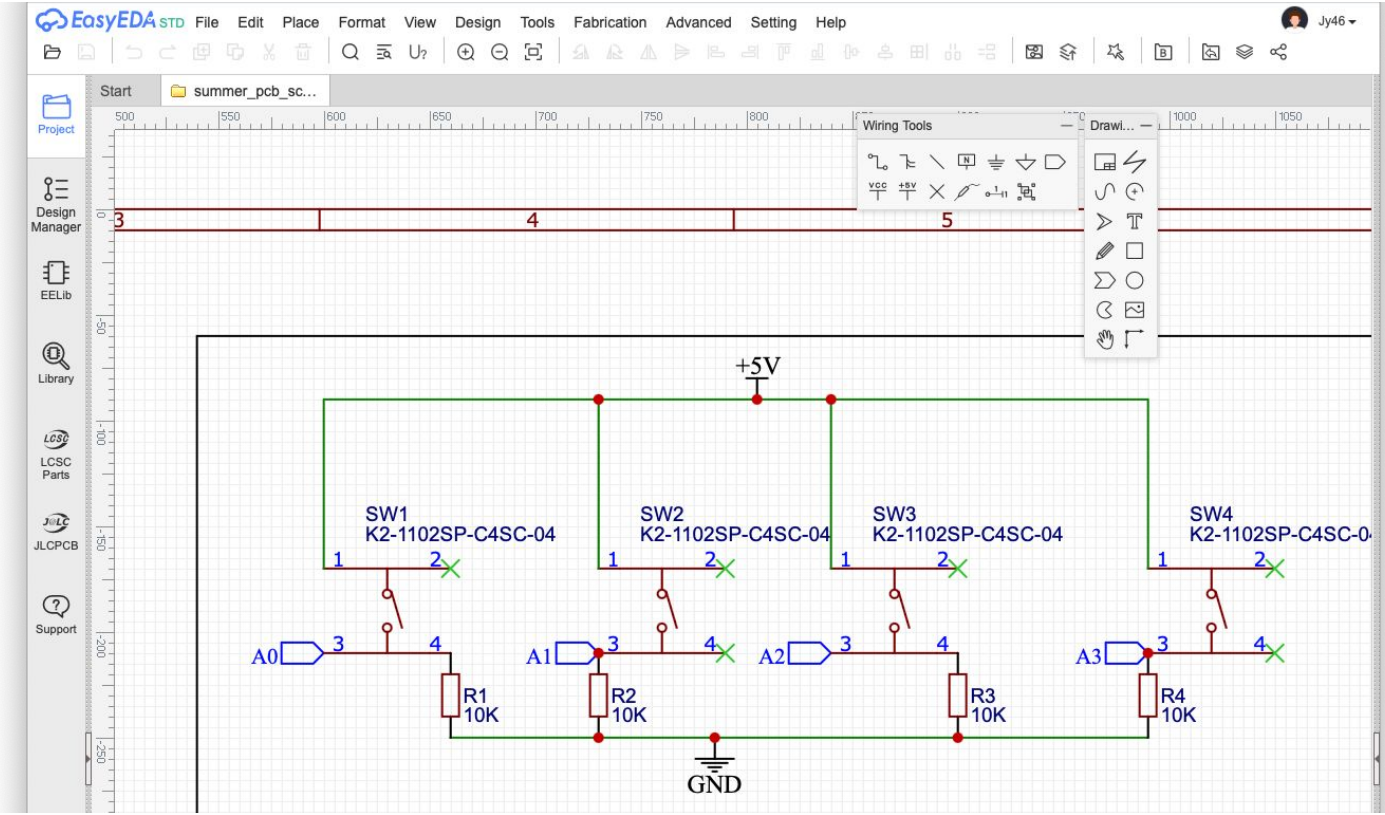
Manufacture

PCB Design Programs

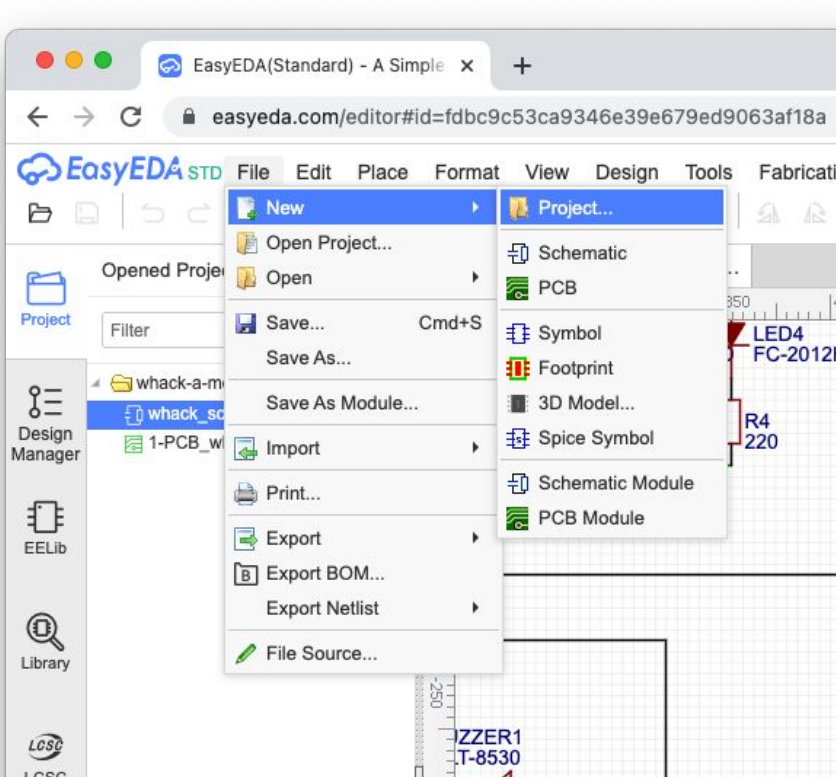
- EAGLE (free student license, part of AutoDesk)
- MultiSim/UltiBoard (National Instruments)
- Allegro (Professional grade)
- KiCad (free)
- **EasyEDA (free, linked to a manufacturer)**
- Altium (Professional grade)

Graphical Schematic Editing

Can simulate schematic

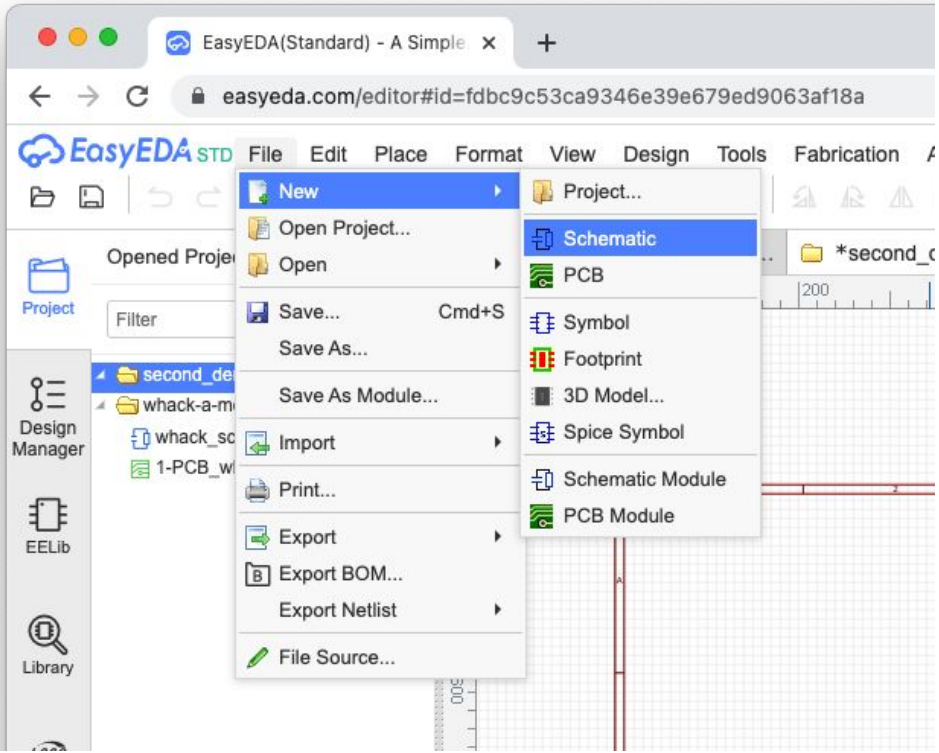


Make New Project in EasyEDA

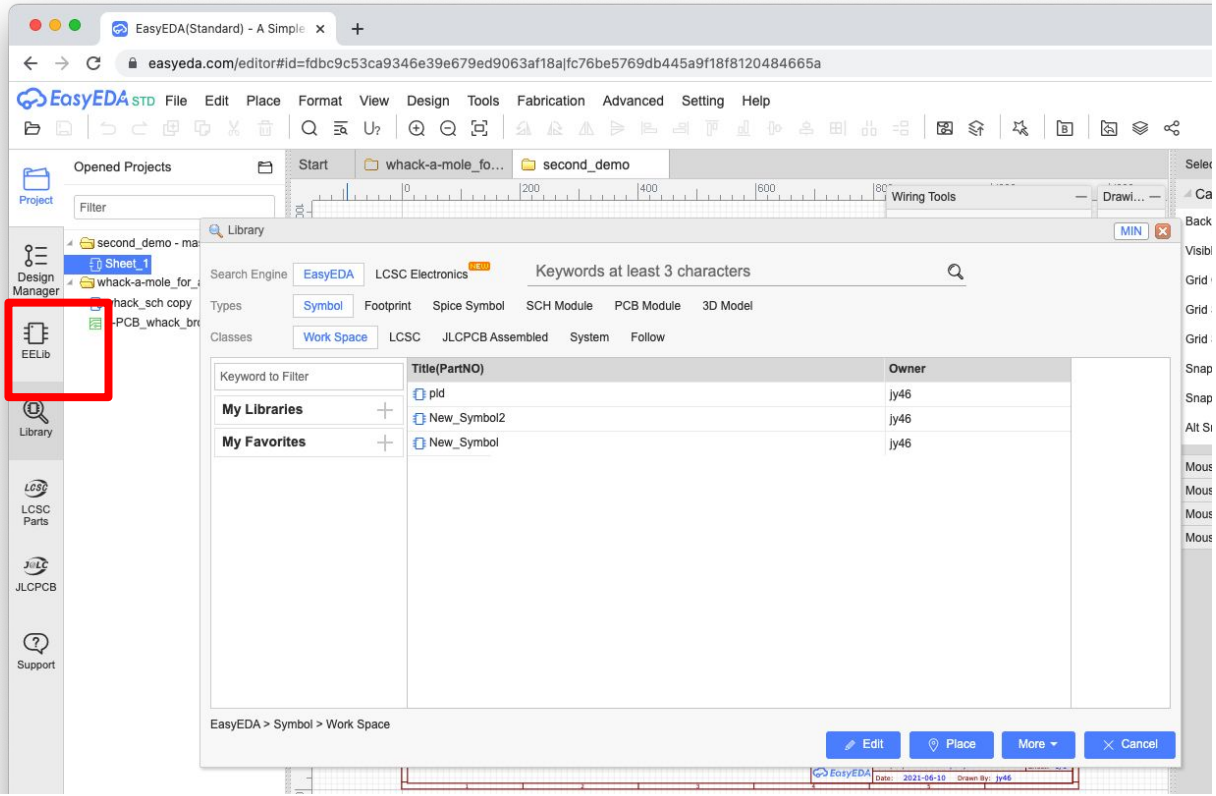


Make New Schematic in EasyEDA

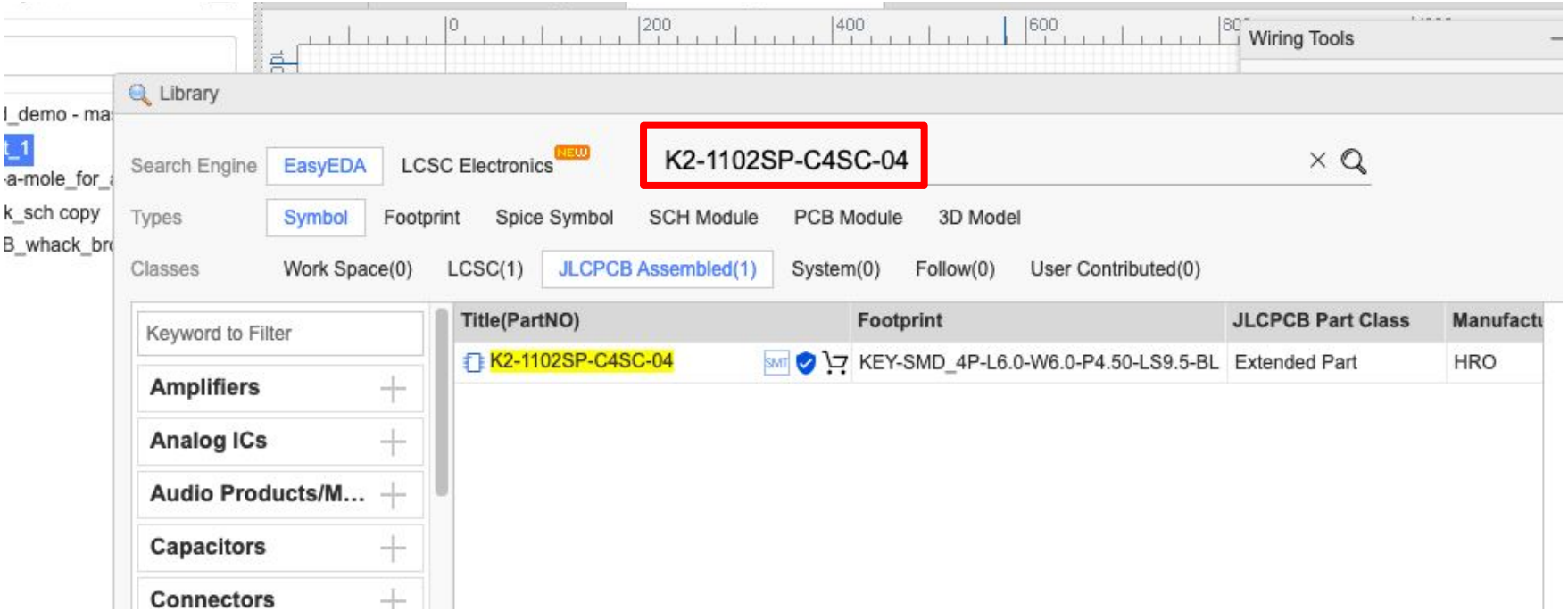
Be sure to save it as whatever you like :)



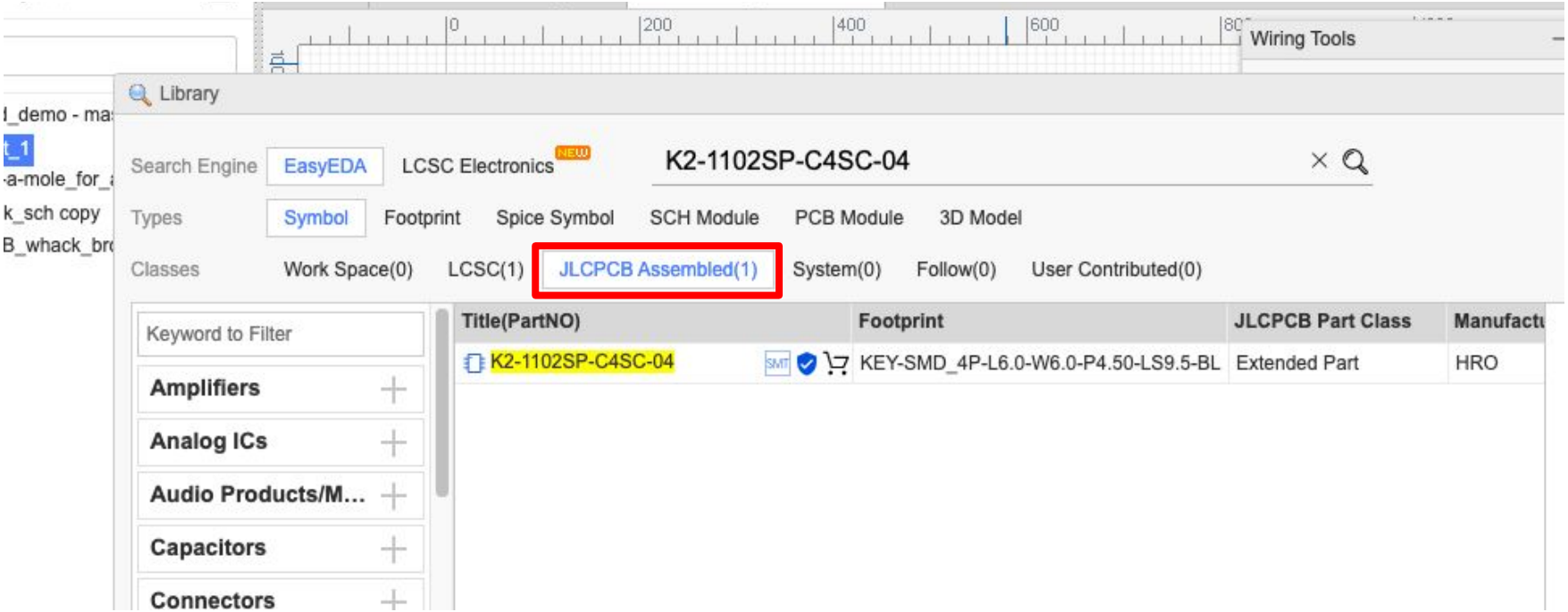
Add the Parts We Need: Start by clicking Library



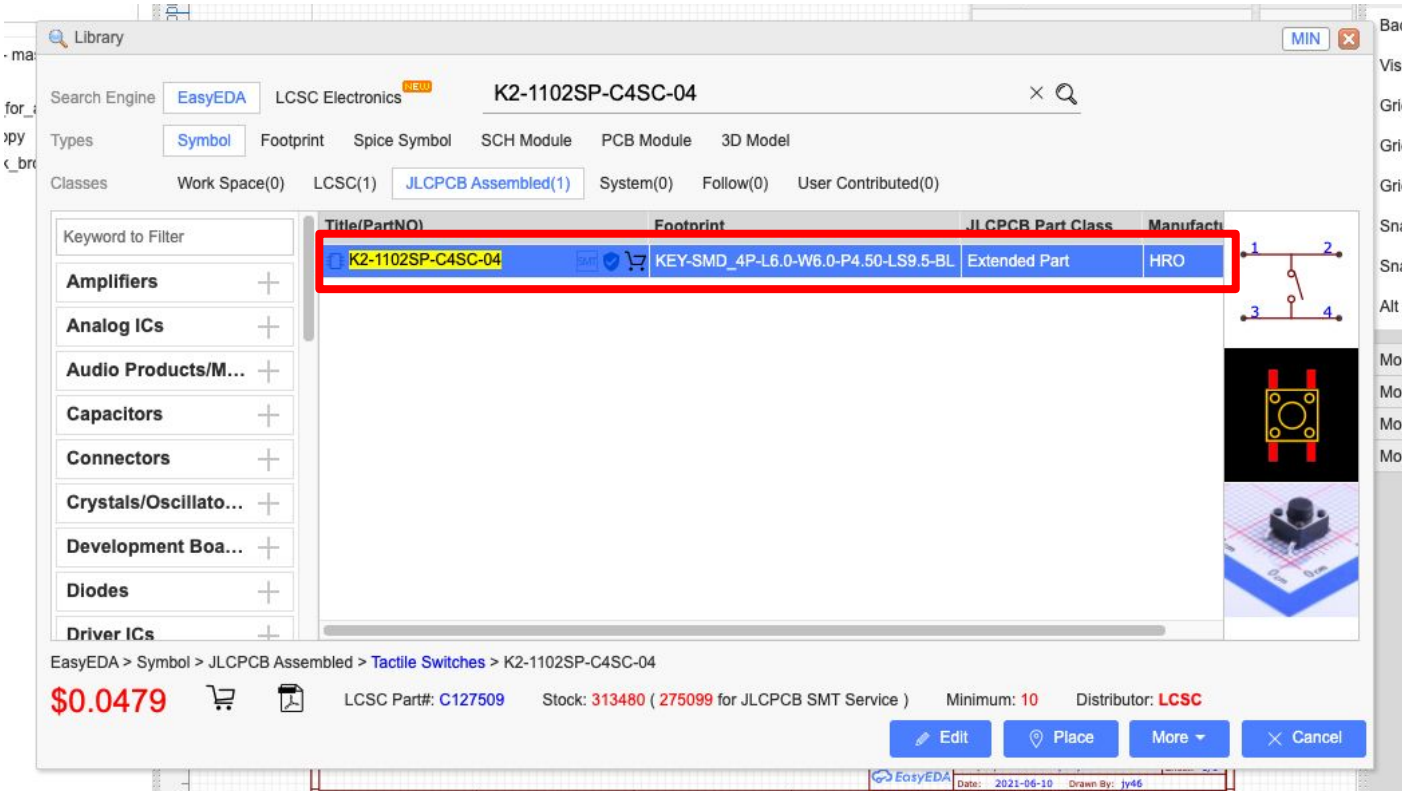
Type in Keyword for Button Model: K2-1102SP-C4SC-04



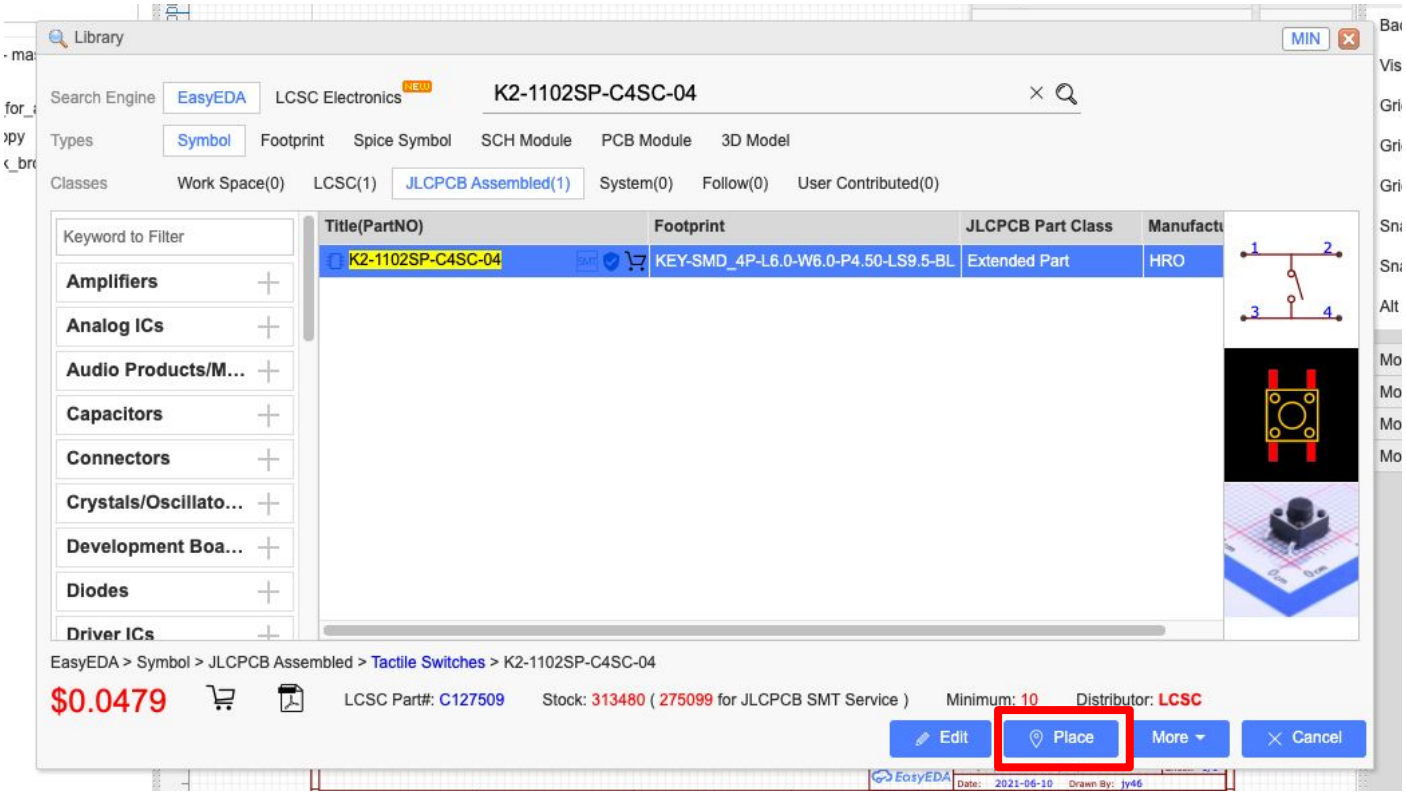
Make Sure JLCPCB Assembled Selected



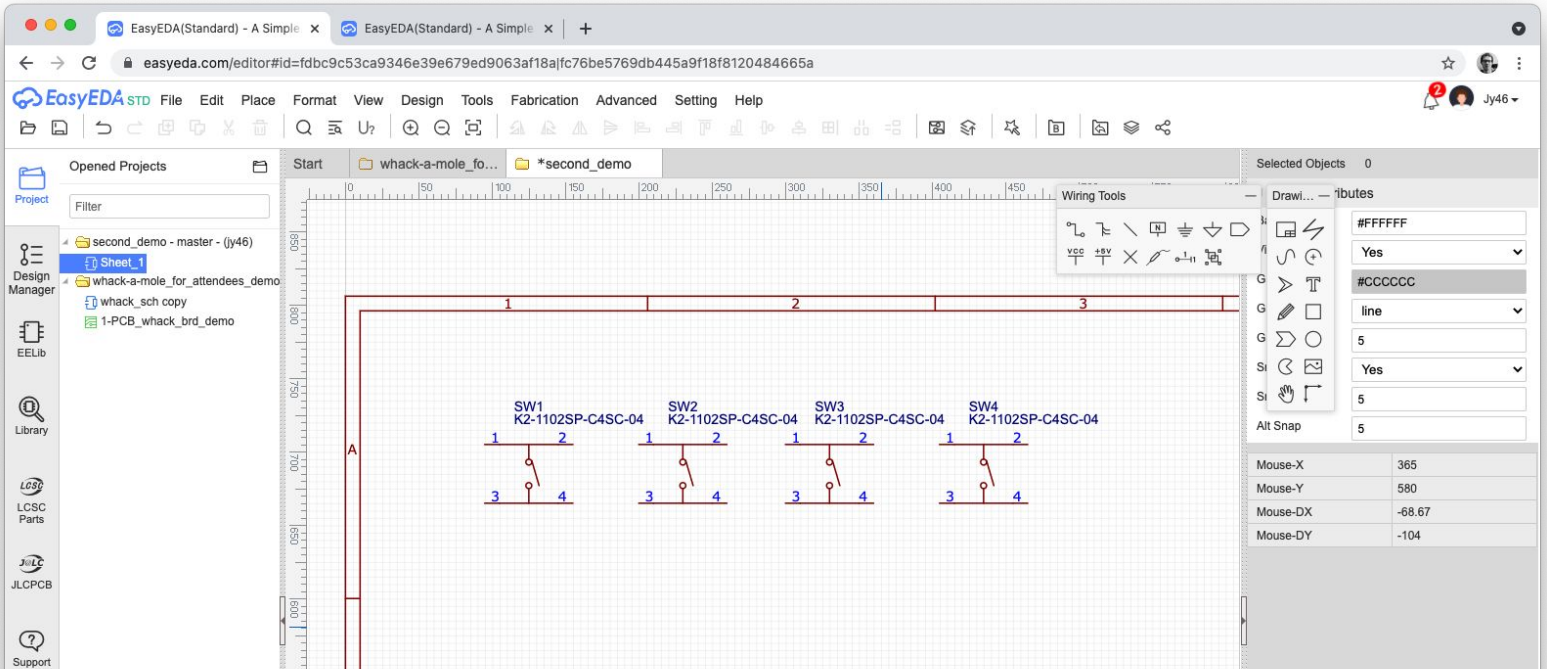
Select Part


Library
MIN
Search Engine
EasyEDA
LCSC Electronics
K2-1102SP-C4SC-04
Types
Symbol
Footprint
Spice Symbol
SCH Module
PCB Module
3D Model
Classes
Work Space(0)
LCSC(1)
JLCPCB Assembled(1)
System(0)
Follow(0)
User Contributed(0)
Keyword to Filter
Amplifiers
Analog ICs
Audio Products/M...
Capacitors
Connectors
Crystals/Oscillato...
Development Boa...
Diodes
Driver ICs
Title(PartNO)
Footprint
JLCPCB Part Class
Manufacti
K2-1102SP-C4SC-04
KEY-SMD_4P-L6.0-W6.0-P4.50-LS9.5-BL
Extended Part
HRO
EasyEDA > Symbol > JLCPCB Assembled > Tactile Switches > K2-1102SP-C4SC-04
$0.0479
LCSC Part#: C127509
Stock: 313480 (275099 for JLCPCB SMT Service)
Minimum: 10
Distributor: LCSC
Edit
Place
More
Cancel

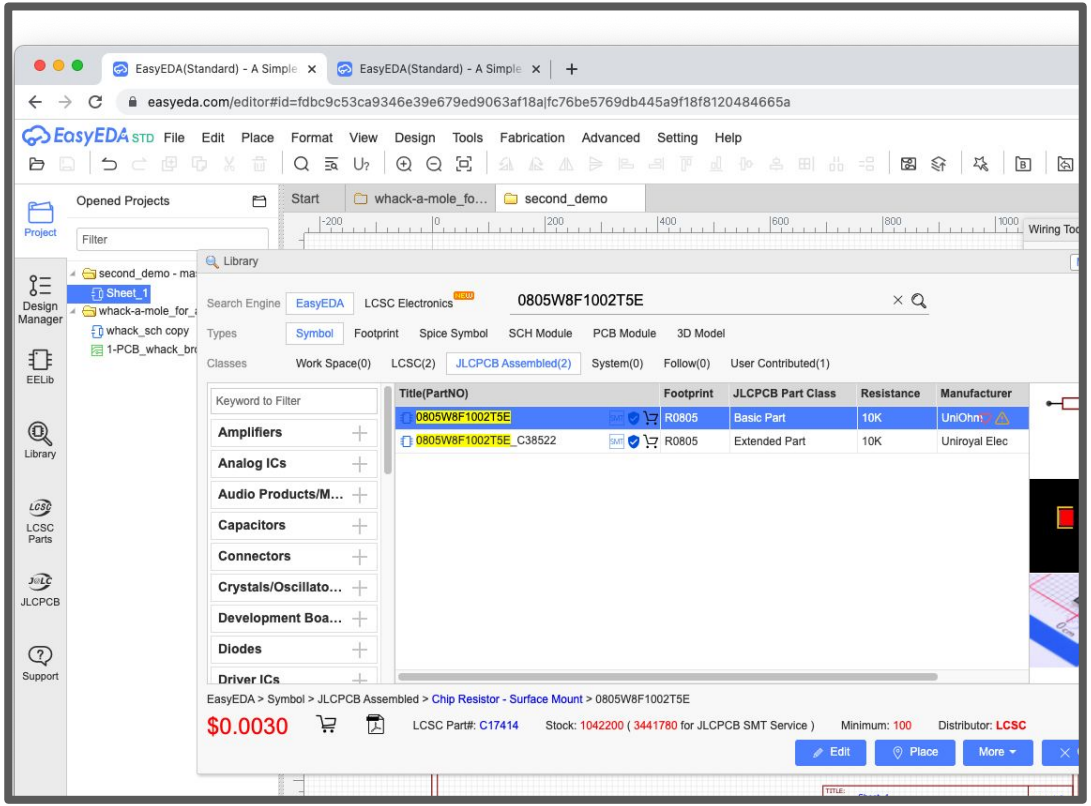
Click Place

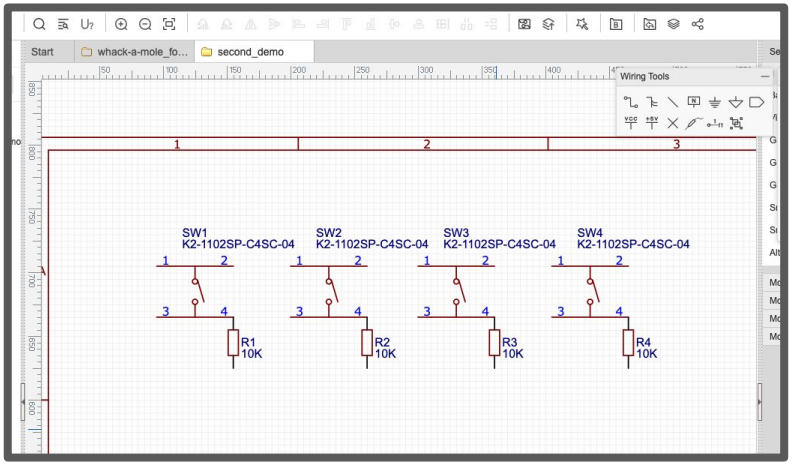

Library
MIN
Search Engine
EasyEDA
LCSC Electronics
K2-1102SP-C4SC-04
Types
Symbol
Footprint
Spice Symbol
SCH Module
PCB Module
3D Model
Classes
Work Space(0)
LCSC(1)
JLCPCB Assembled(1)
System(0)
Follow(0)
User Contributed(0)
Keyword to Filter
Amplifiers
Analog ICs
Audio Products/M...
Capacitors
Connectors
Crystals/Oscillato...
Development Boa...
Diodes
Driver ICs
Title(PartNO)
Footprint
JLCPCB Part Class
Manufactu
K2-1102SP-C4SC-04
KEY-SMD_4P-L6.0-W6.0-P4.50-LS9.5-BL
Extended Part
HRO
EasyEDA > Symbol > JLCPCB Assembled > Tactile Switches > K2-1102SP-C4SC-04
$0.0479
LCSC Part#: C127509
Stock: 313480 (275099 for JLCPCB SMT Service)
Minimum: 10
Distributor: LCSC
Edit
Place
More
Cancel

Place 4 by Left Clicking 4 Times & Then Stop by Right Clicking



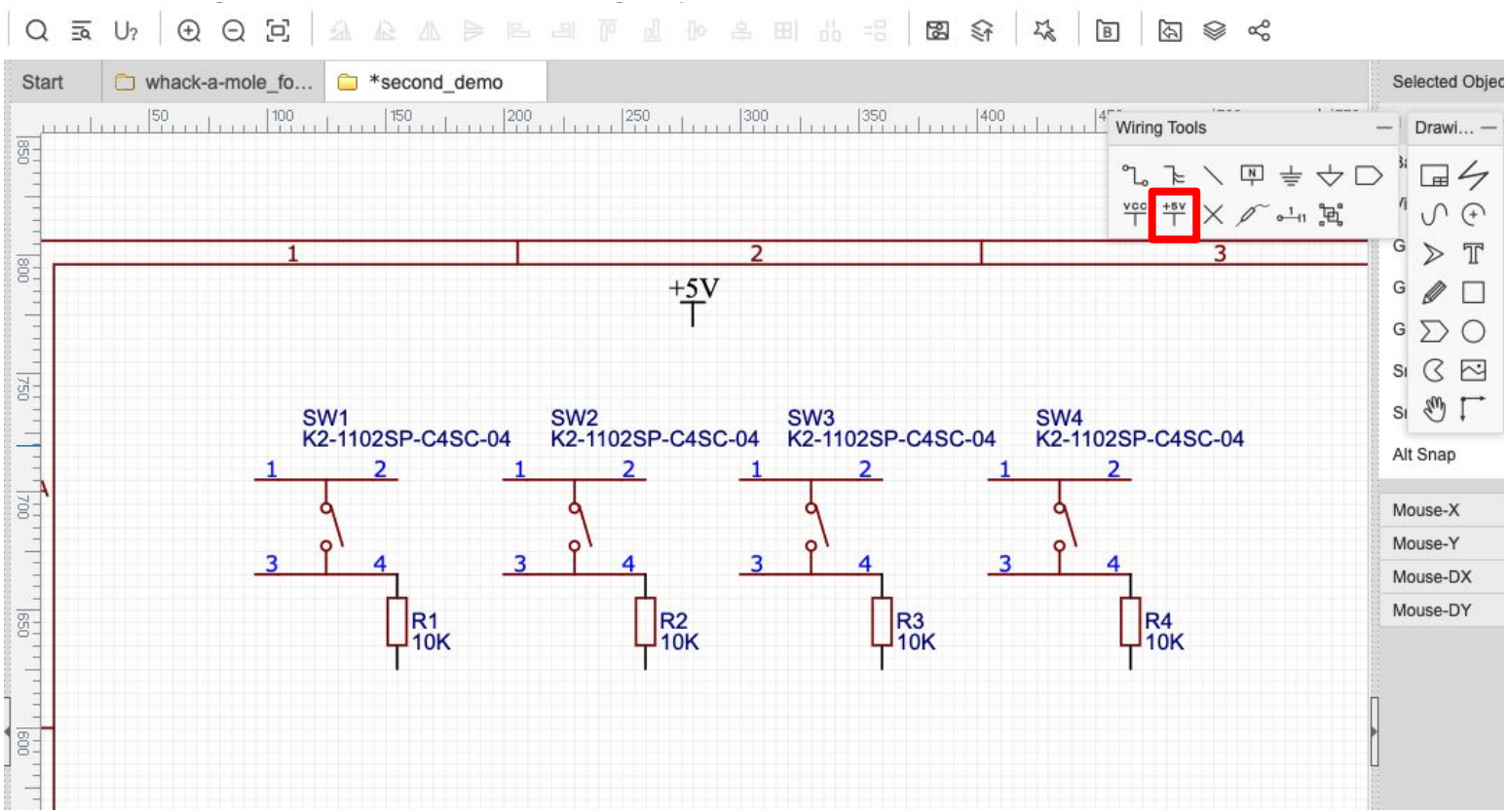
Click Library, Search & Place the “0805W8F1002T5E” Resistor



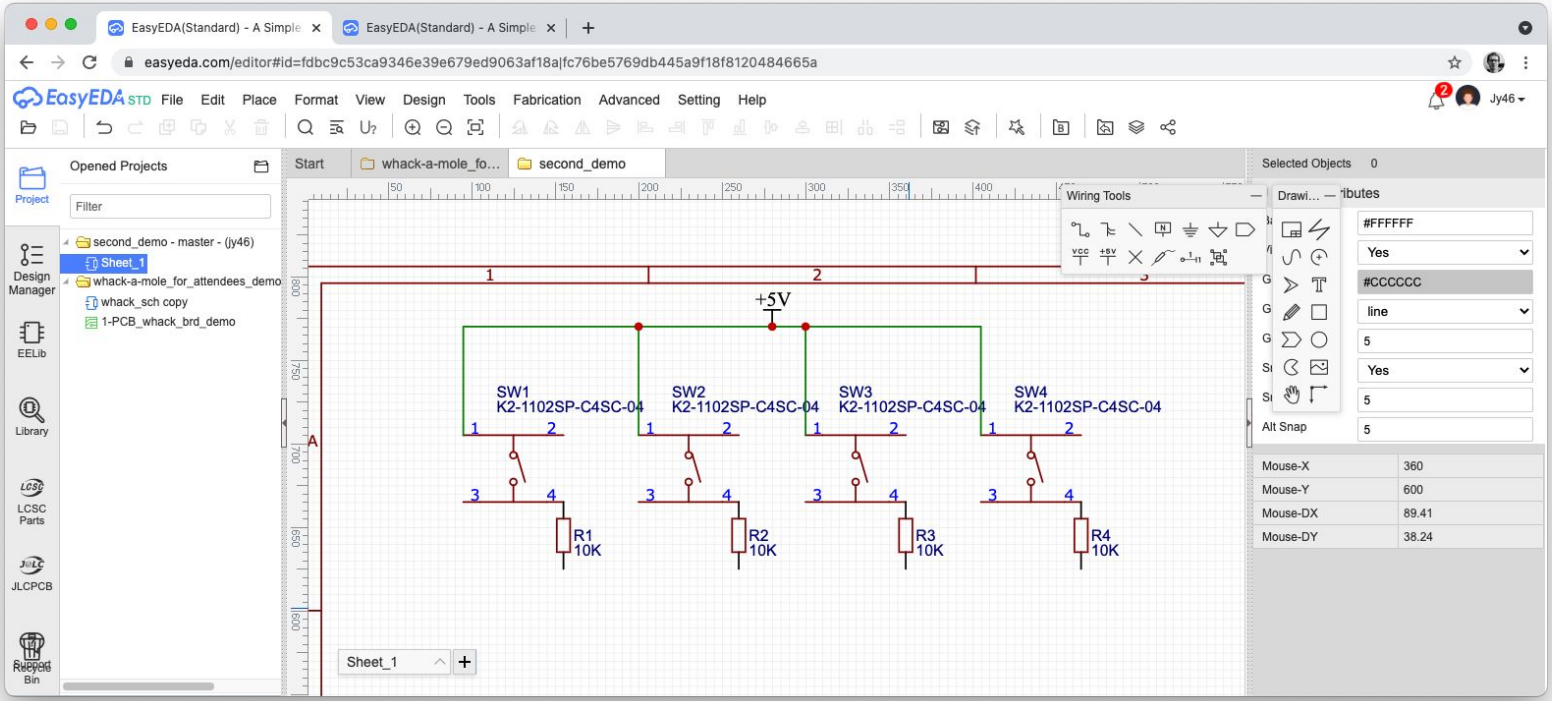


Type R to rotate the 10k pull-down resistor

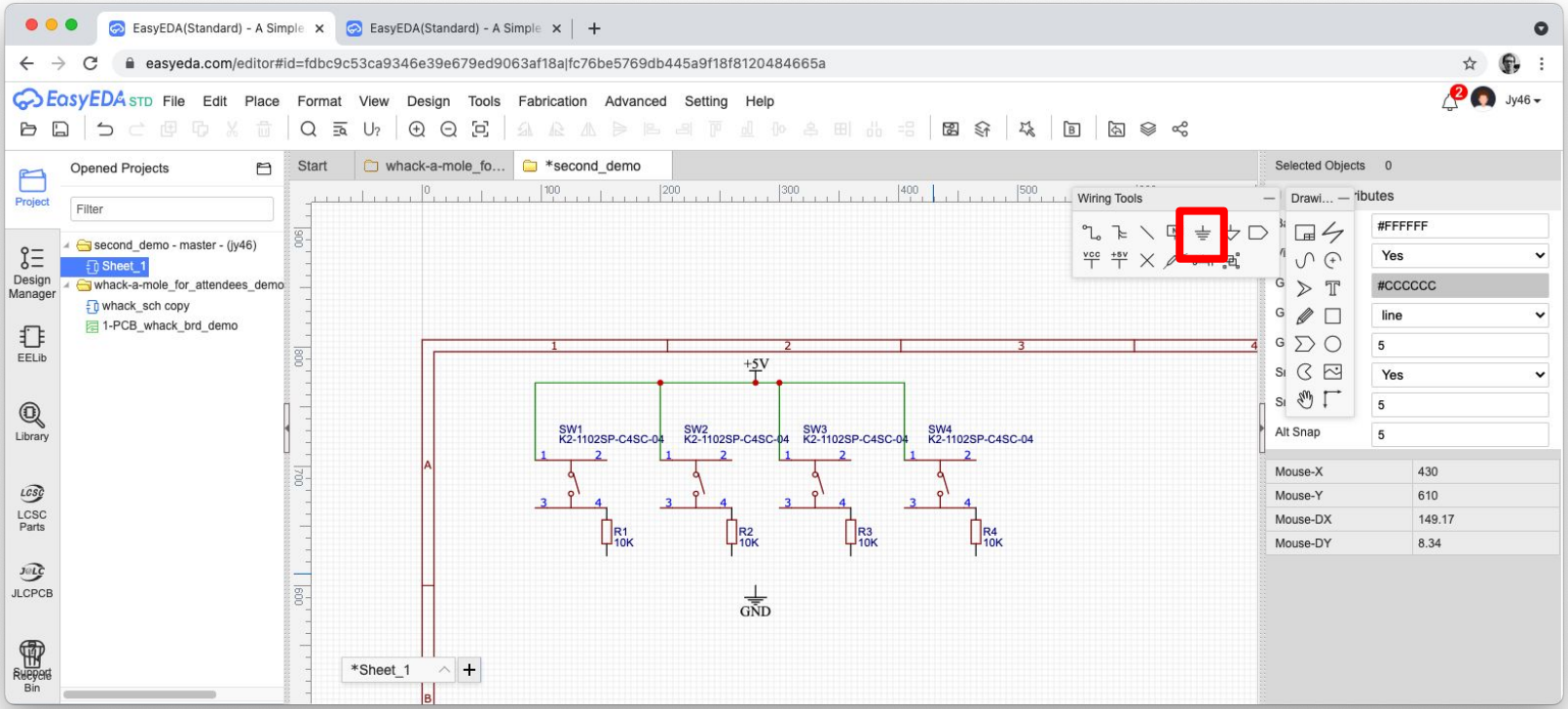
Place +5 V “Net Flag”



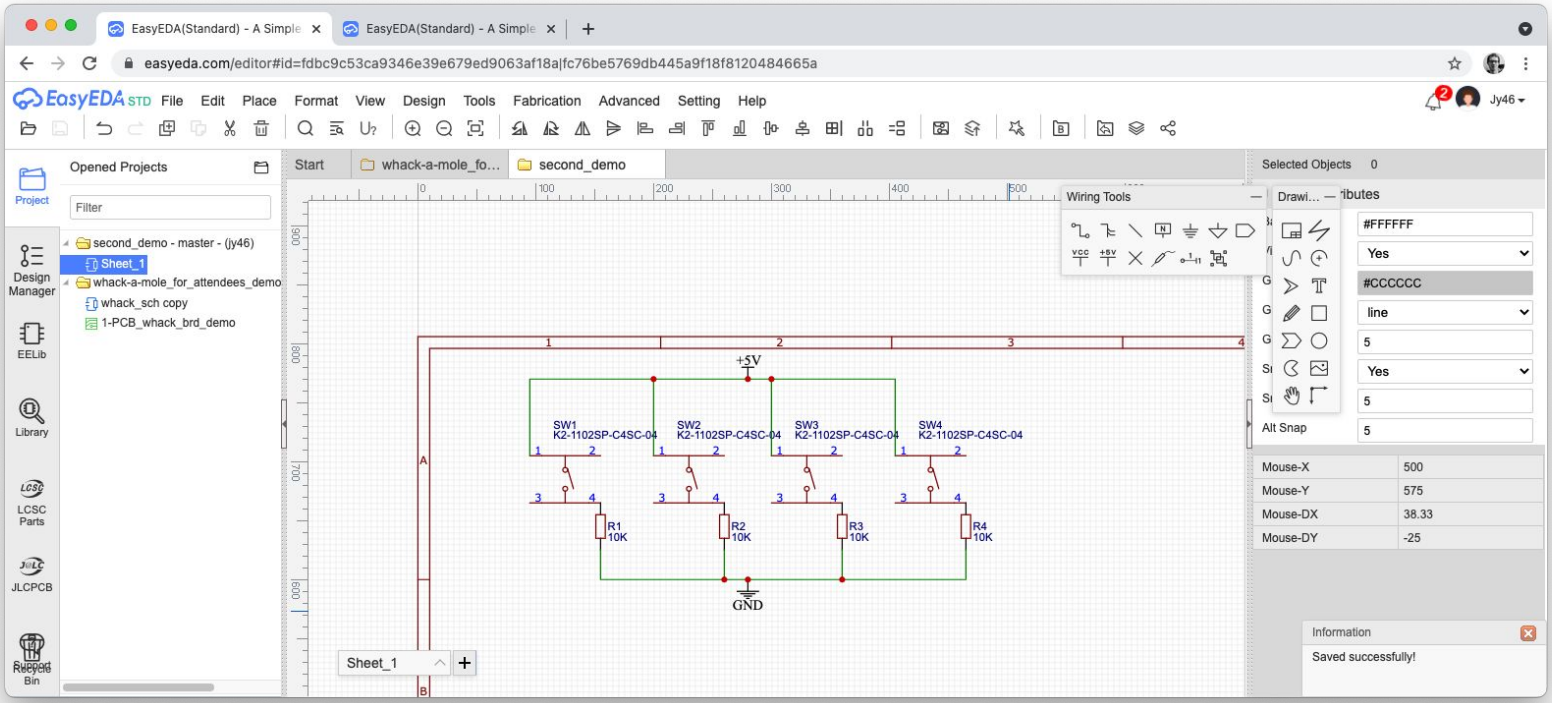
Connect Switches to +5 V via Wires (Type W or click wire symbol)



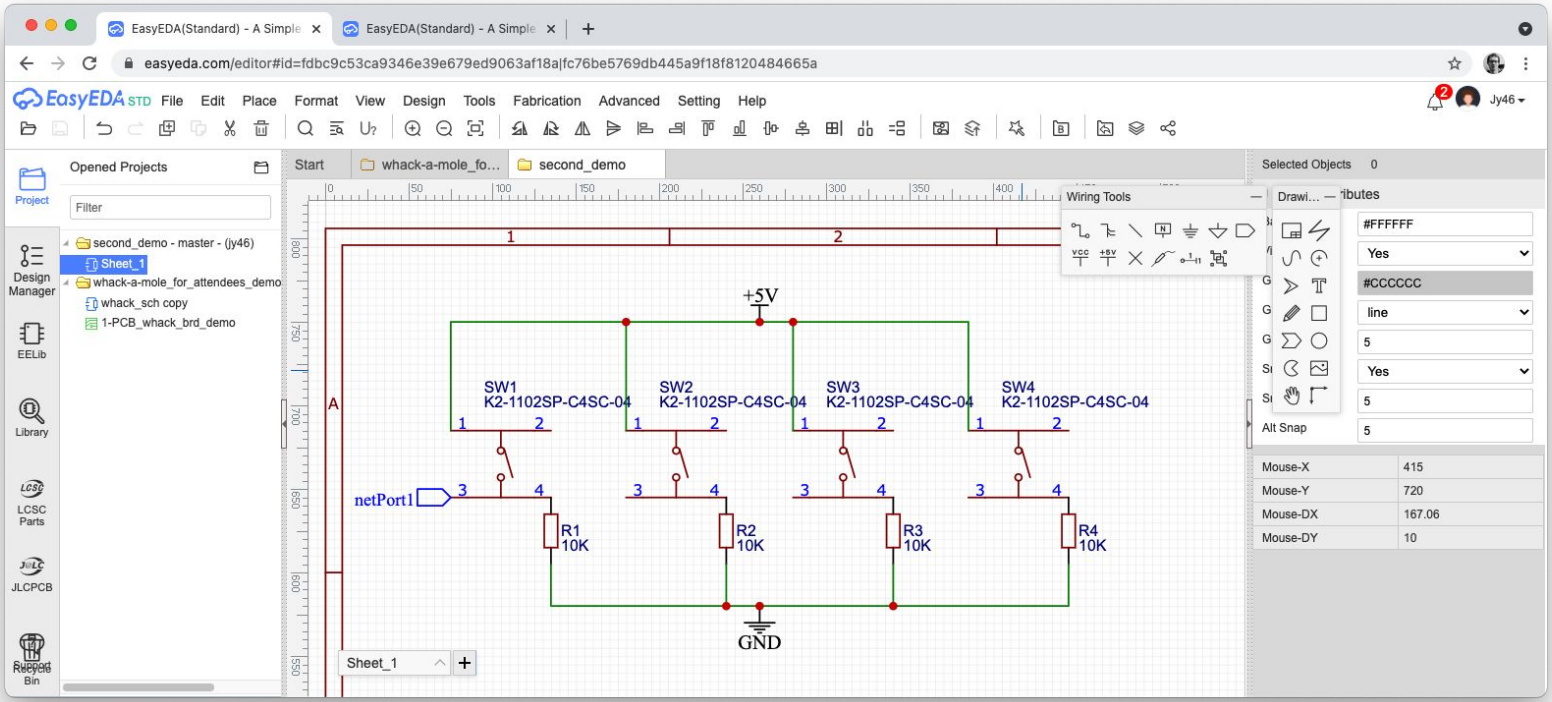
Place GND (ground) “Net Flag”



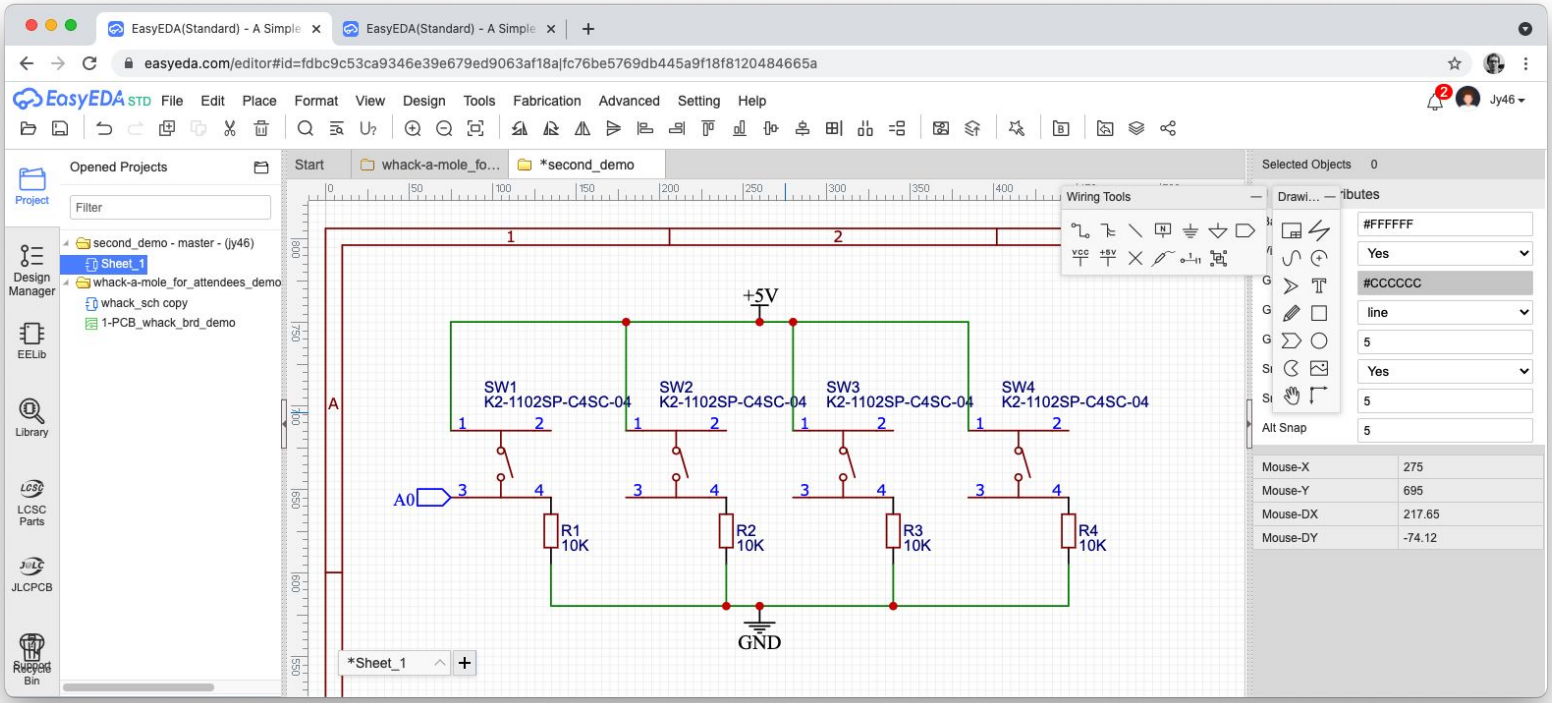
Connect Switches to GND via Wires



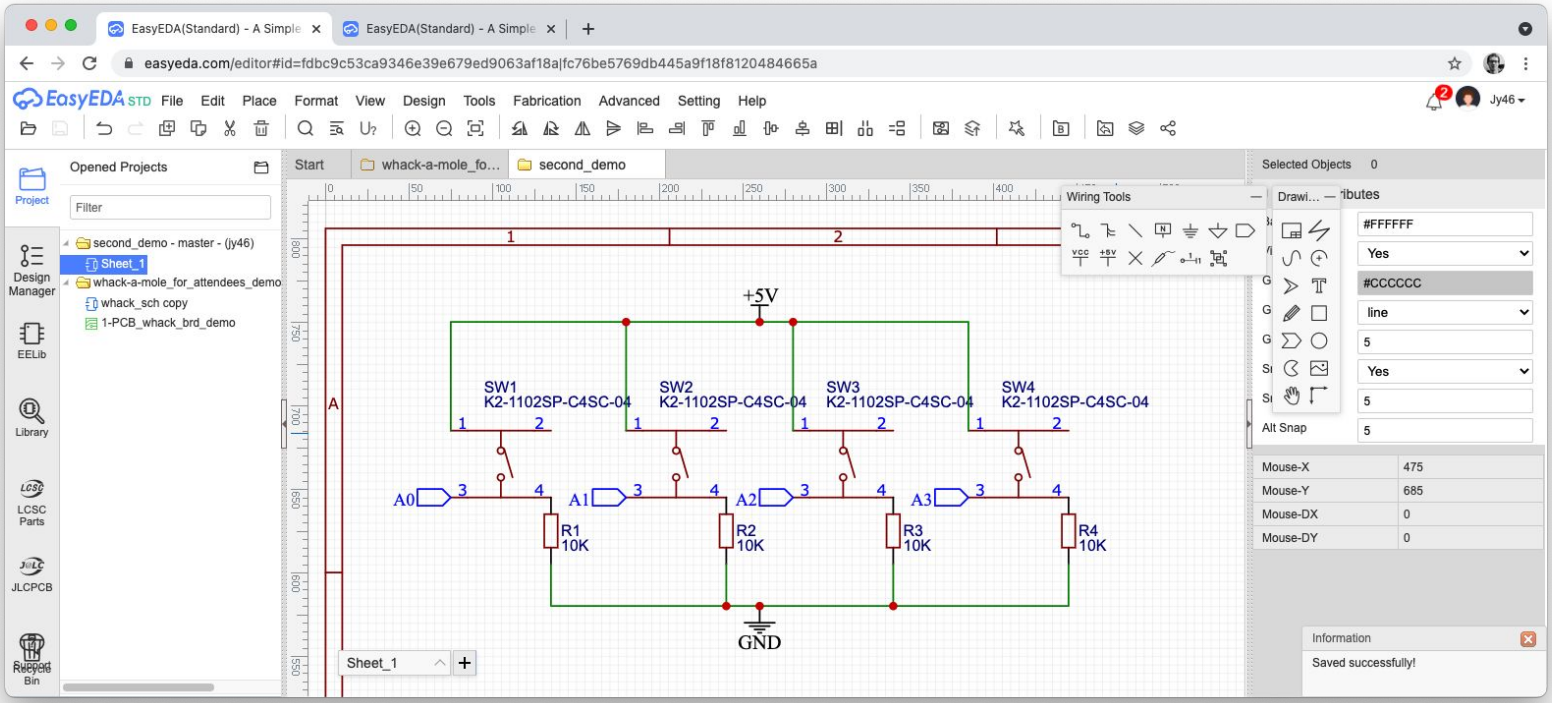
Add Net Port To Switch



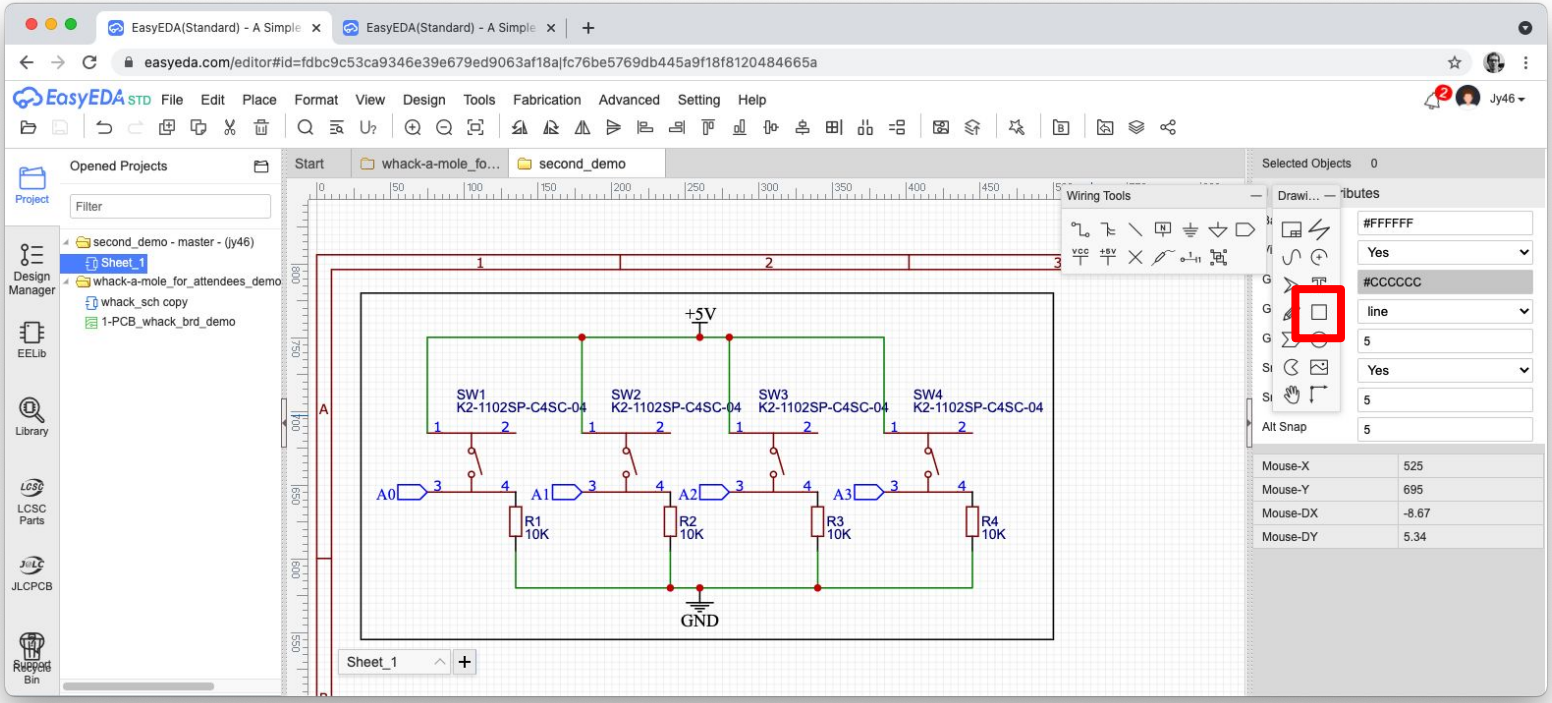
Rename Net Port to A0



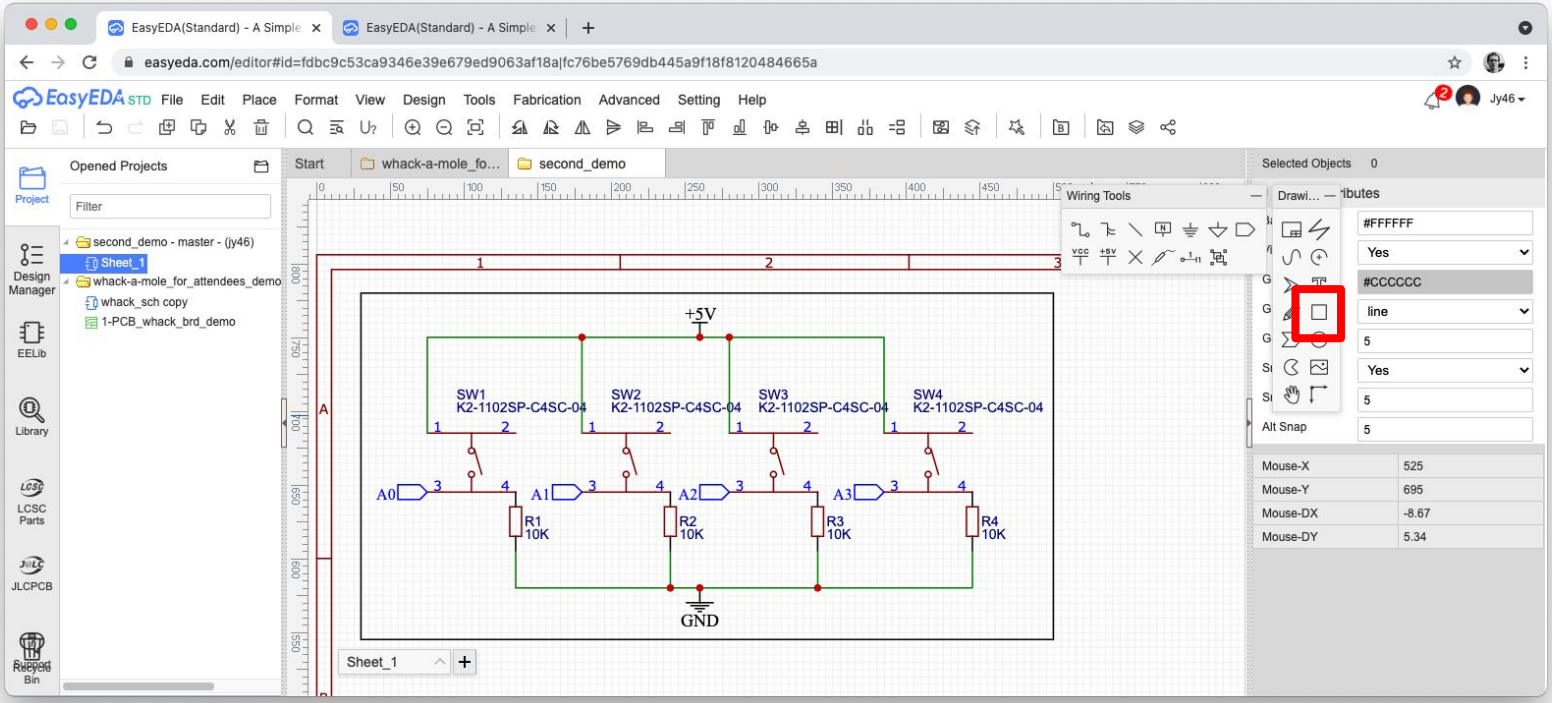
Copy & Paste Net Port to Other Switches - Rename to A1, A2, A3



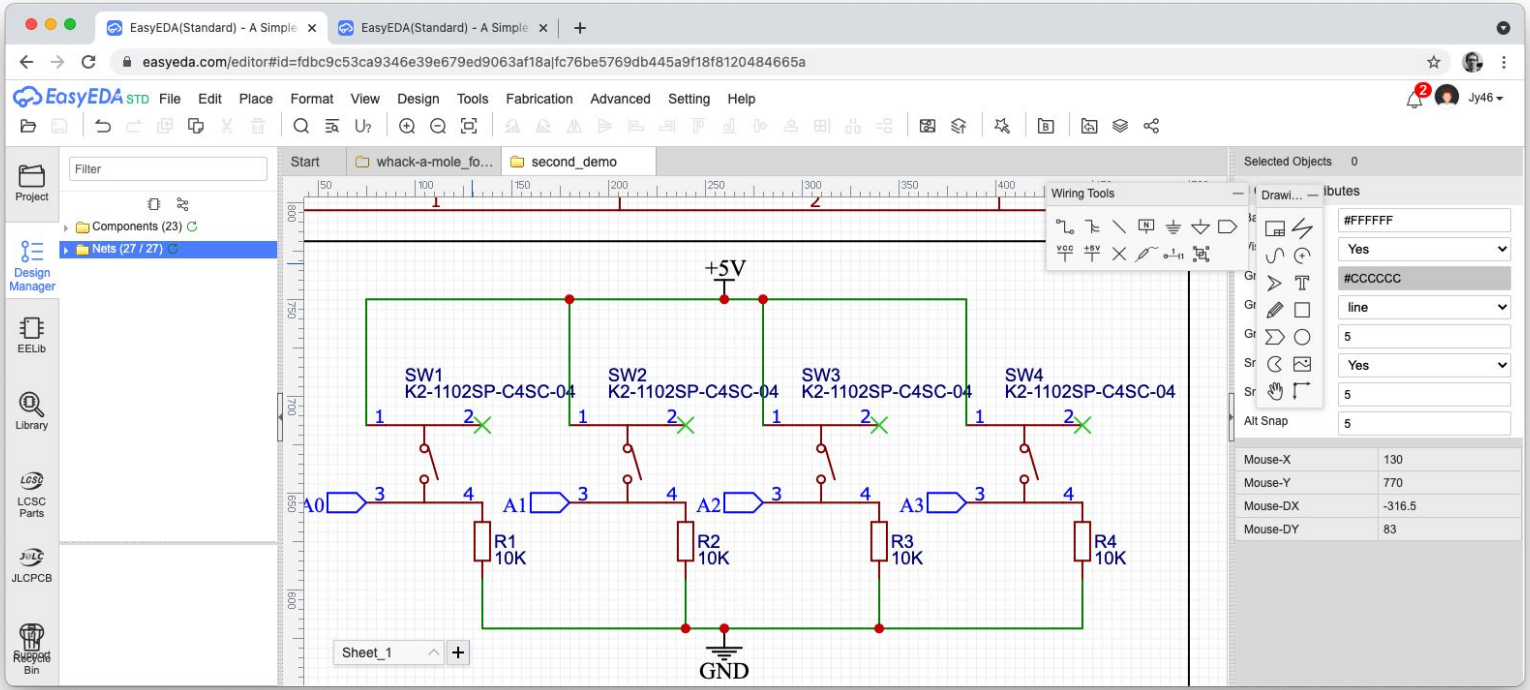
Draw Rectangle Around Diagram



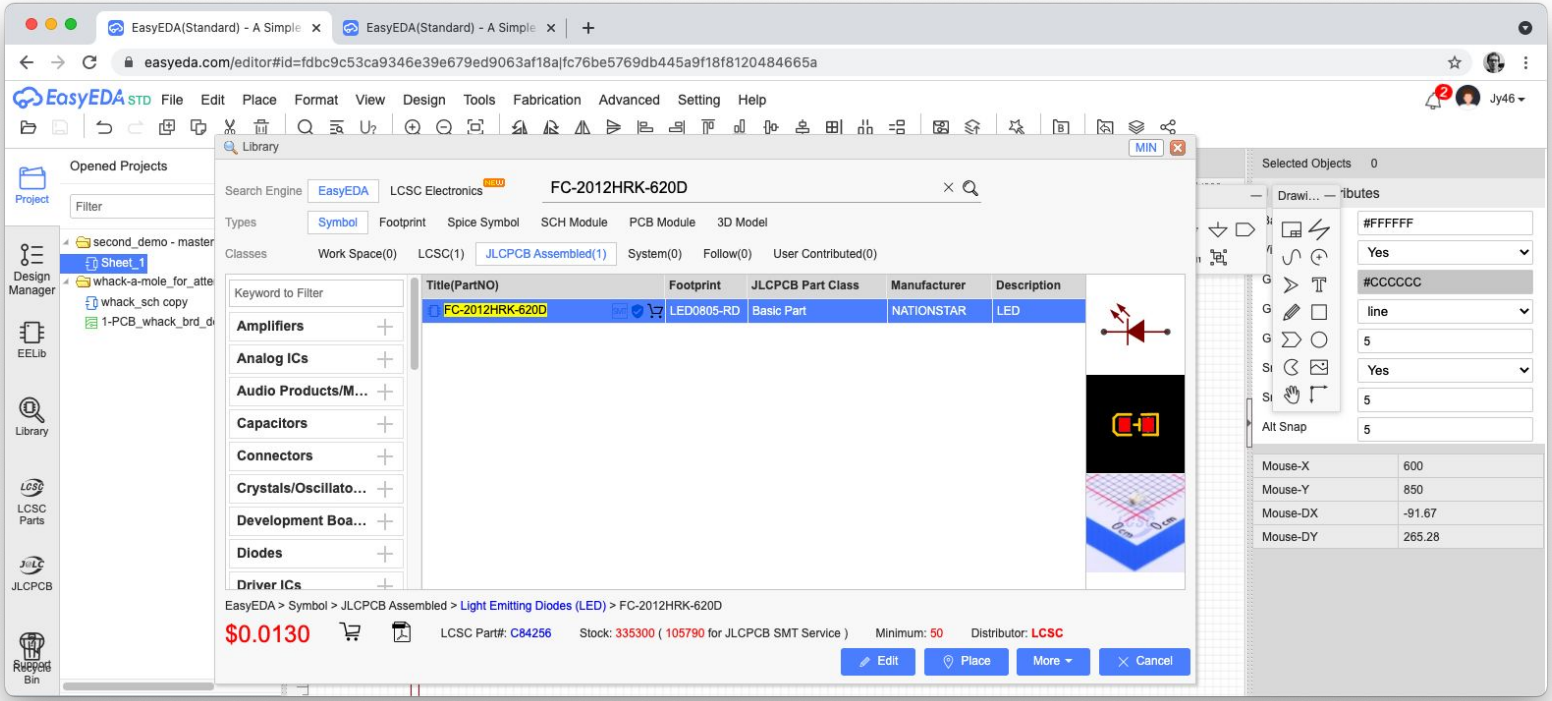
Draw Rectangle Around Diagram



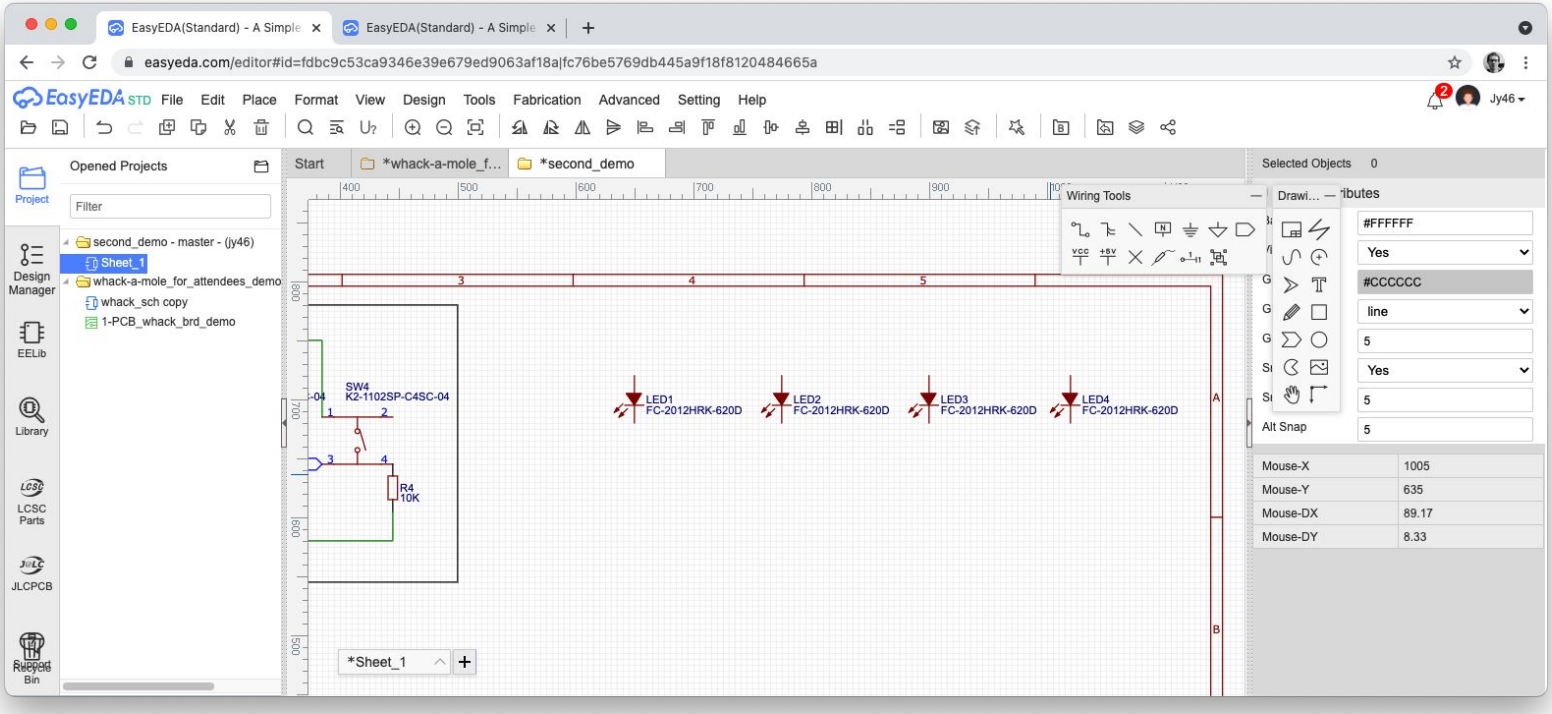
Also Add No Connect Flags to Switches



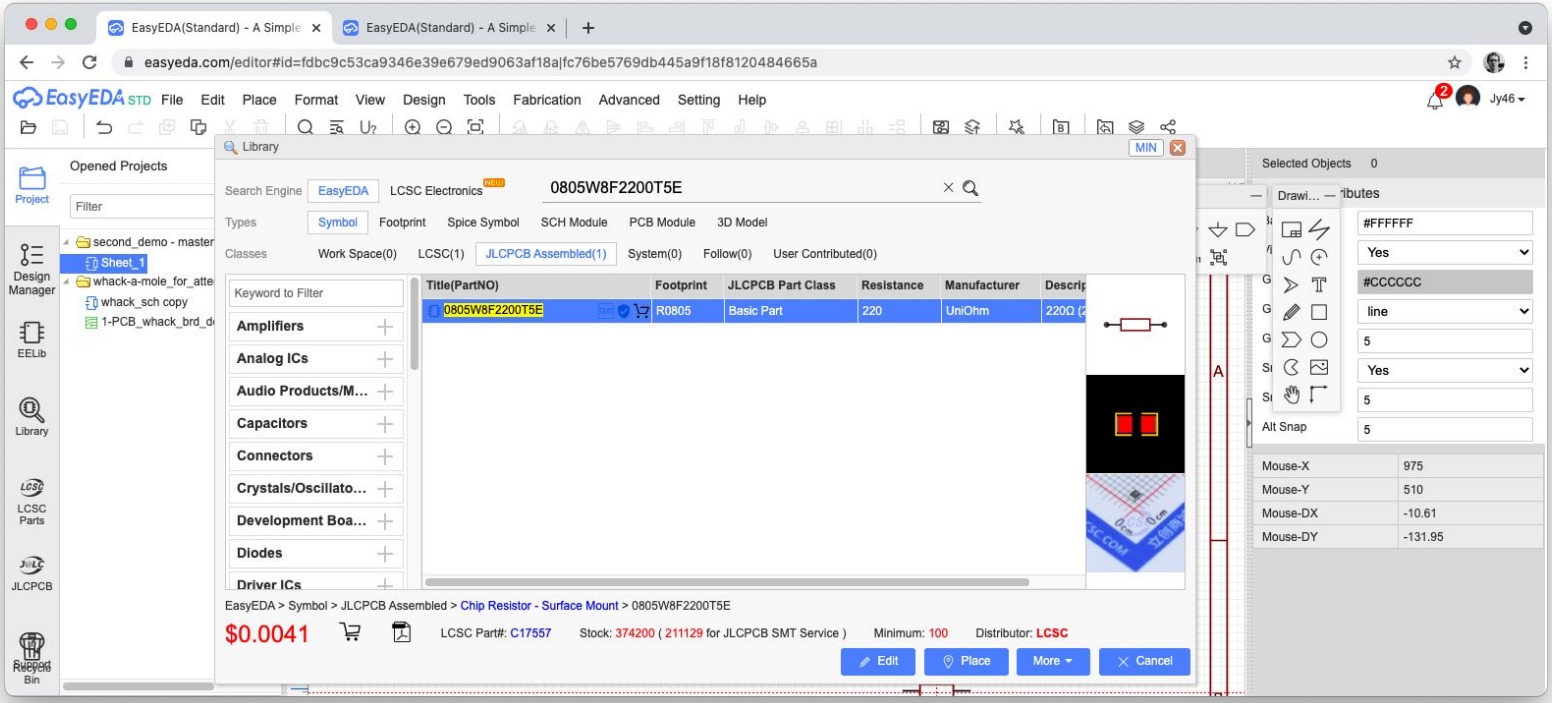
Go to Library and Grab LEDs: “FC-2012HRK-620D”



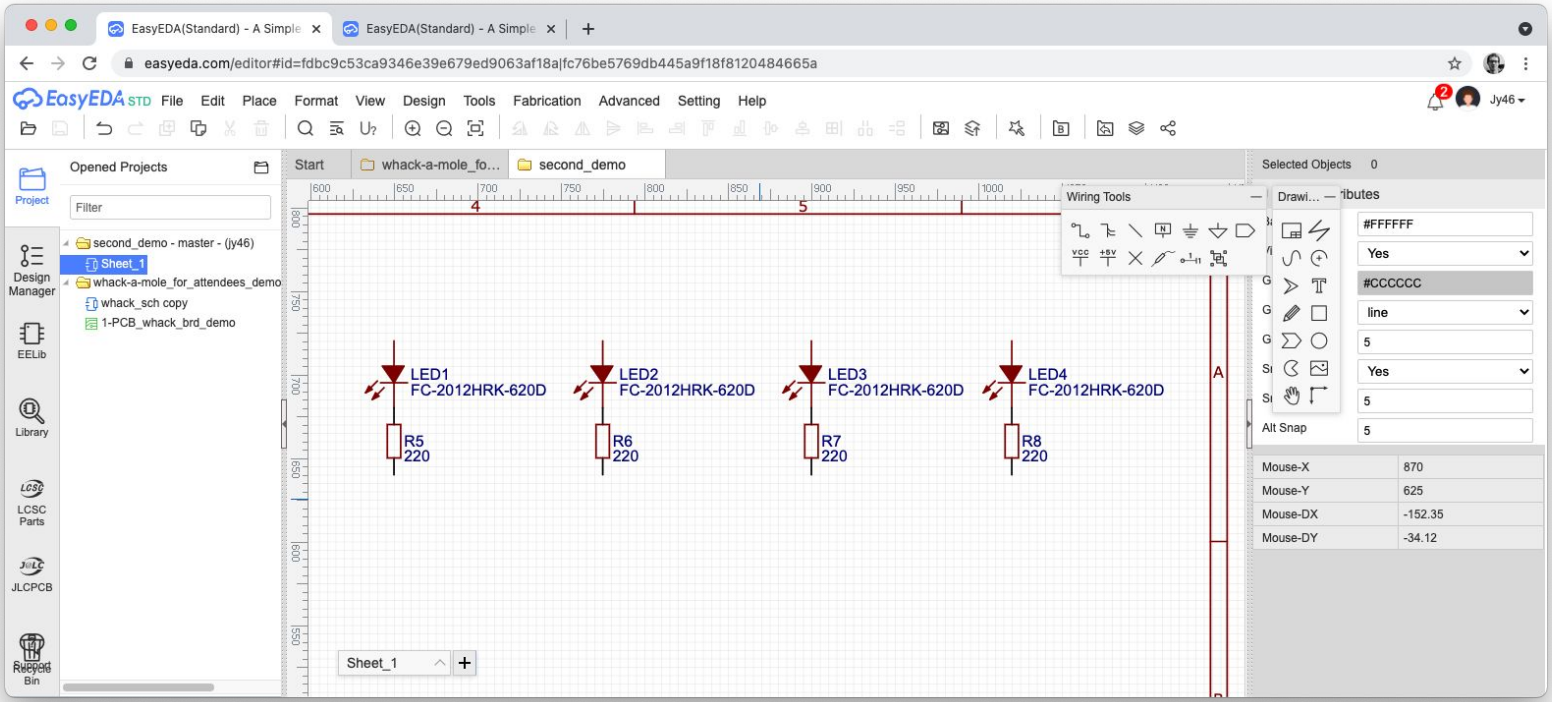
Place 4 LEDs


EasyEDA(Standard) - A Simple
easyeda.com/editor#id=fdbc9c53ca9346e39e679ed9063af18a|fc76be5769db445a9f18f8120484665a
EasyEDA STD File Edit Place Format View Design Tools Fabrication Advanced Setting Help
Opened Projects
Filter
second_demo - master - (jy46)
Sheet_1
whack-a-mole_for_attendees_demo
whack_sch copy
1-PCB_whack_brd_demo
Start
*whack-a-mole_f...
*second_demo
Wiring Tools
SW4
K2-1102SP-C4SC-04
R4
10K
LED1
FC-2012HRK-620D
LED2
FC-2012HRK-620D
LED3
FC-2012HRK-620D
LED4
FC-2012HRK-620D
*Sheet_1
Selected Objects 0
Alt Snap
Mouse-X 1005
Mouse-Y 635
Mouse-DX 89.17
Mouse-DY 8.33

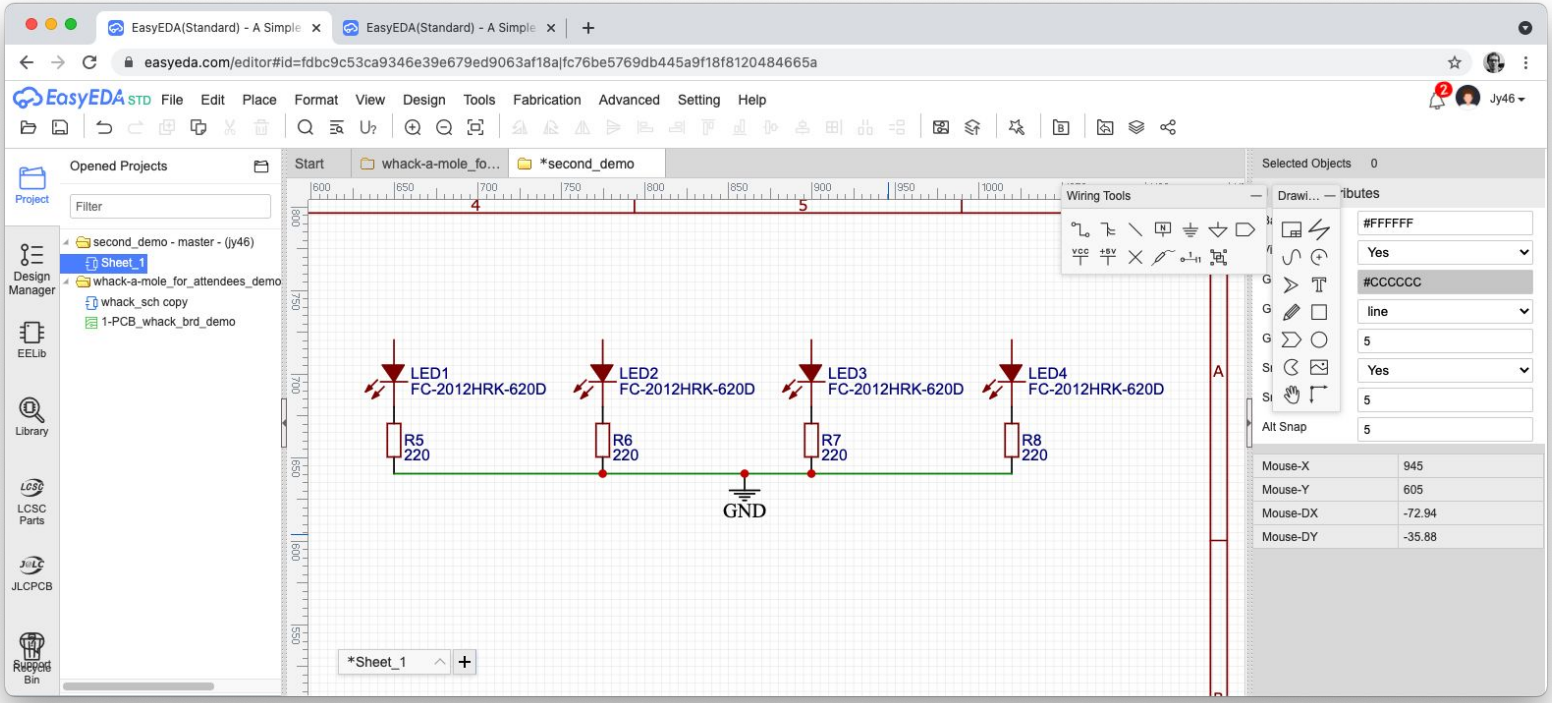
Go to Library & Grab 220 Ohm Resistors: “0805W8F2200T5E”



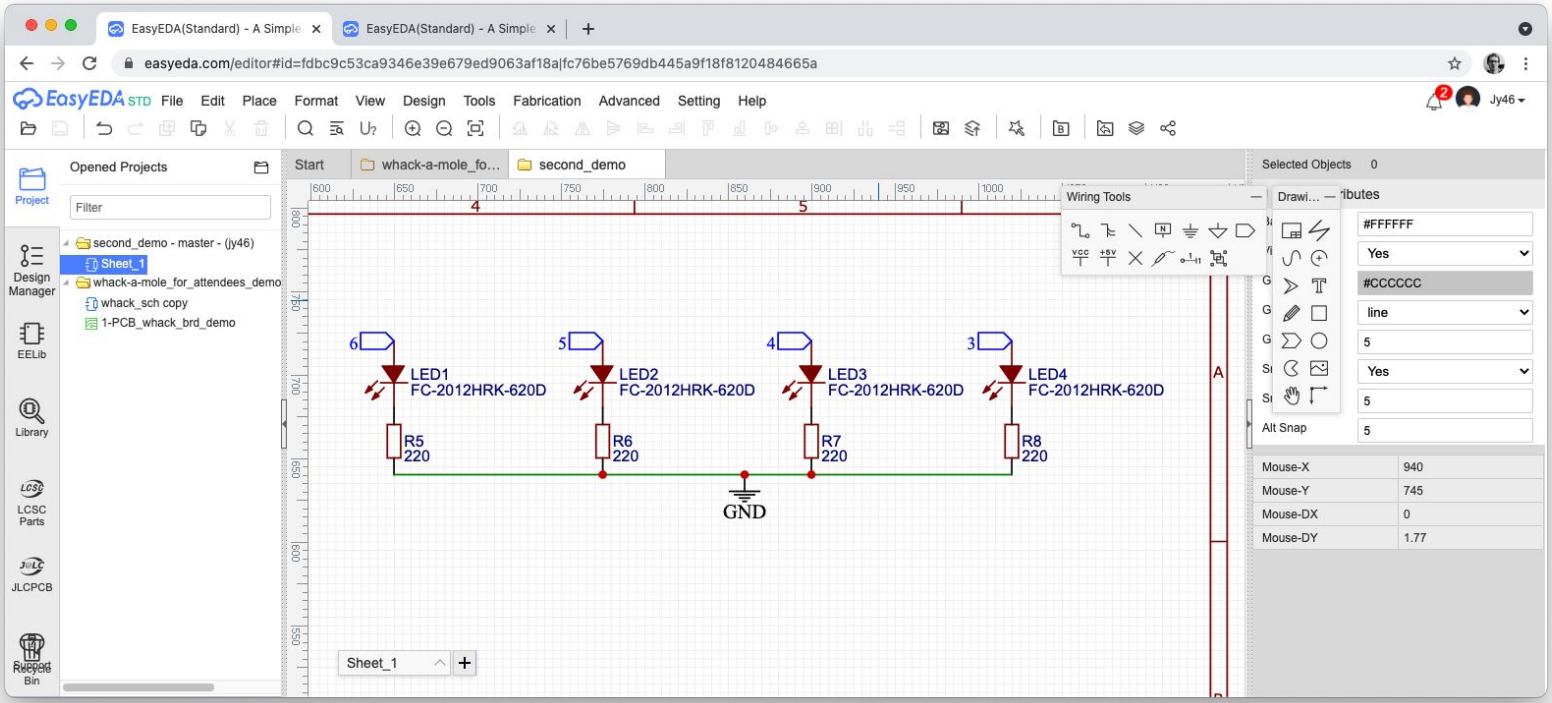
Place 4 of the 220 Ohm Resistors



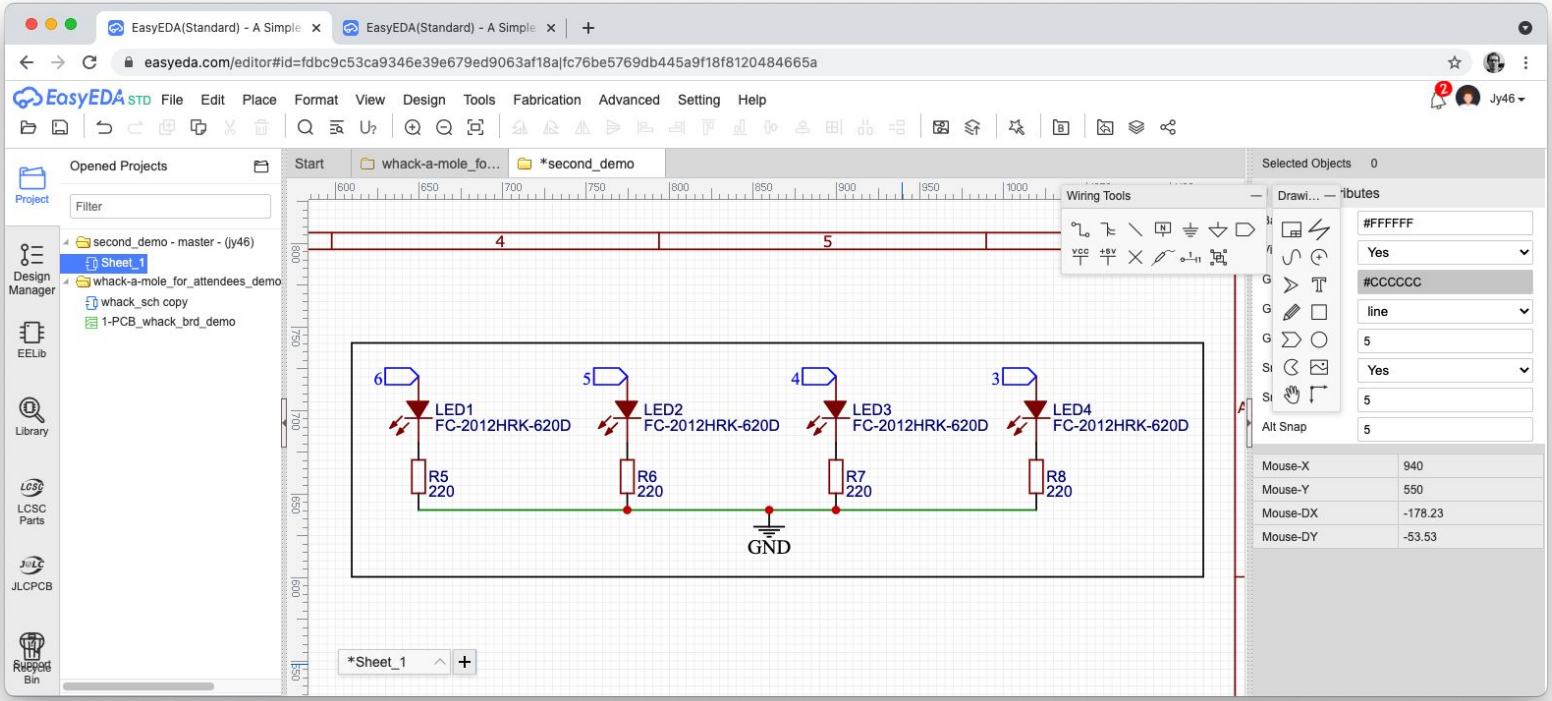
Place GND & Connect Resistors to GND



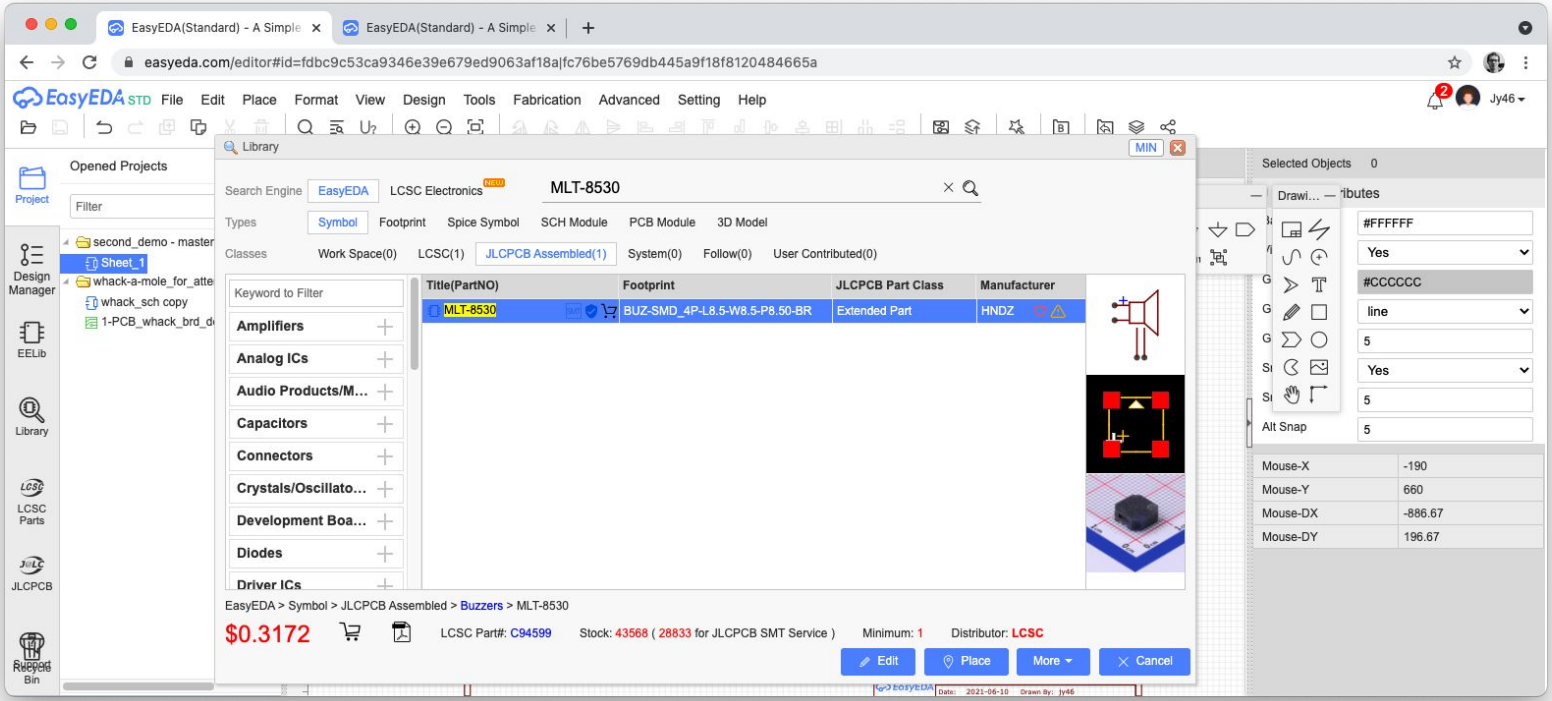
Add Net Ports 6, 5, 4, 3 to LEDs



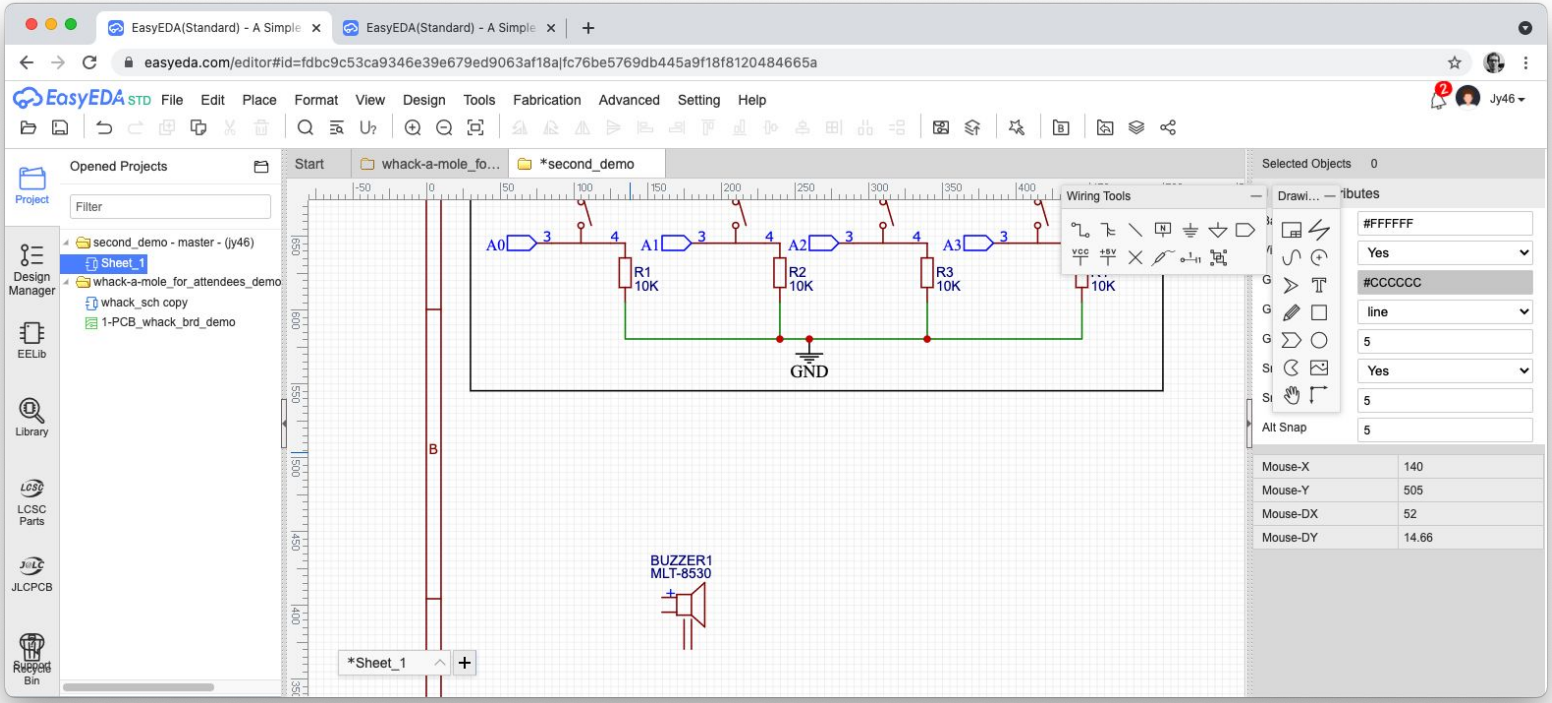
Draw Box Around This



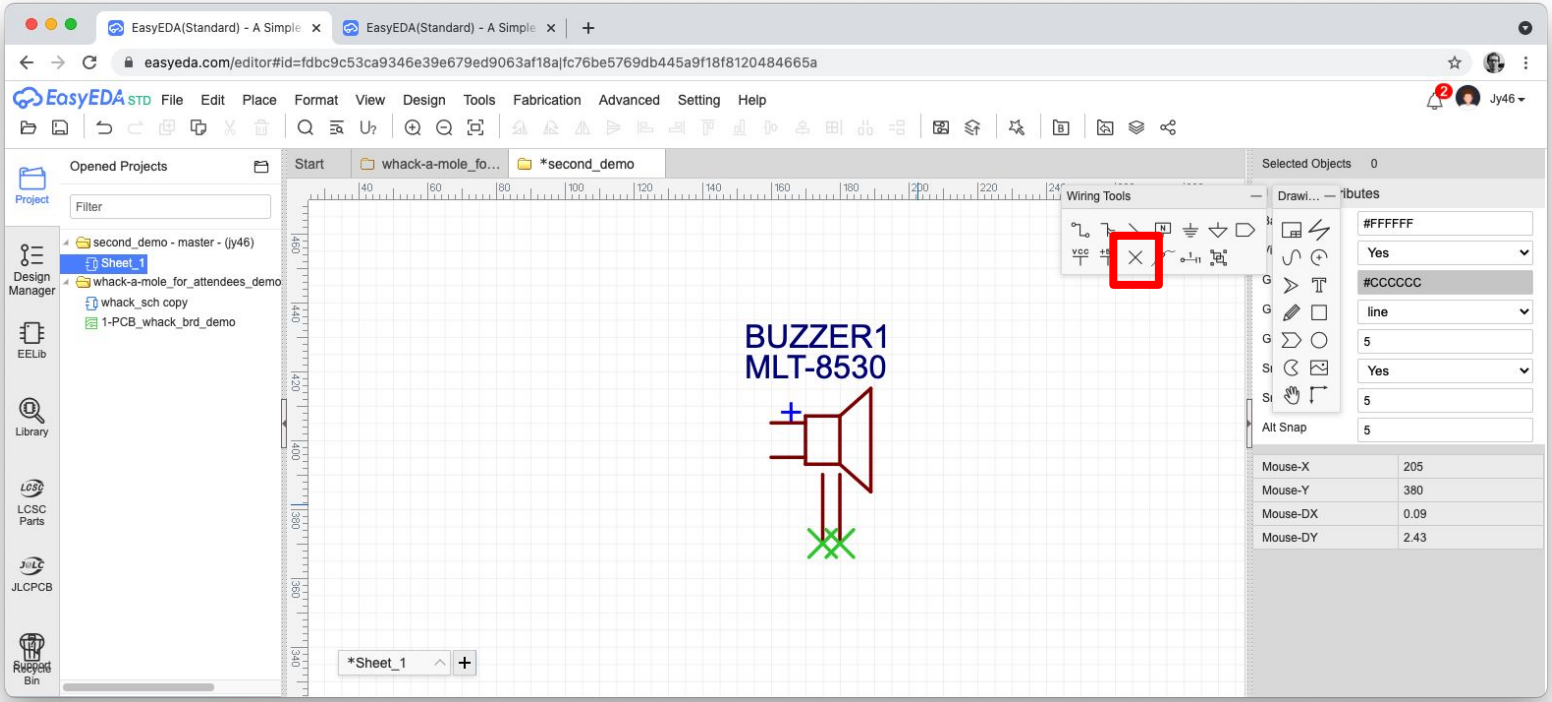
Grab Buzzer from Library: “MLT-8530”



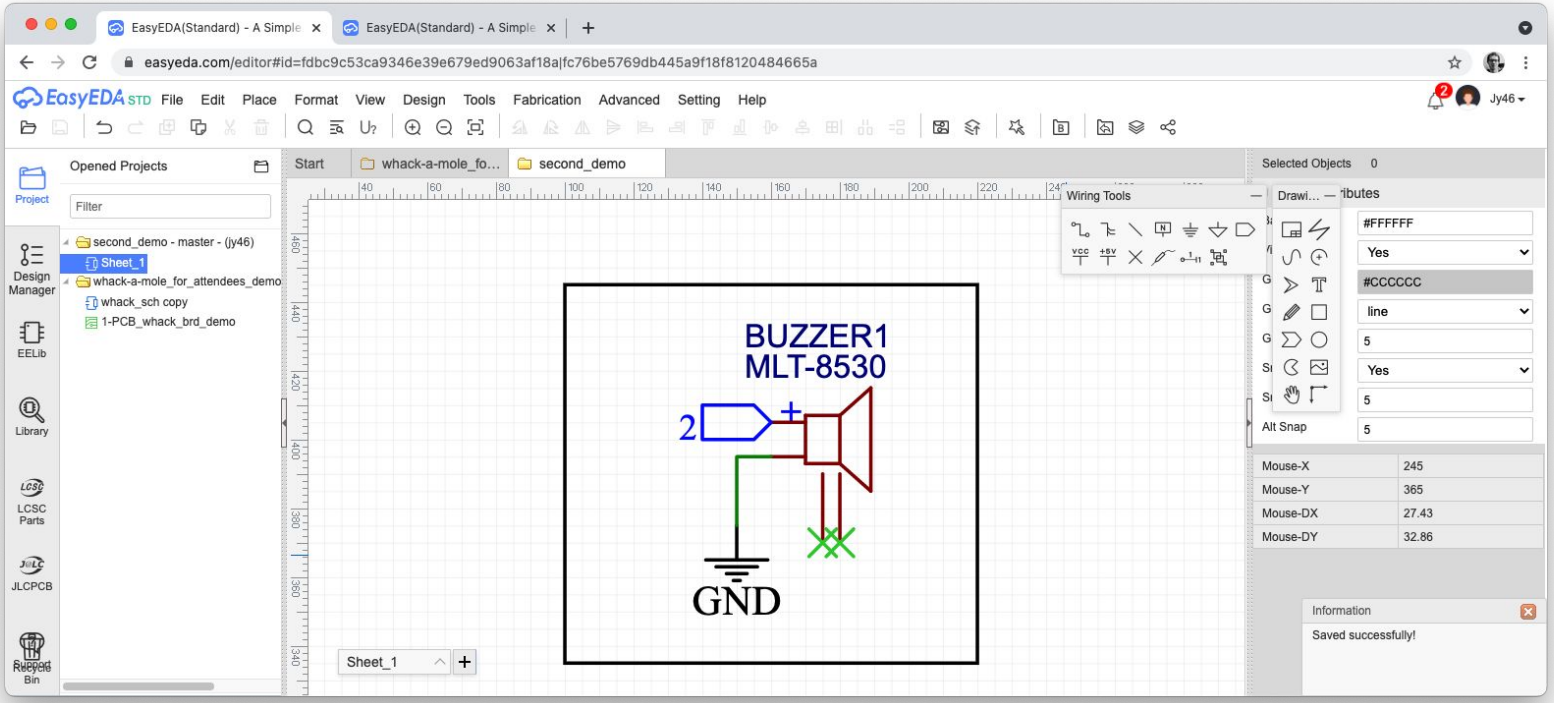
Place Buzzer



We Don’t Use the Bottom Terminals: Place No Connect Flags

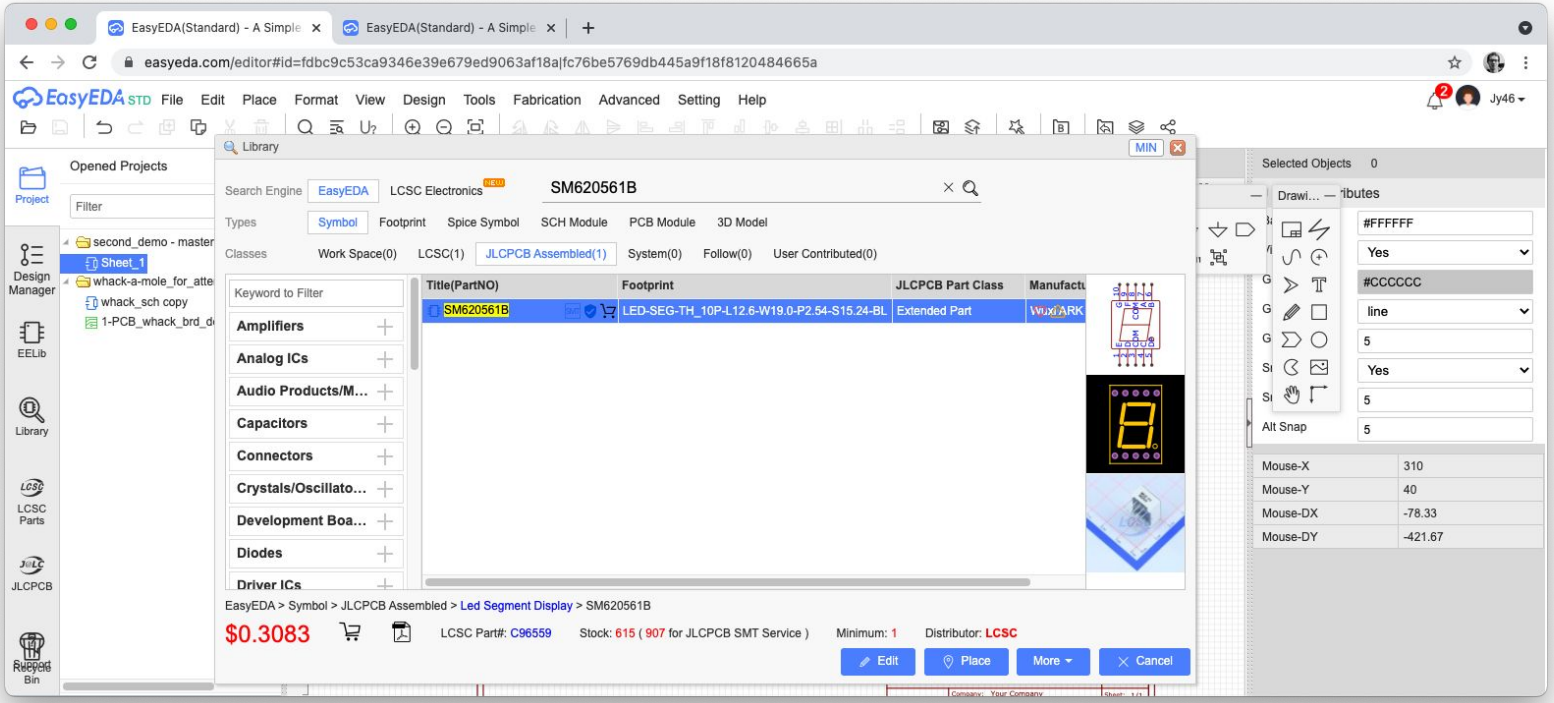


Connect Other Terminals to GND & Net Port 2

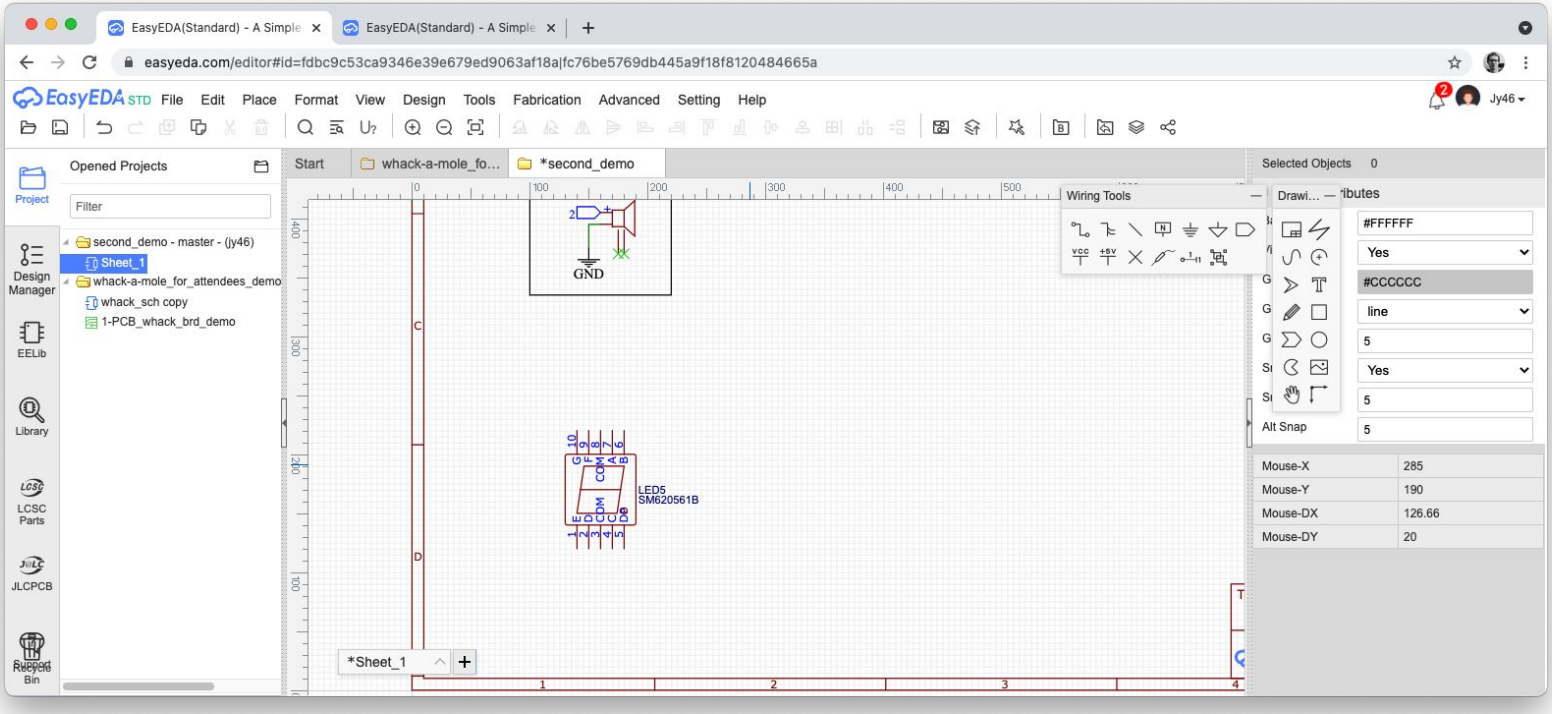


Also add a box!

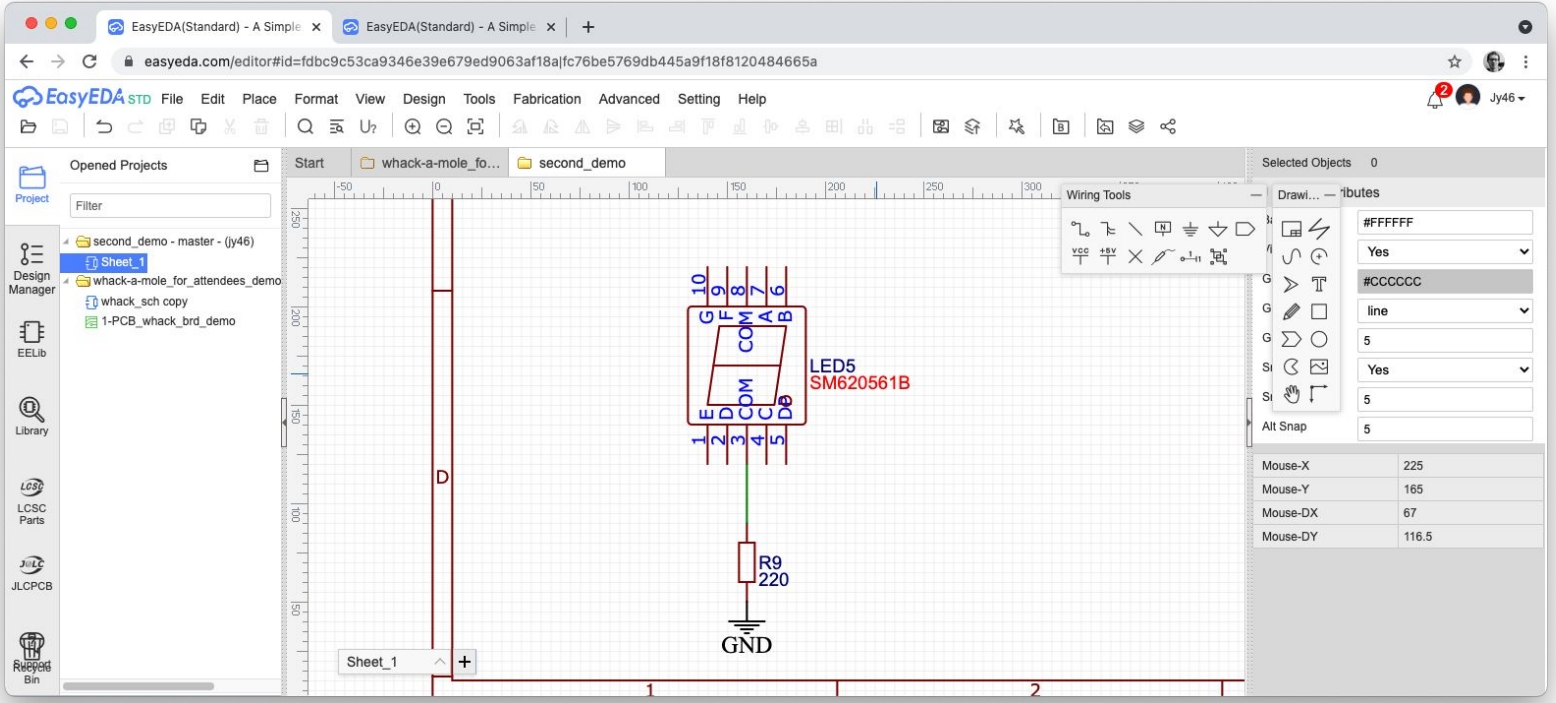
Grab 7 Segment Display from Library: “SM620561B”



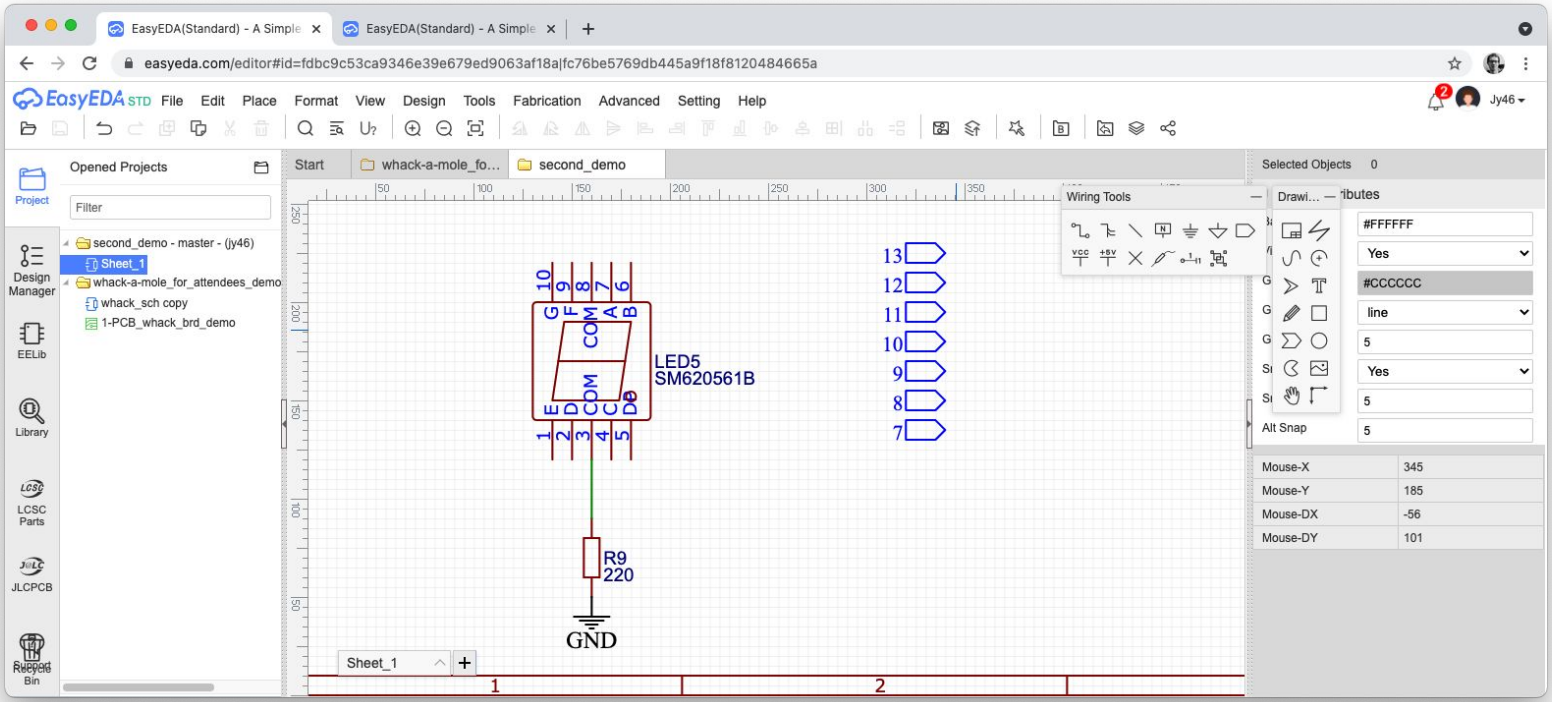
Place Display



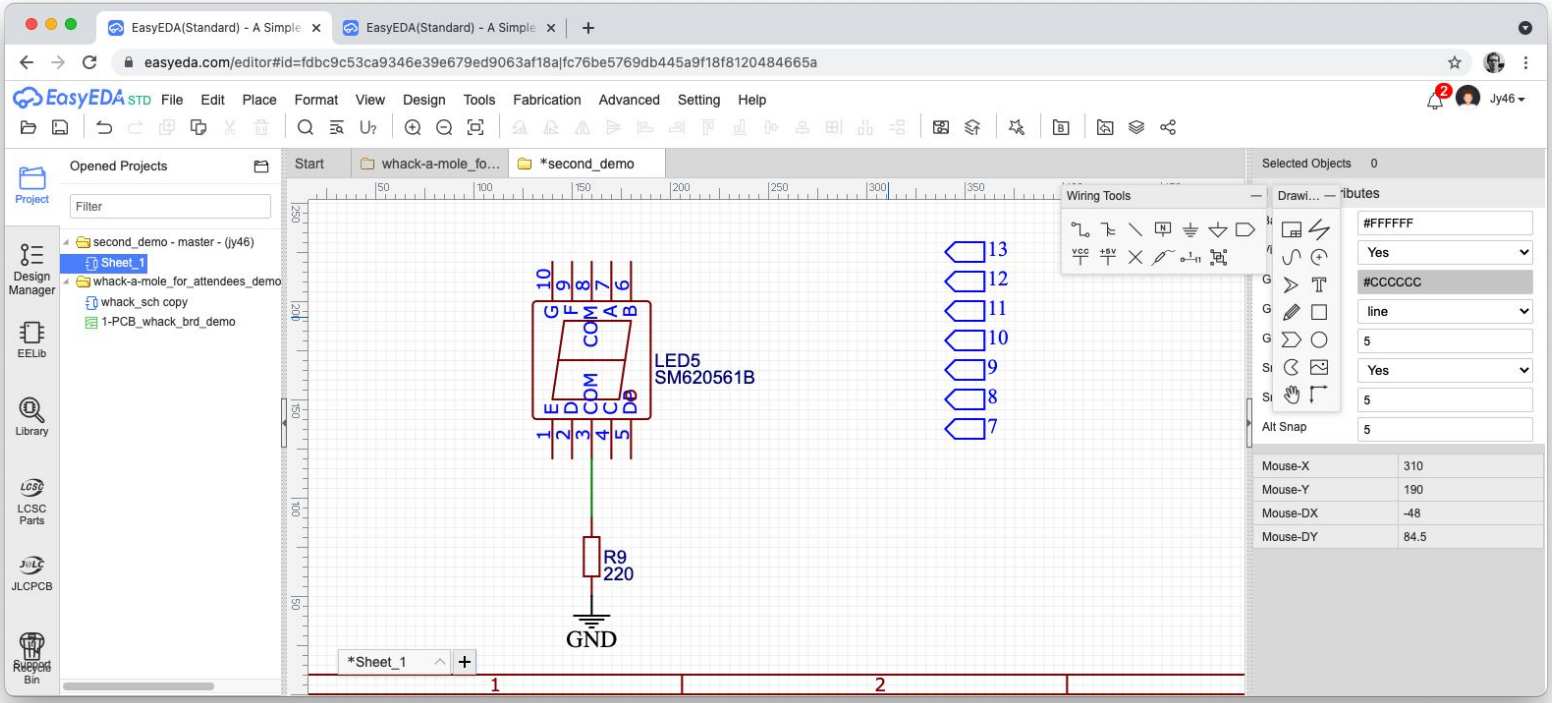
Copy and Paste Resistor Used with LEDs
Connect the Resistor to GND & Pin 3



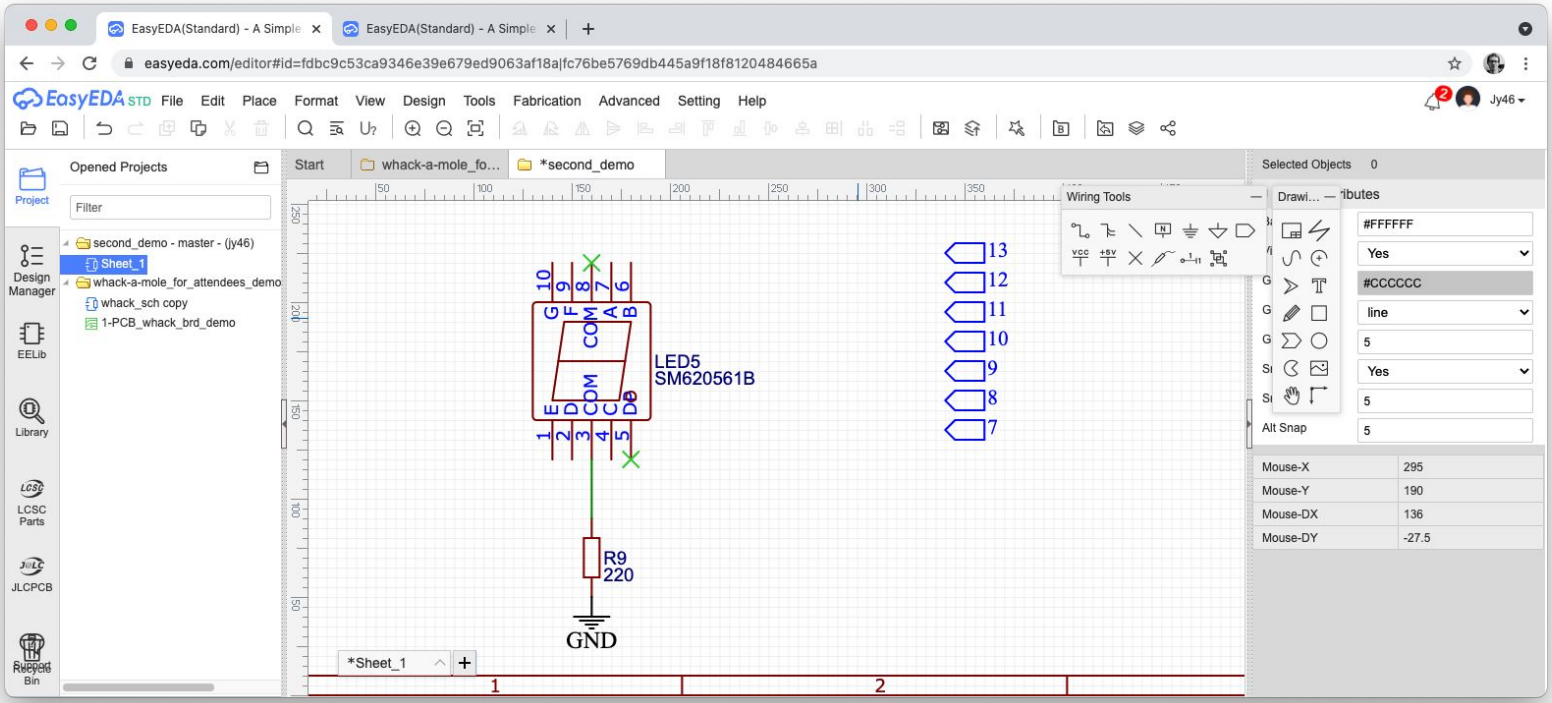
Add Net Ports 7 to 13



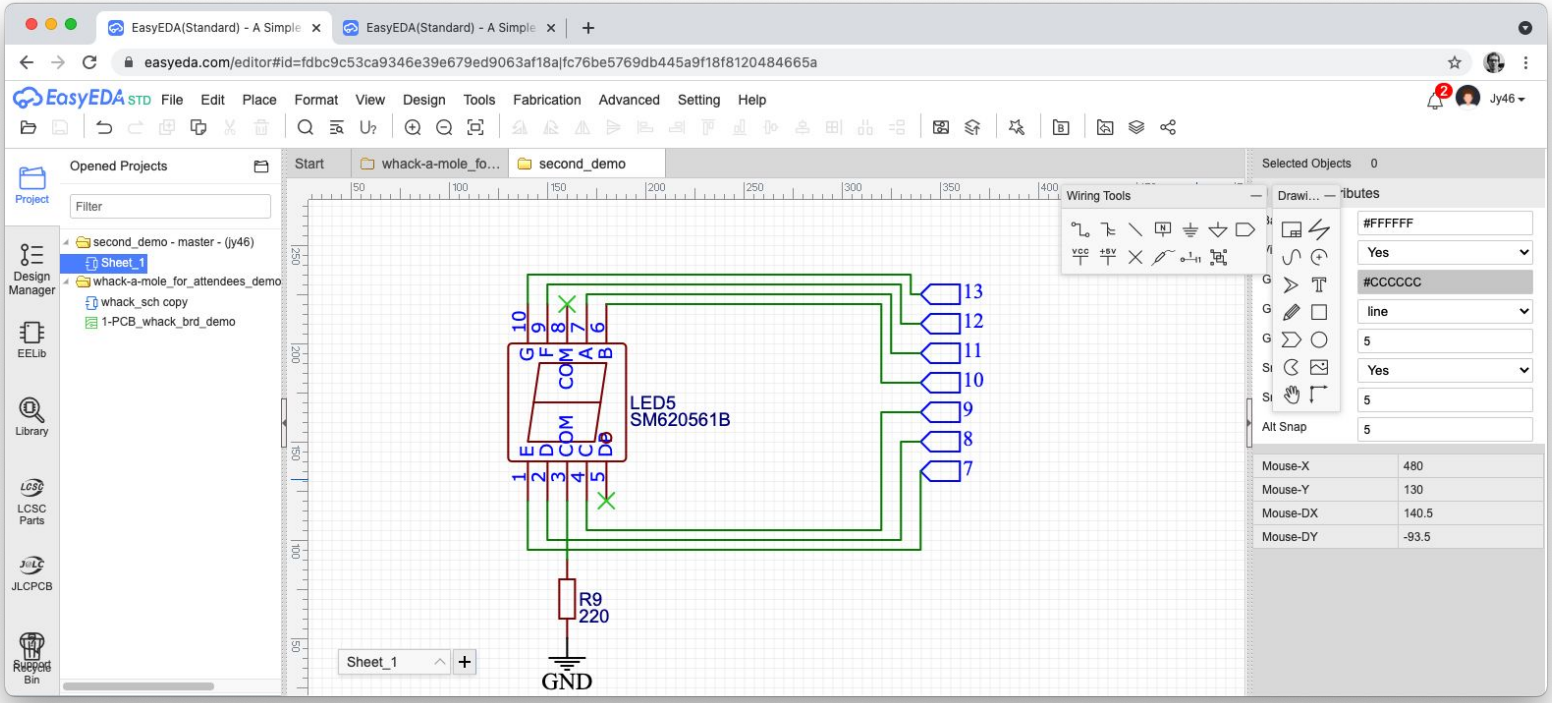
Rotate Net Ports



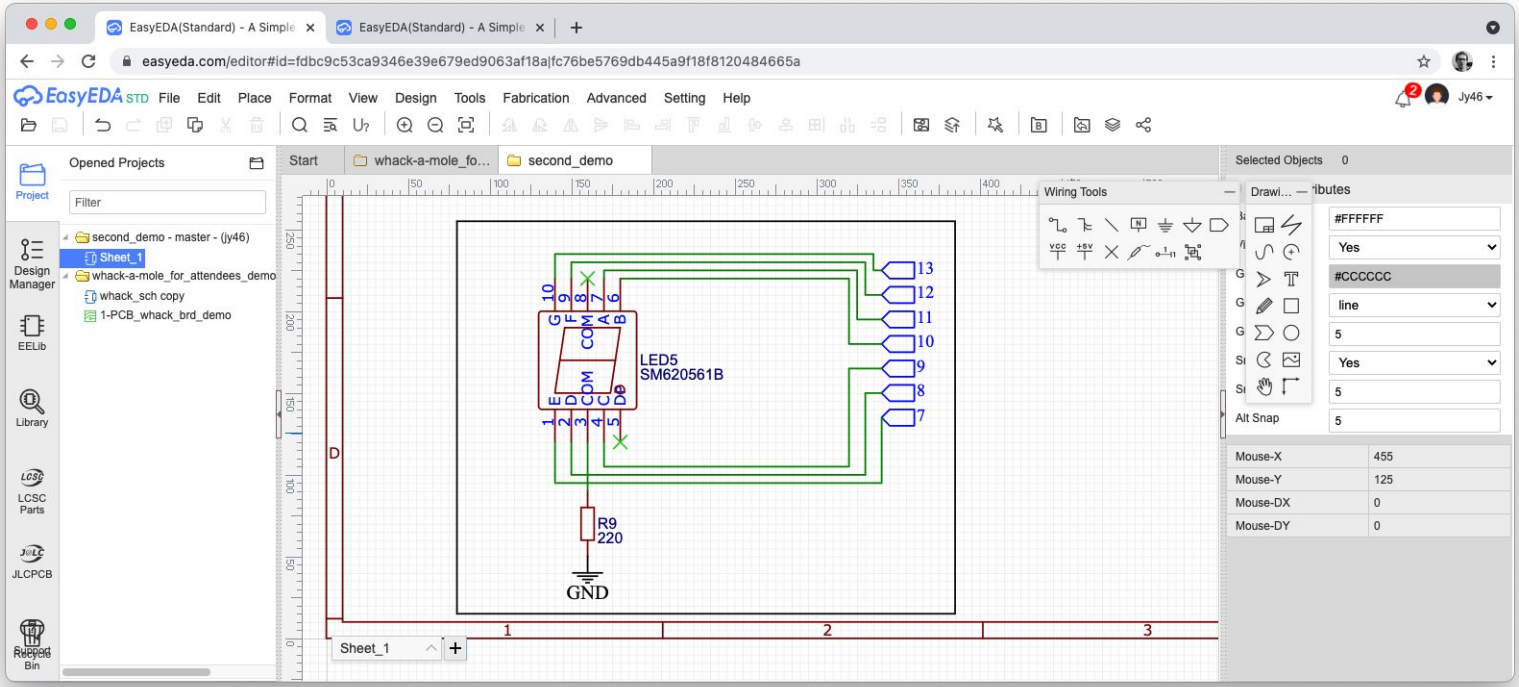
Add No Connect Flags to Pins 5 and 8



Wire Other Pins to Net Ports (counter-clockwise)

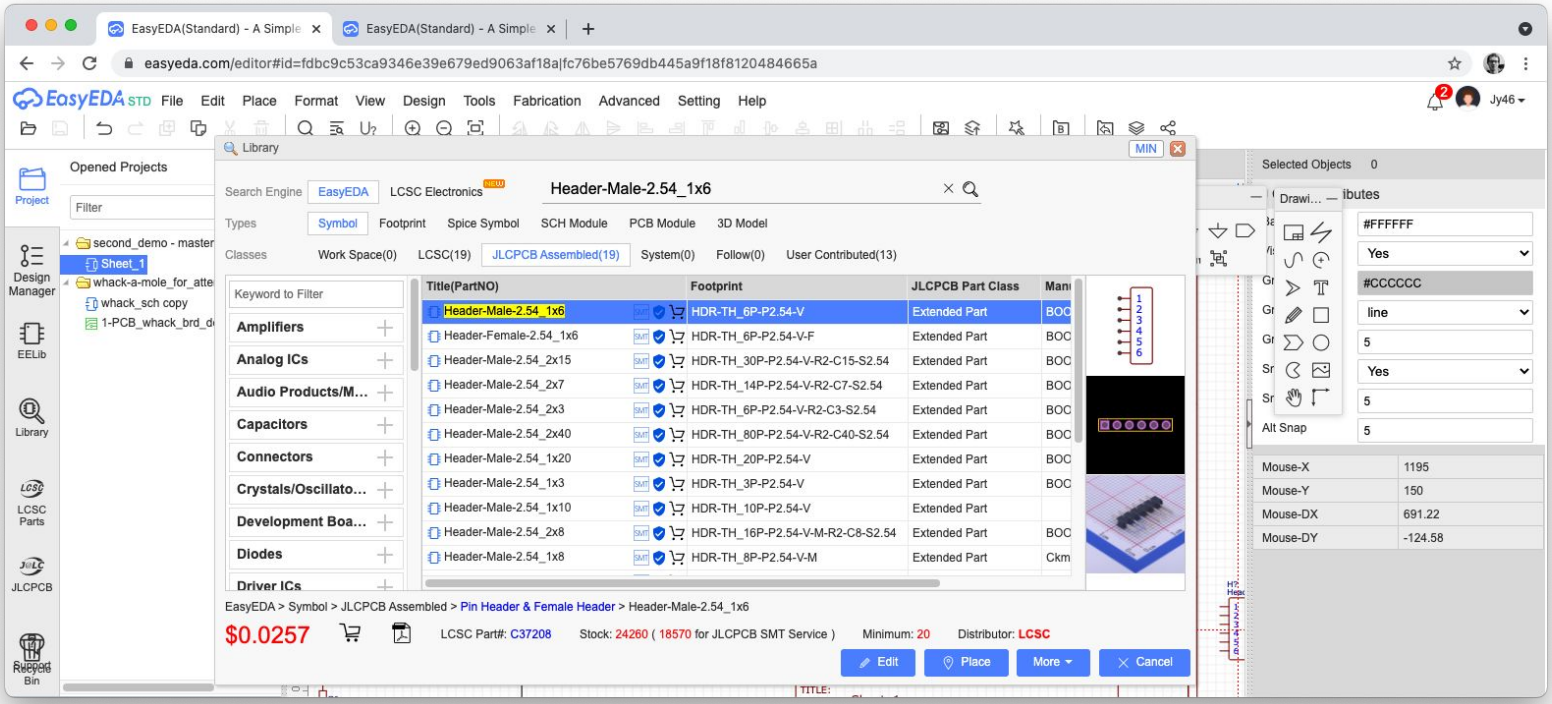


Wire Other Pins to Net Ports (counter-clockwise)

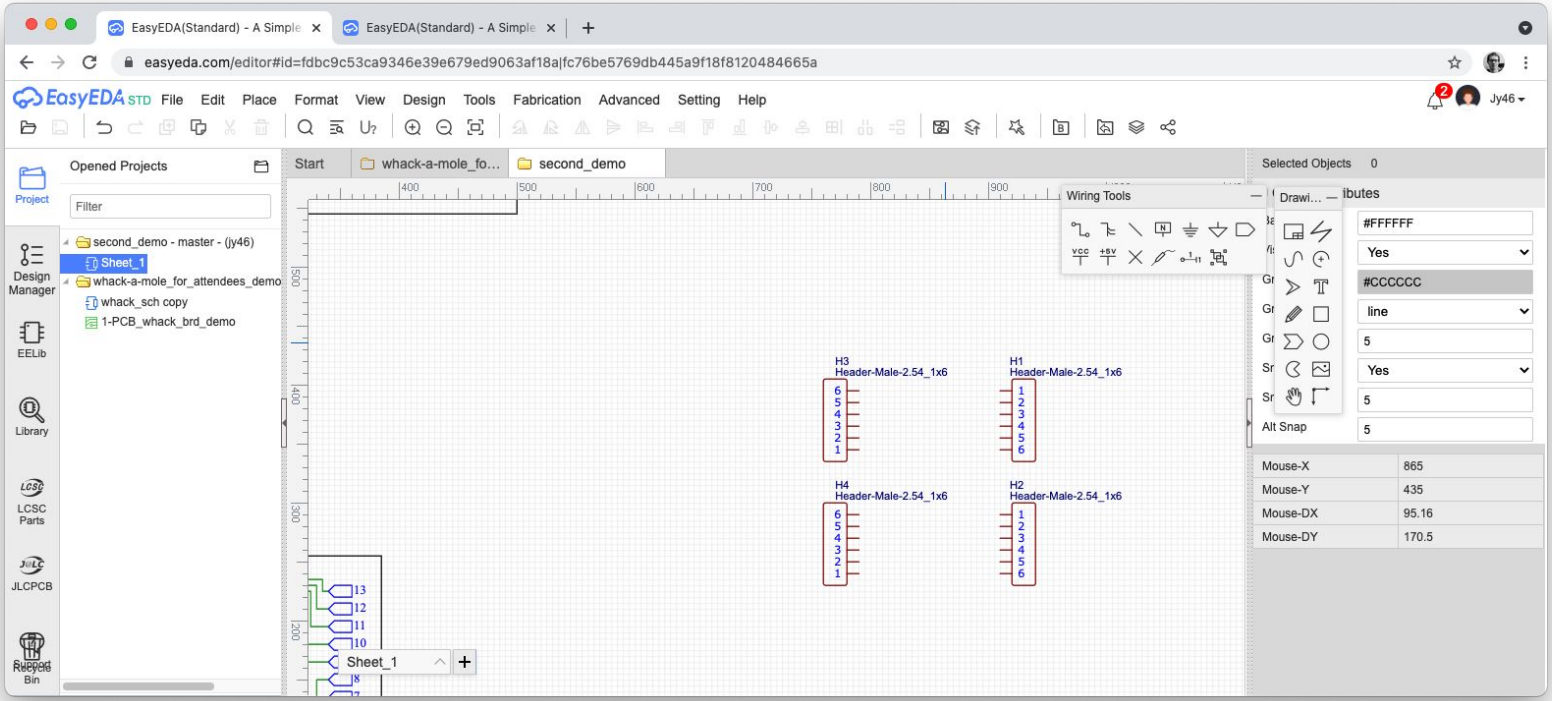


Also add a box!

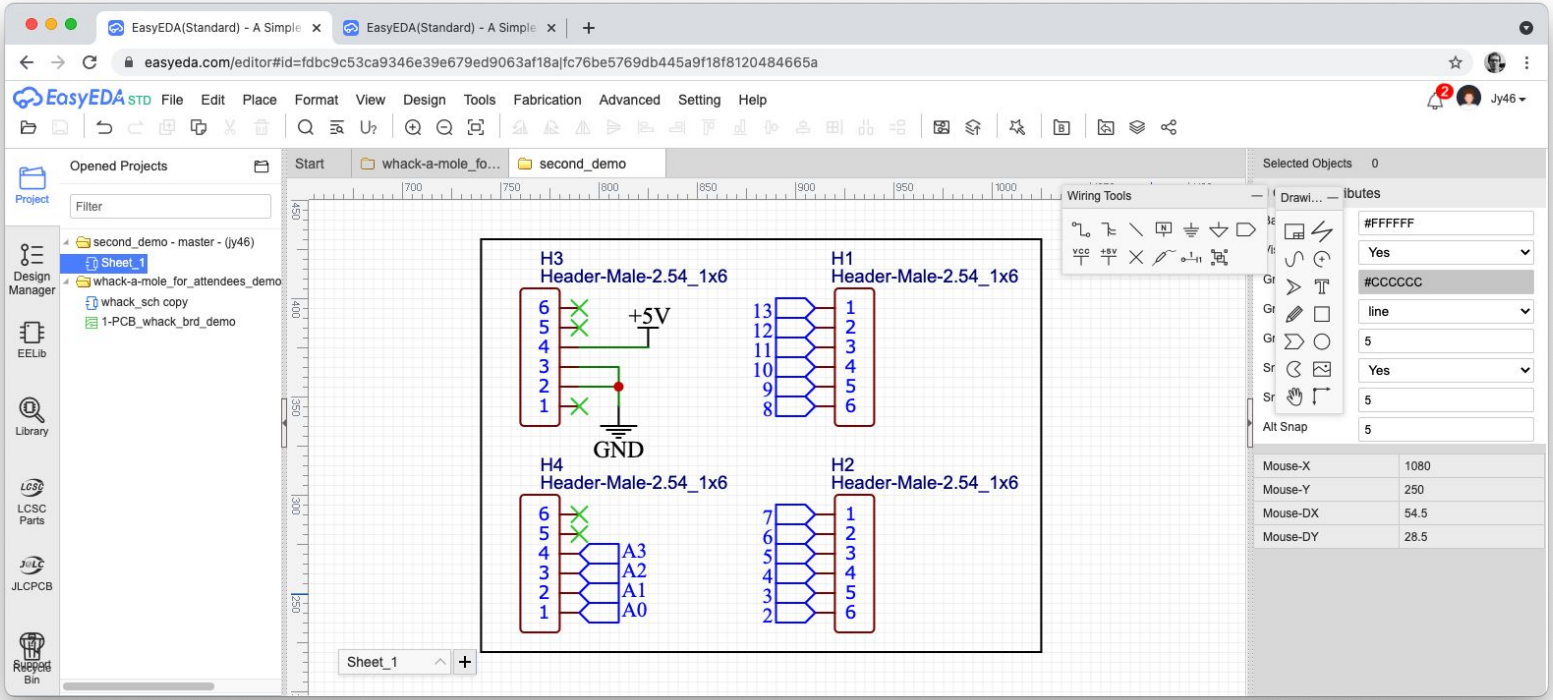
Now Let's Grab Header from the Library: "Header-Male-2.54_1x6"



Place 4 Headers

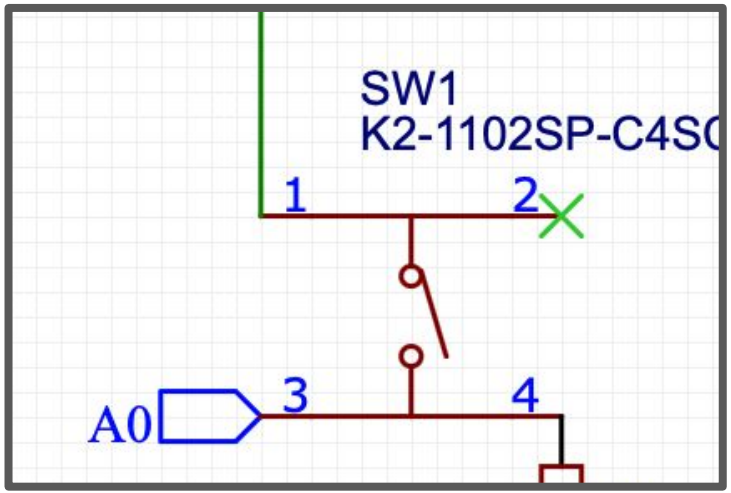


Add Net Ports, No Connect Flags, +5 V, and GND

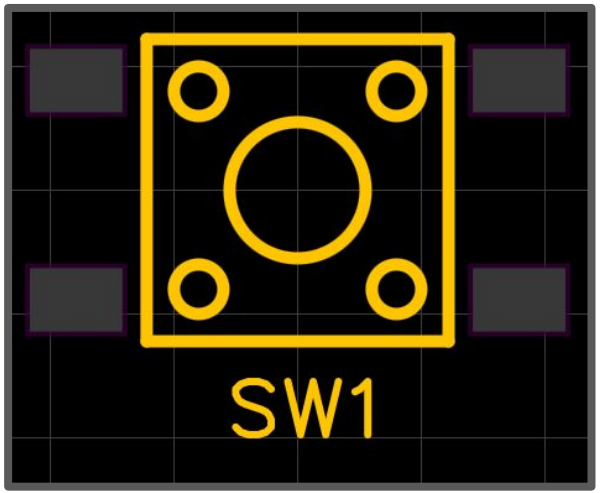


Also add a box!

Schematic Components Associated with PCB Footprints



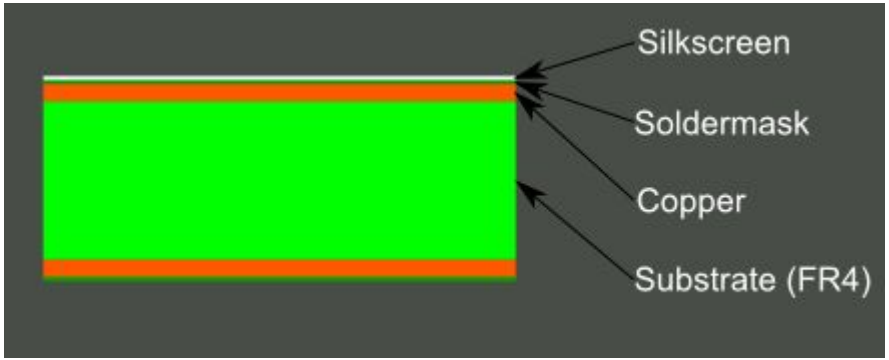
Schematic



PCB

Information Needed by PCB Program: Board size+layers

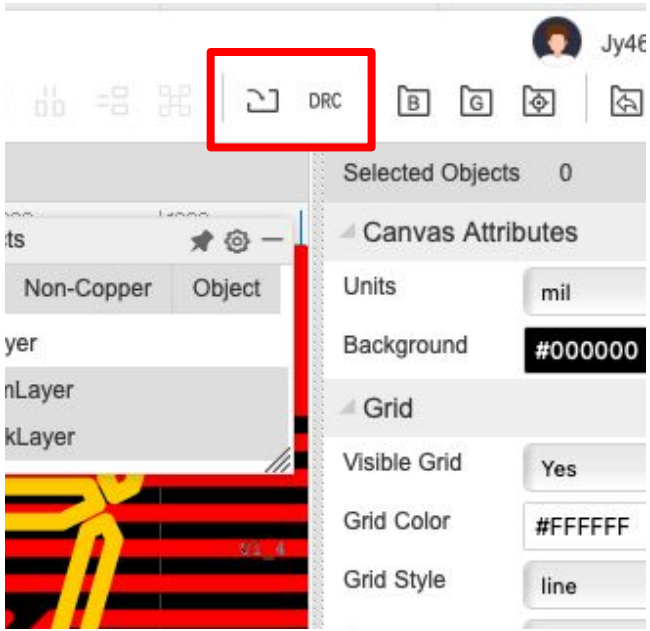
- Board size
- # layers of copper
  - 2 or 4 common
  - More layers means higher cost
  - Motherboards could have 16 layers
  - Other layers exist by default
    - Solder mask
    - Silkscreen



https://learn.sparkfun.com/tutorials/pcb-basics/all

Information Needed by PCB Program: Design rules

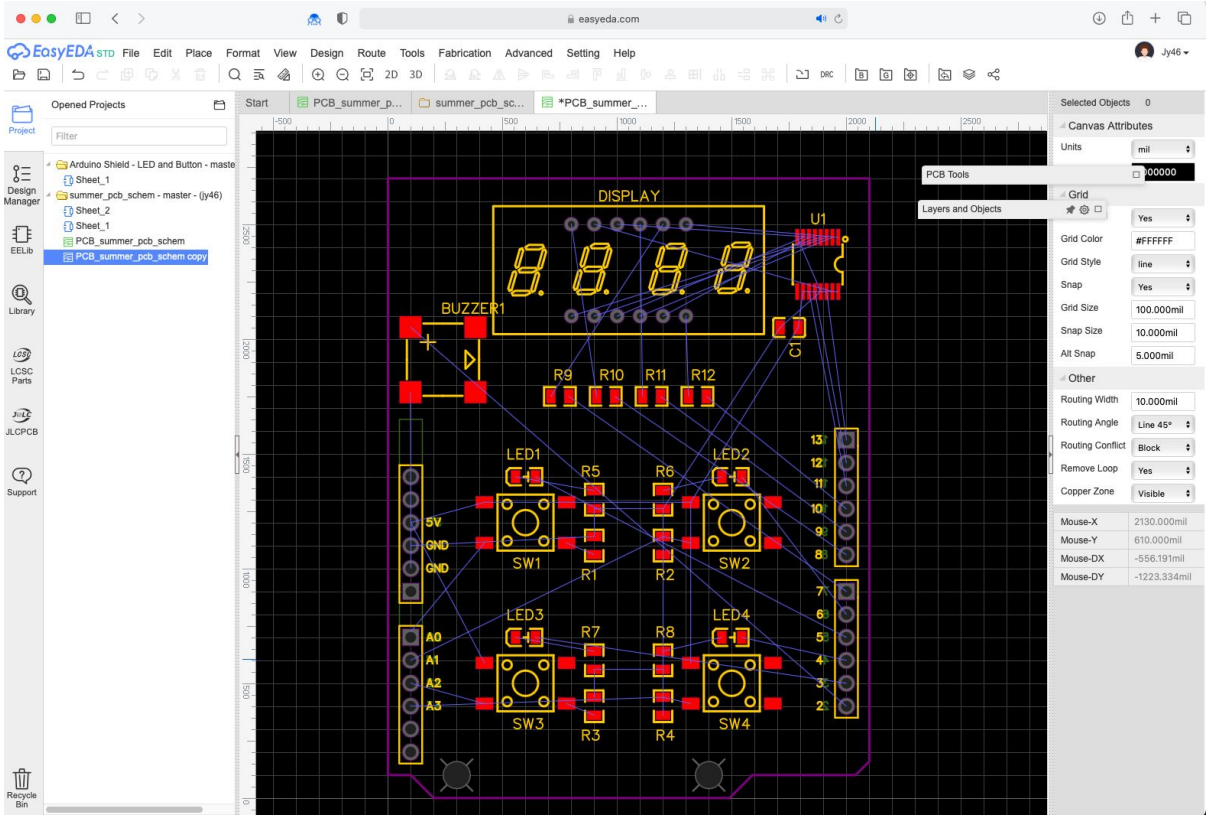
- Design rules
  - Specified by manufacturer (fabrication house)
  - For example: minimum metal line size or spacing



You've Finished a Schematic, What's Next?

Move parts (footprints) around on board

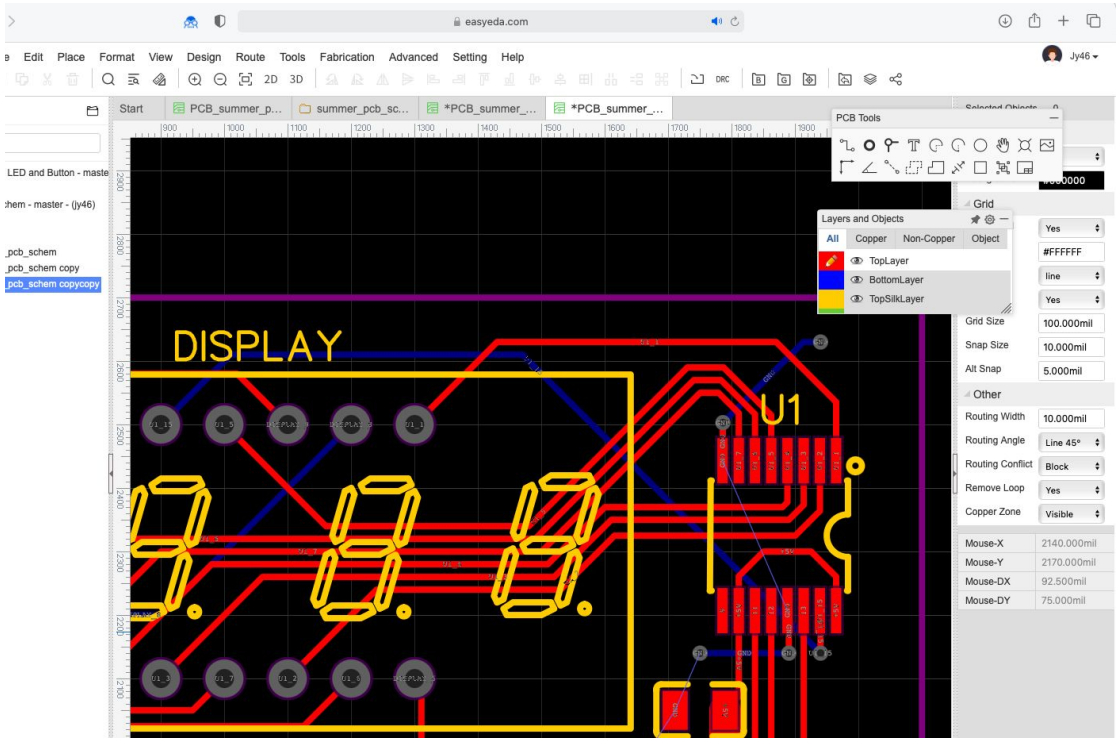
This view is called "rats nest"



You've Finished a Schematic, What's Next?

Route wires (traces) on multiple layers between parts/pads

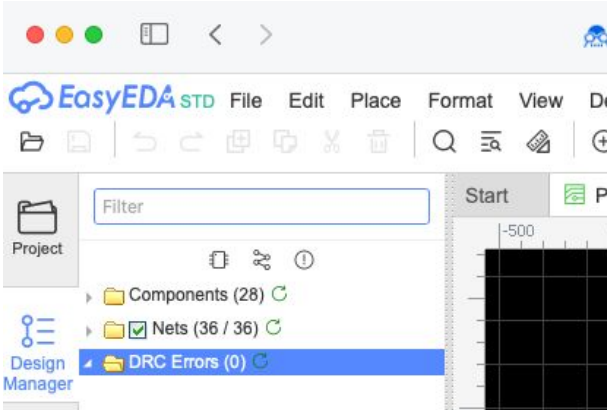
- Manually route critical traces
- Automatically route remaining traces via autorouter

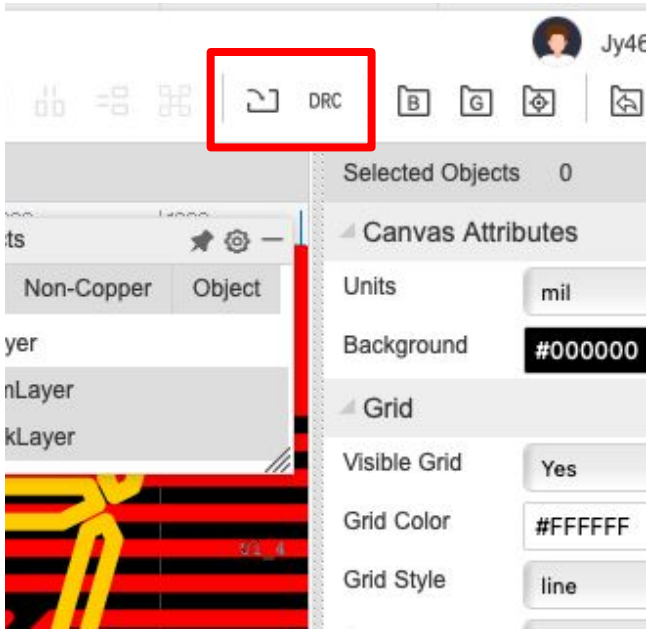


You've Finished a Schematic, What's Next?

Perform design rules check (DRC)

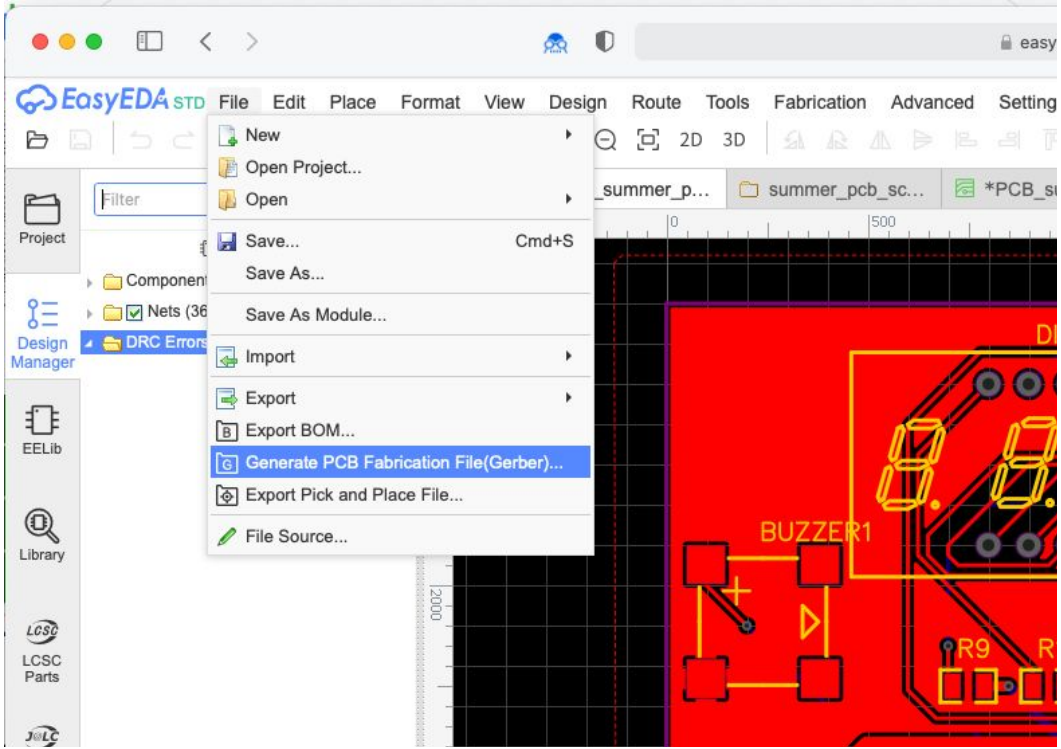
- Can the fab make the PCB?
- Space between traces
- Keep out zones for components
- Space from edges





You've Finished Placement & Routing, What's Next?

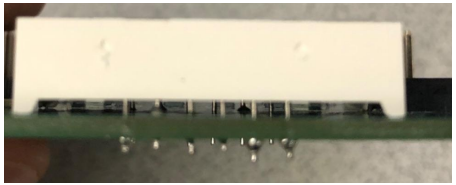
- Produce files for manufacturing
  - "Gerber" files (1 per layer)
    - Metal, solder mask, silkscreen, pads, thru-hole plating
  - Drill files (hole locations, drill size)
- Produce bill of materials (BOM)
  - All components in the design

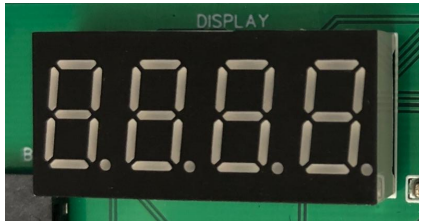


Component Sizes & Packages

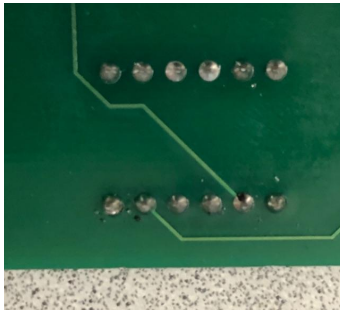
Surface Mount (SMT)

Side





Top

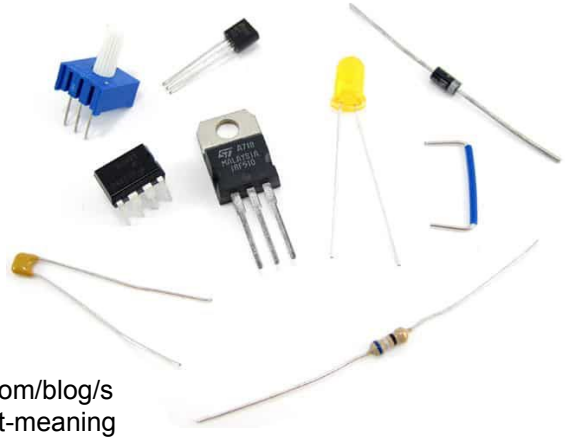


Bottom

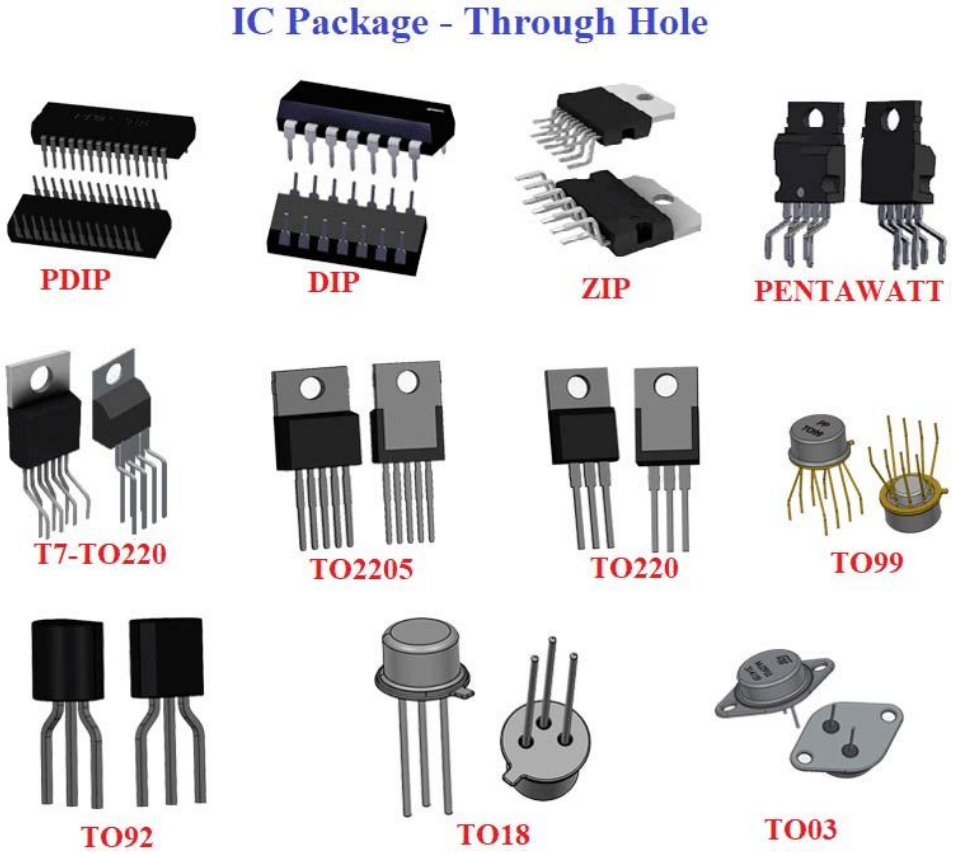
Thru-hole

Thru-hole

- Older
- Requires more space
- Easy to hand-solder & de-solder
- Many parts no longer have thru-hole packages



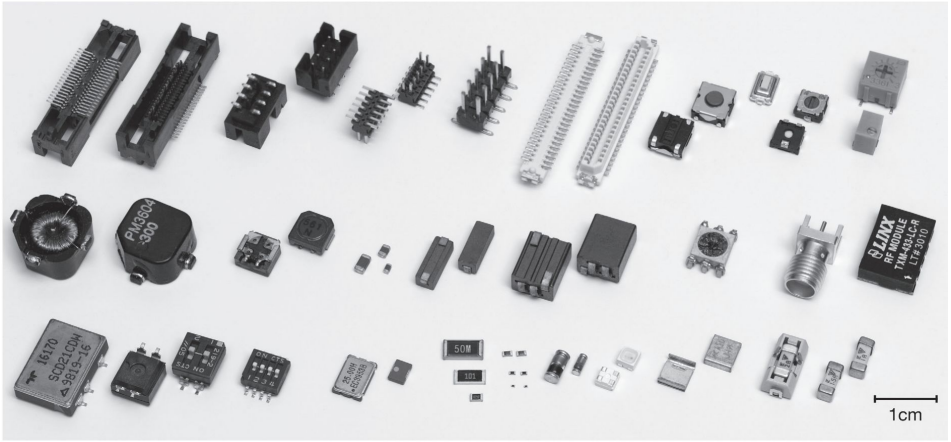
https://titoma.com/blog/smt-smd-bga-tht-meaning



https://components101.com/articles/different-ic-package-types-and-which-one-should-you-select

Surface Mount (SMT)

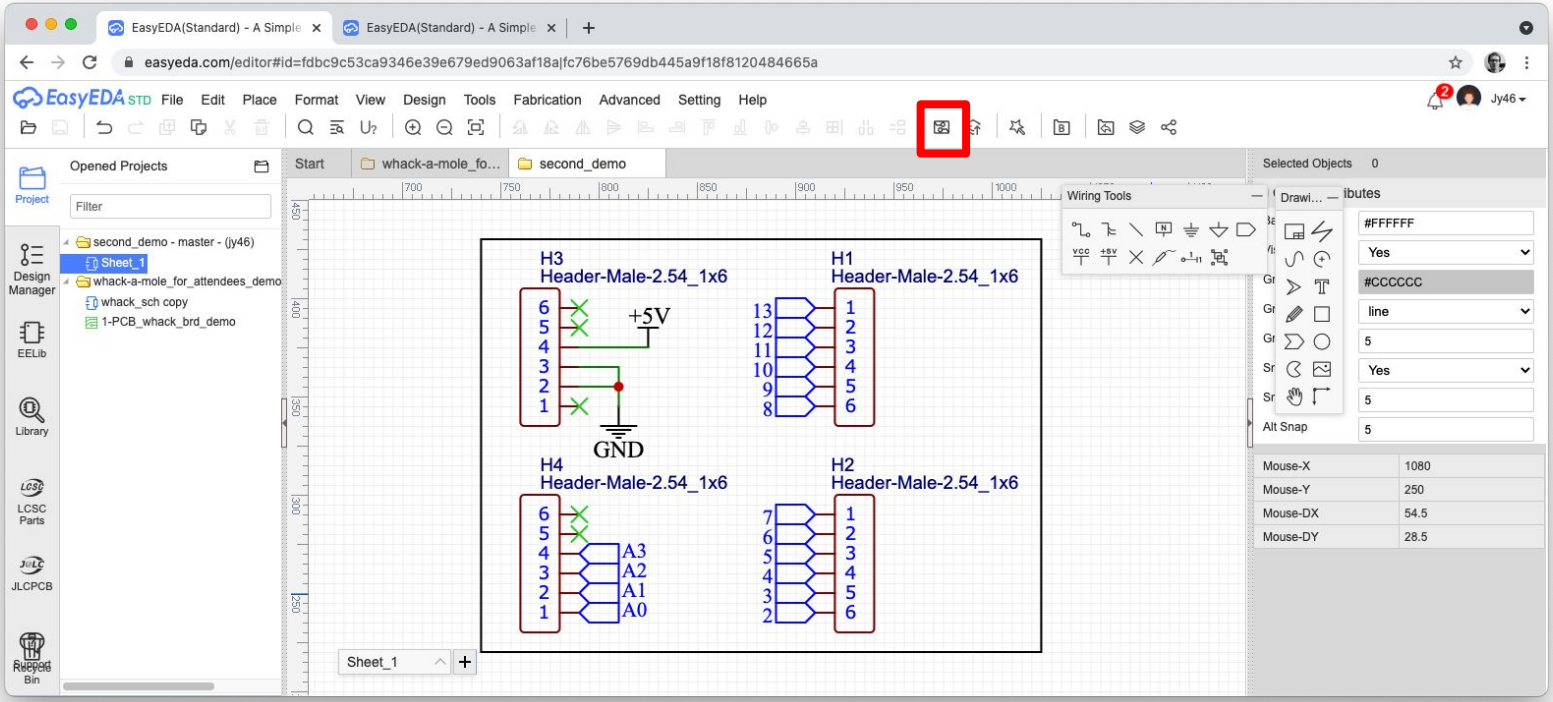
- Modern
- Requires less space
- Some can be hand-soldered



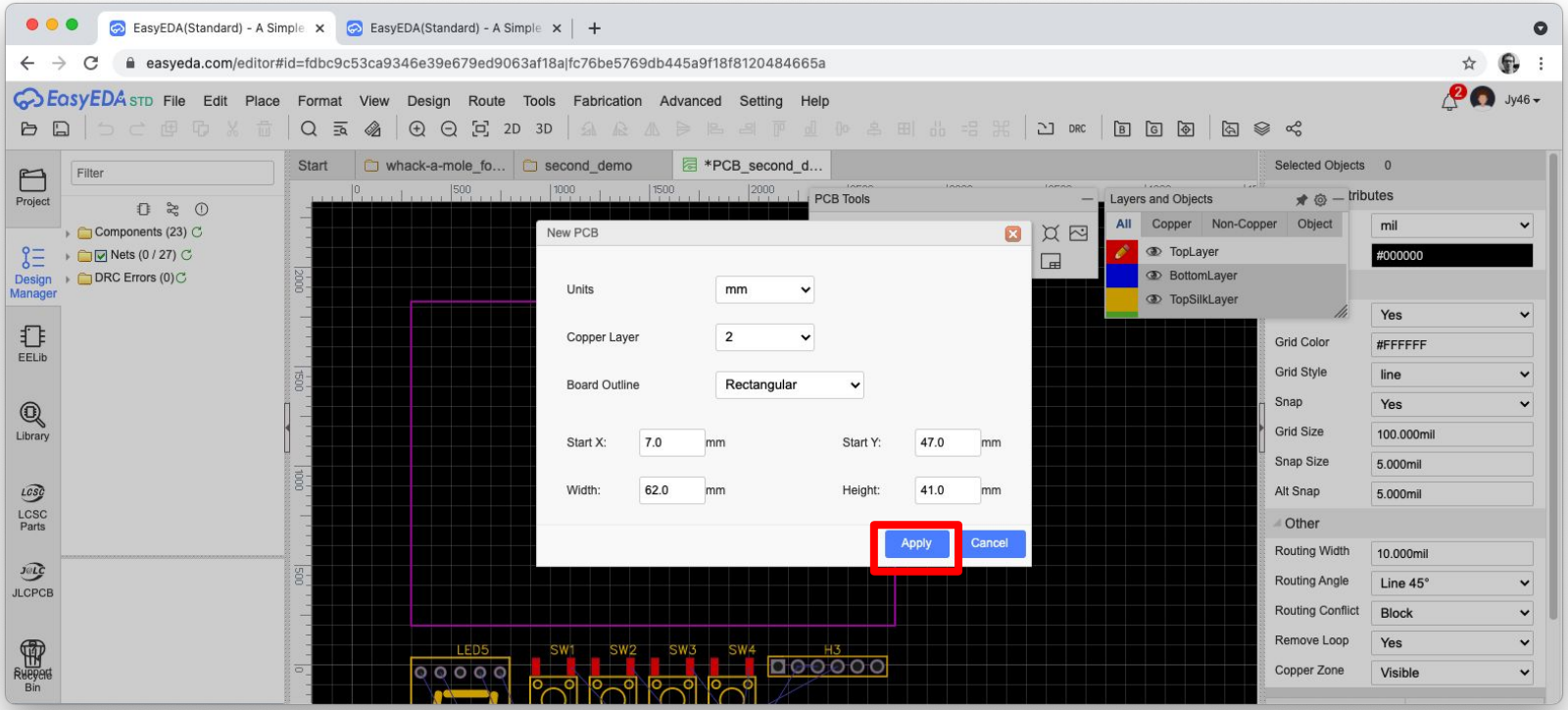
Horrowitz & Hill. *The Art of Electronics*, 3rd ed. (2015)

https://components101.com/articles/different-ic-package-types-and-which-one-should-you-select

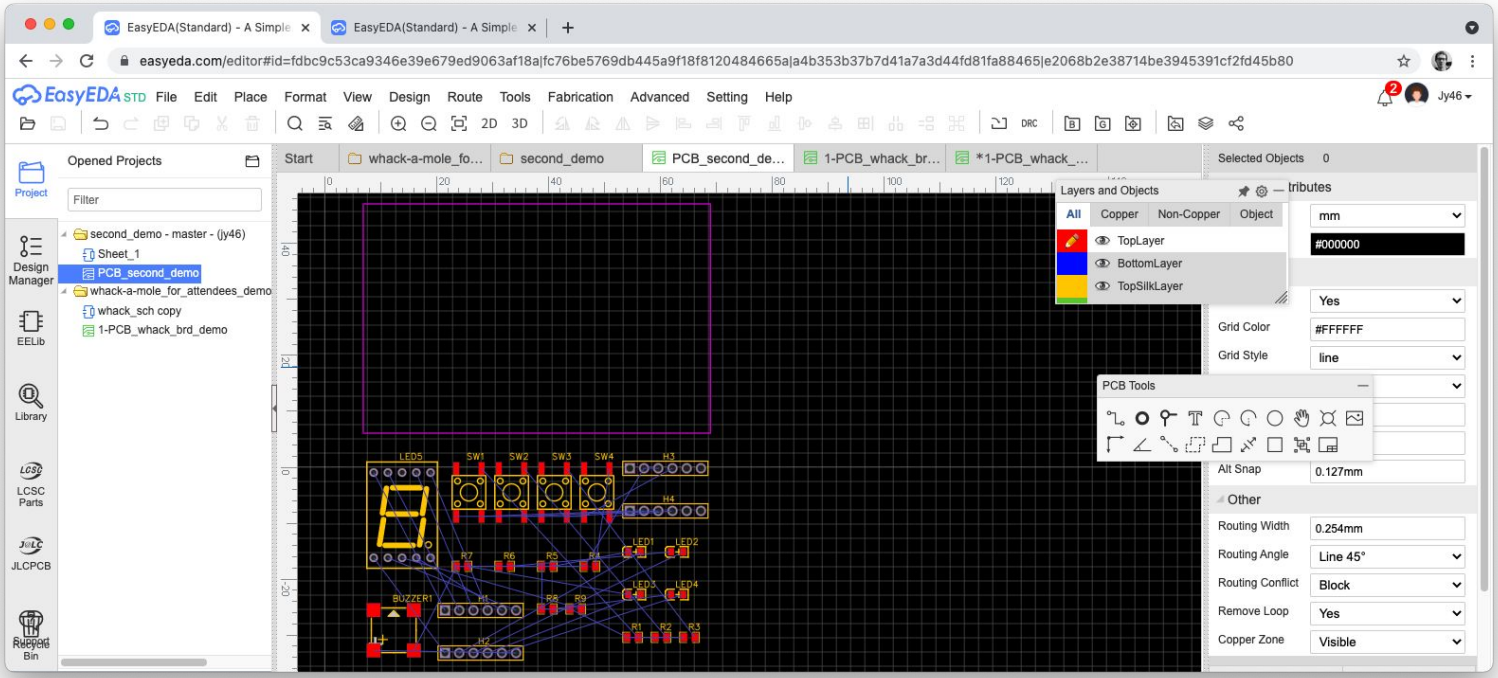
Now Convert Schematic to PCB



Click Apply for Board Sizing



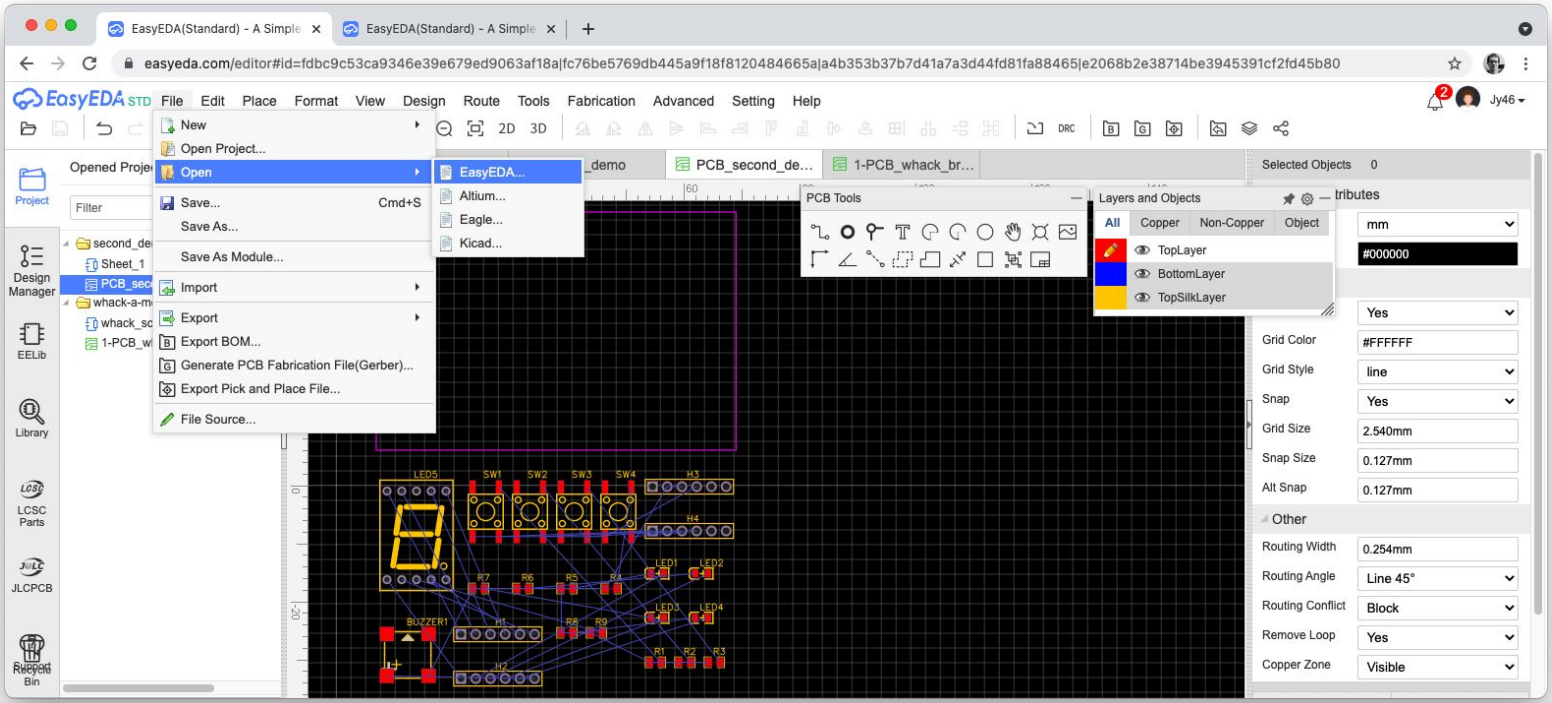
Components are Ready for Placement
However, Need Arduino Shield Layout



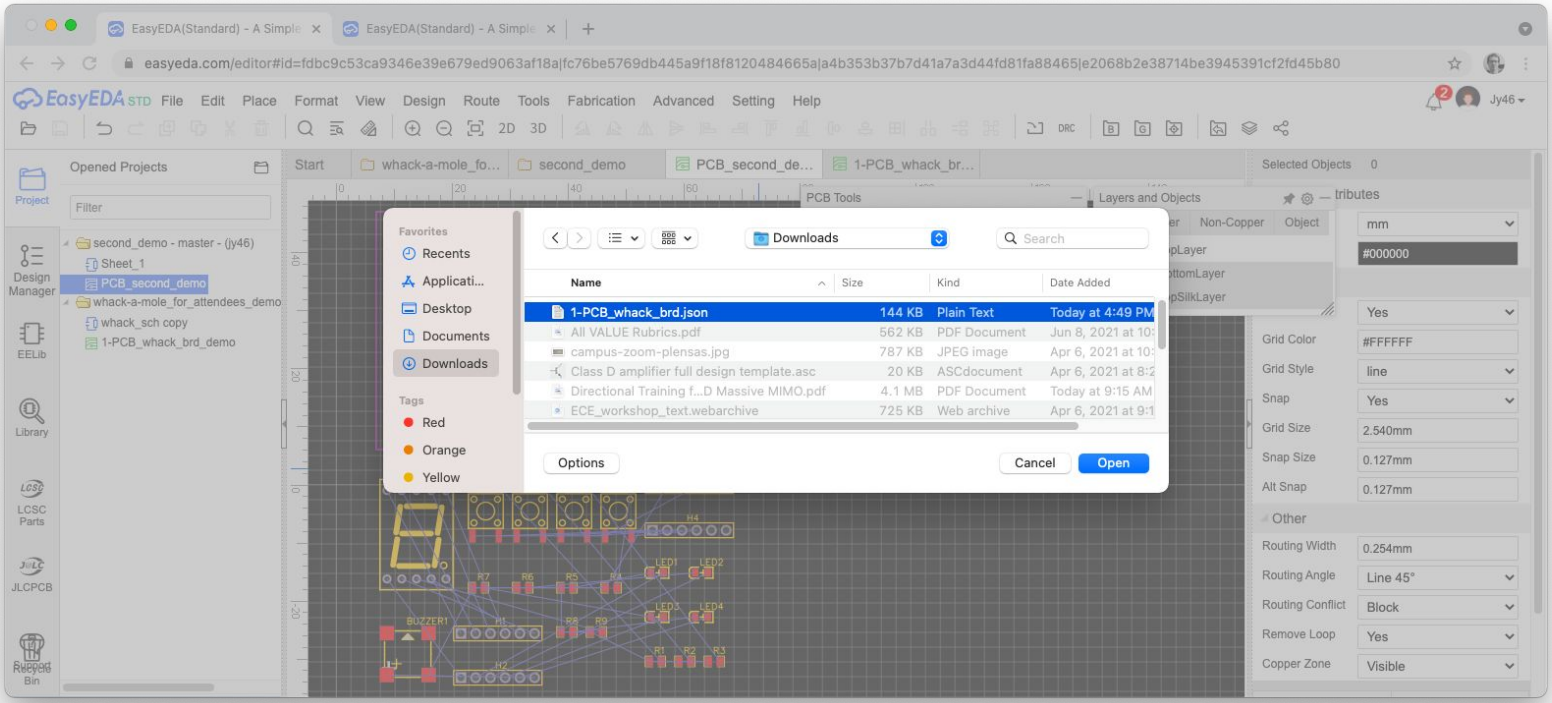
Download File with Arduino Shield Layout

Download file from here:
https://drive.google.com/file/d/1bG_XOHcTIye5dCddasBaLiAk78t8u-0F/view?usp=sharing

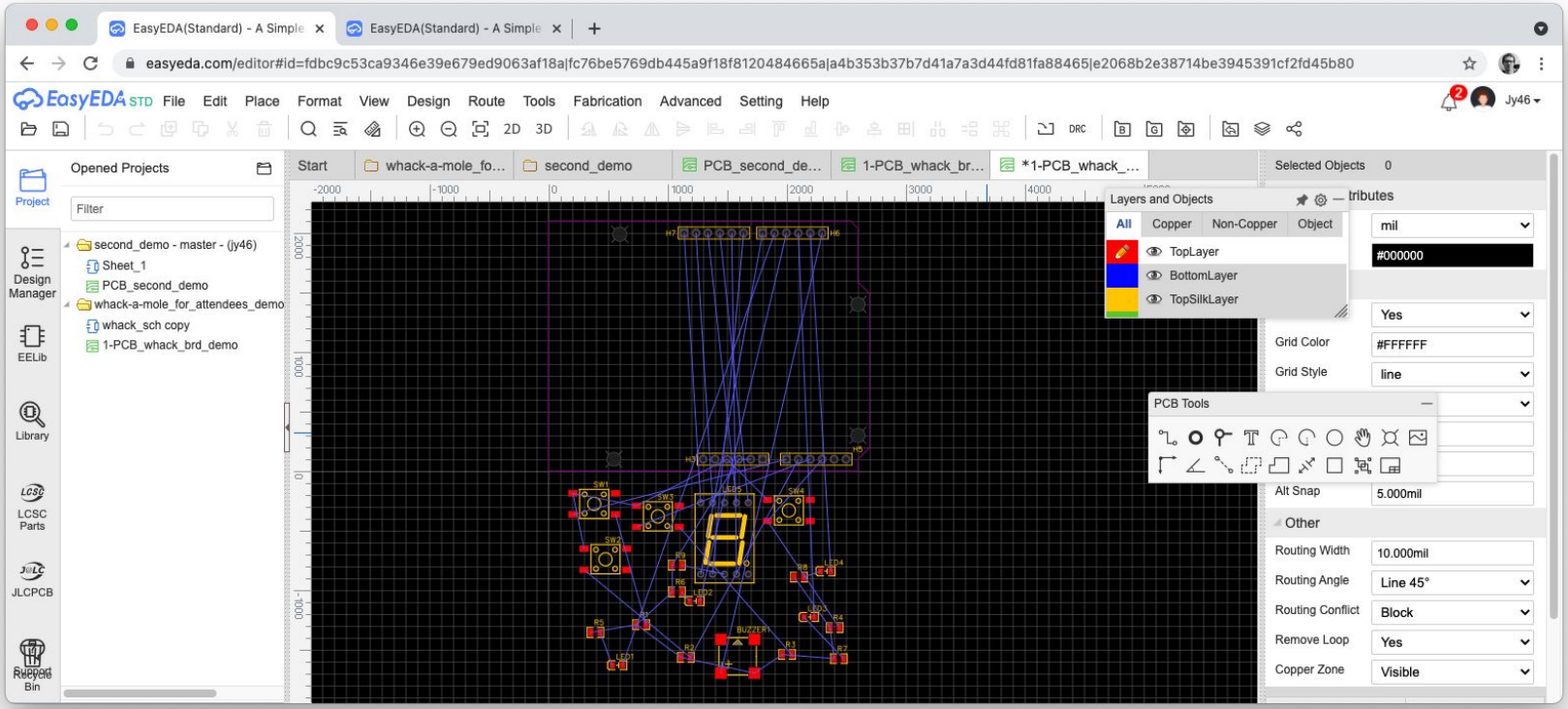
Import Downloaded File with Arduino Shield Layout



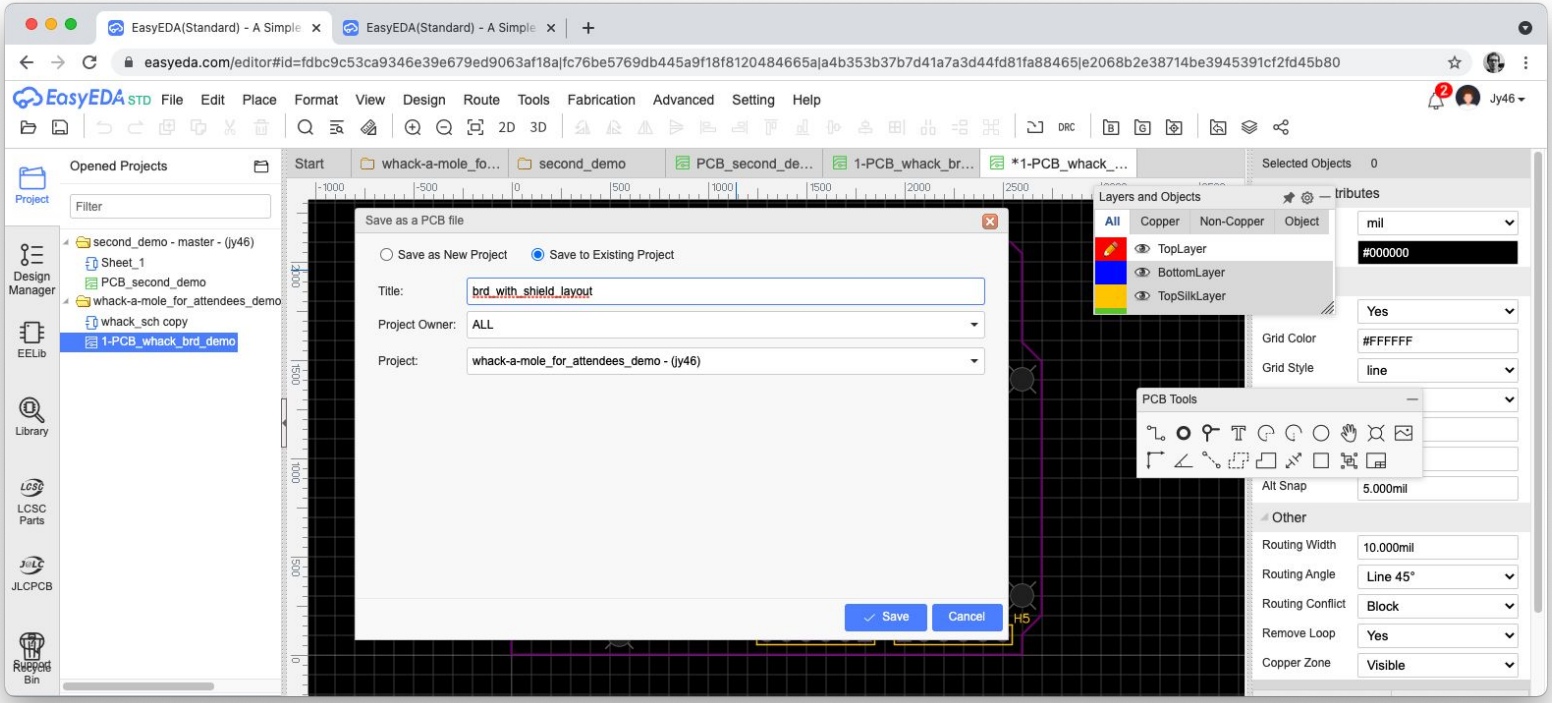
Import Downloaded File with Arduino Shield Layout



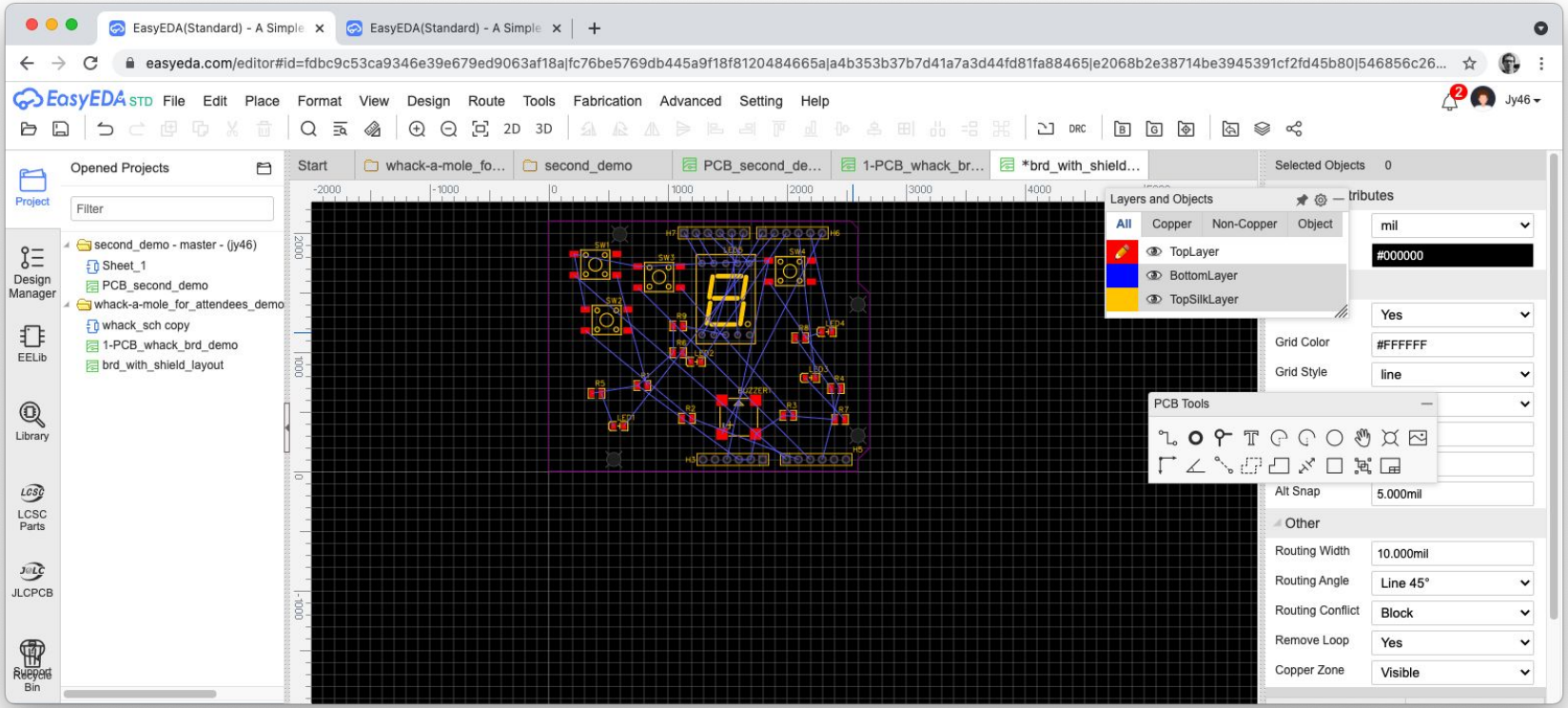
Import Downloaded File with Arduino Shield Layout



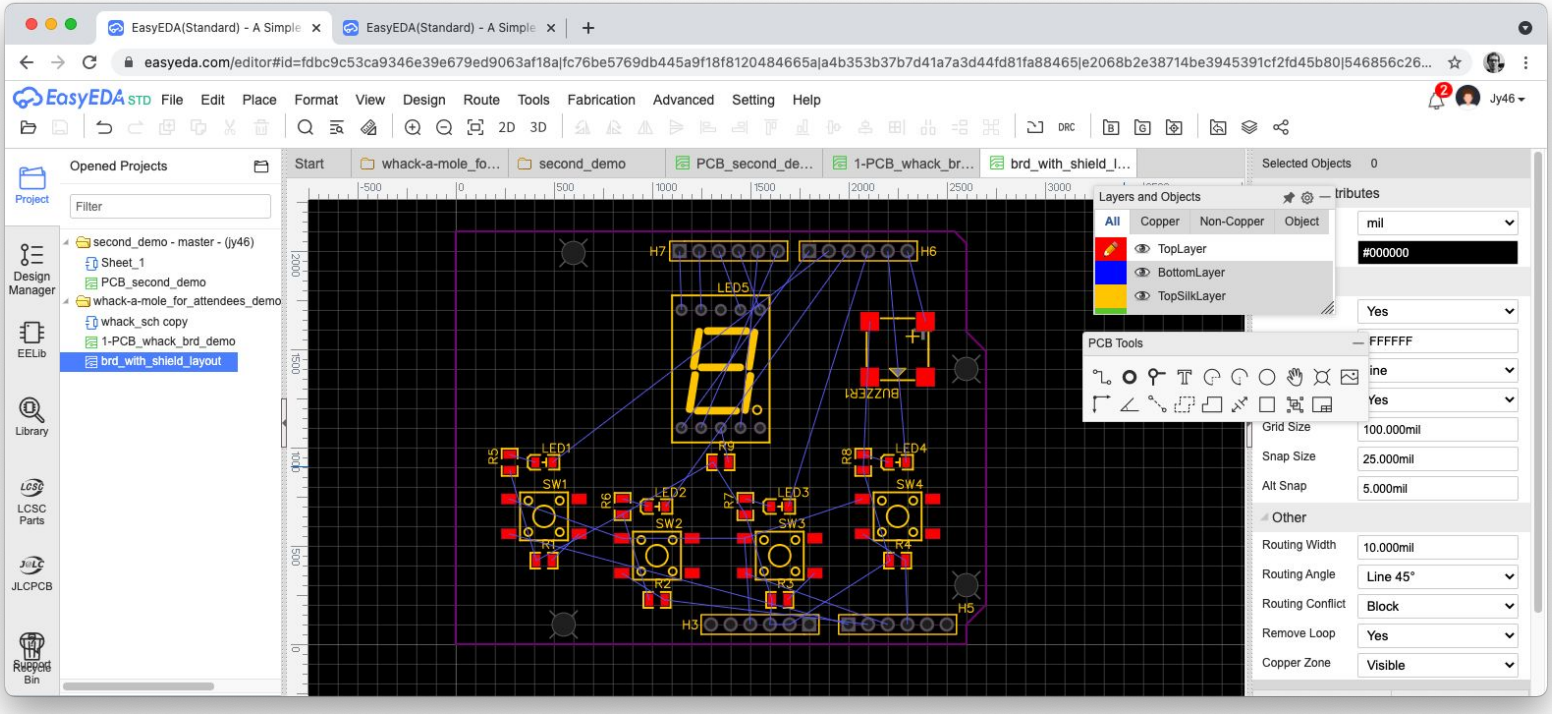
Save it in the Same Project



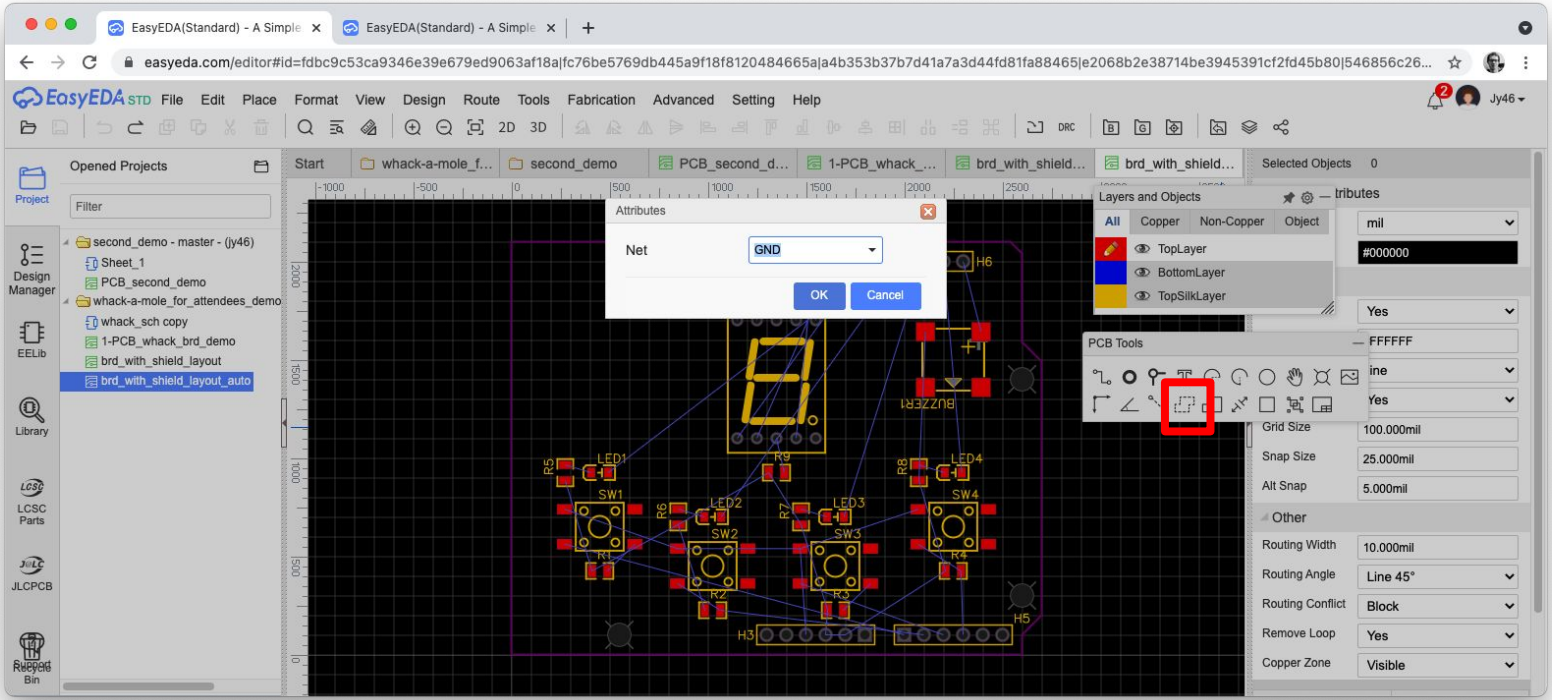
Now Move Components Onto the Board



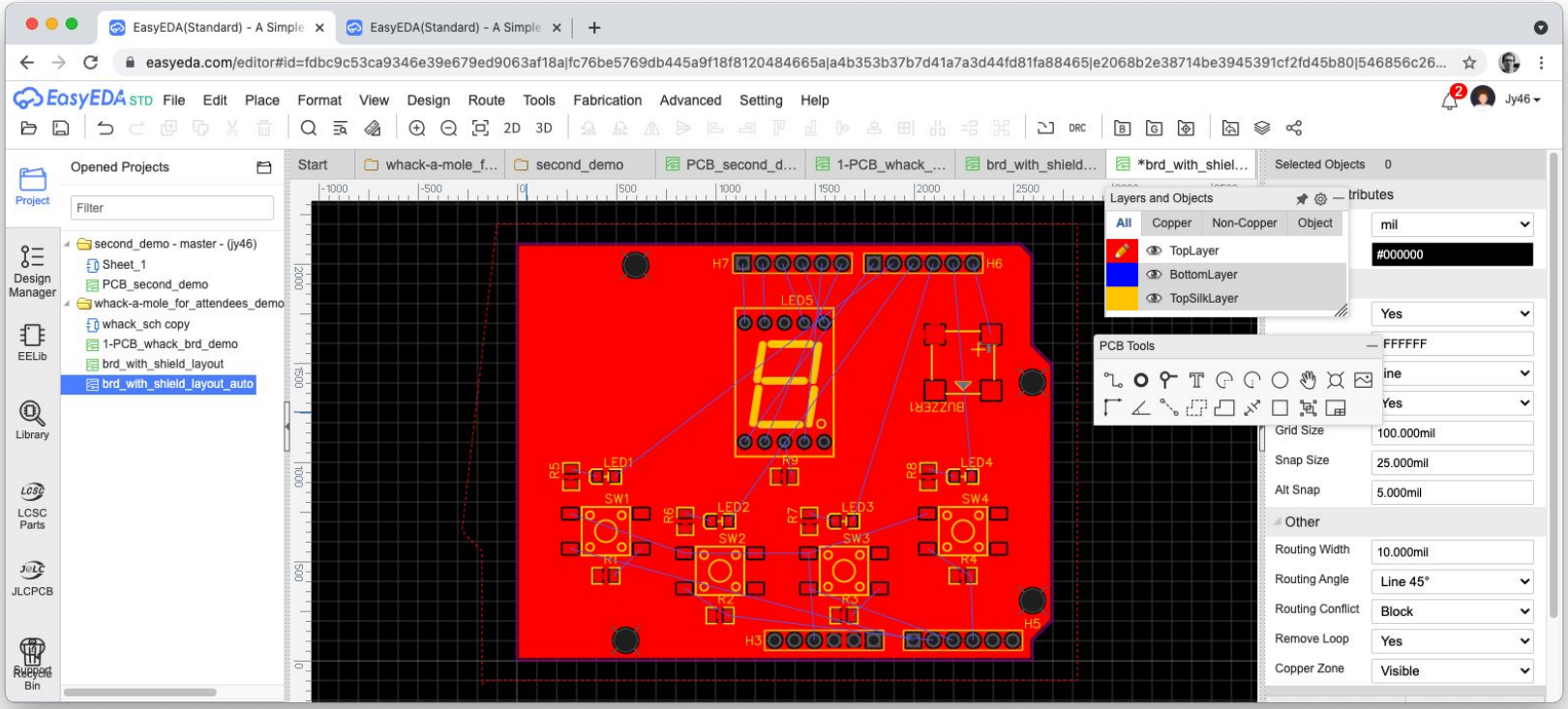
Move Components Around to Get a Design You Like



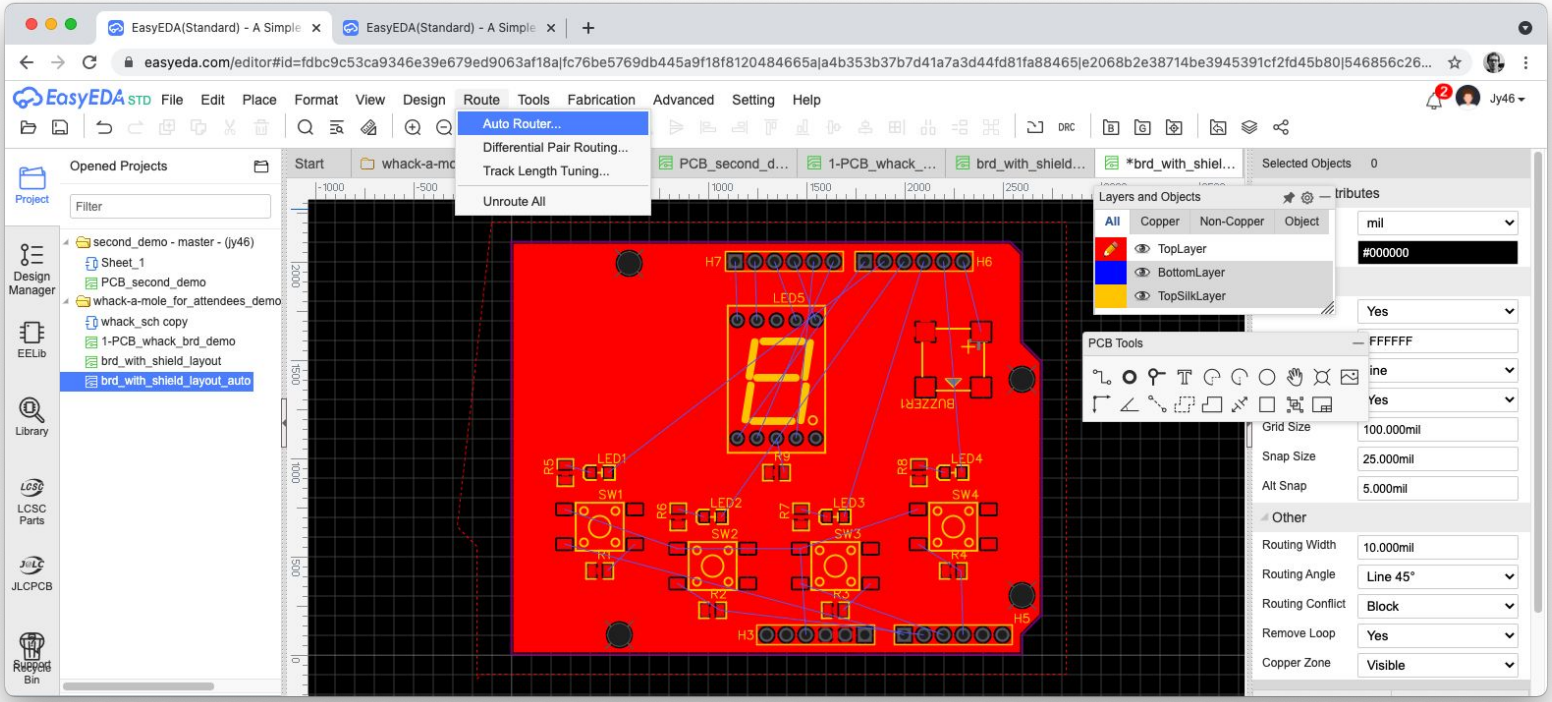
Copper Pour for GND



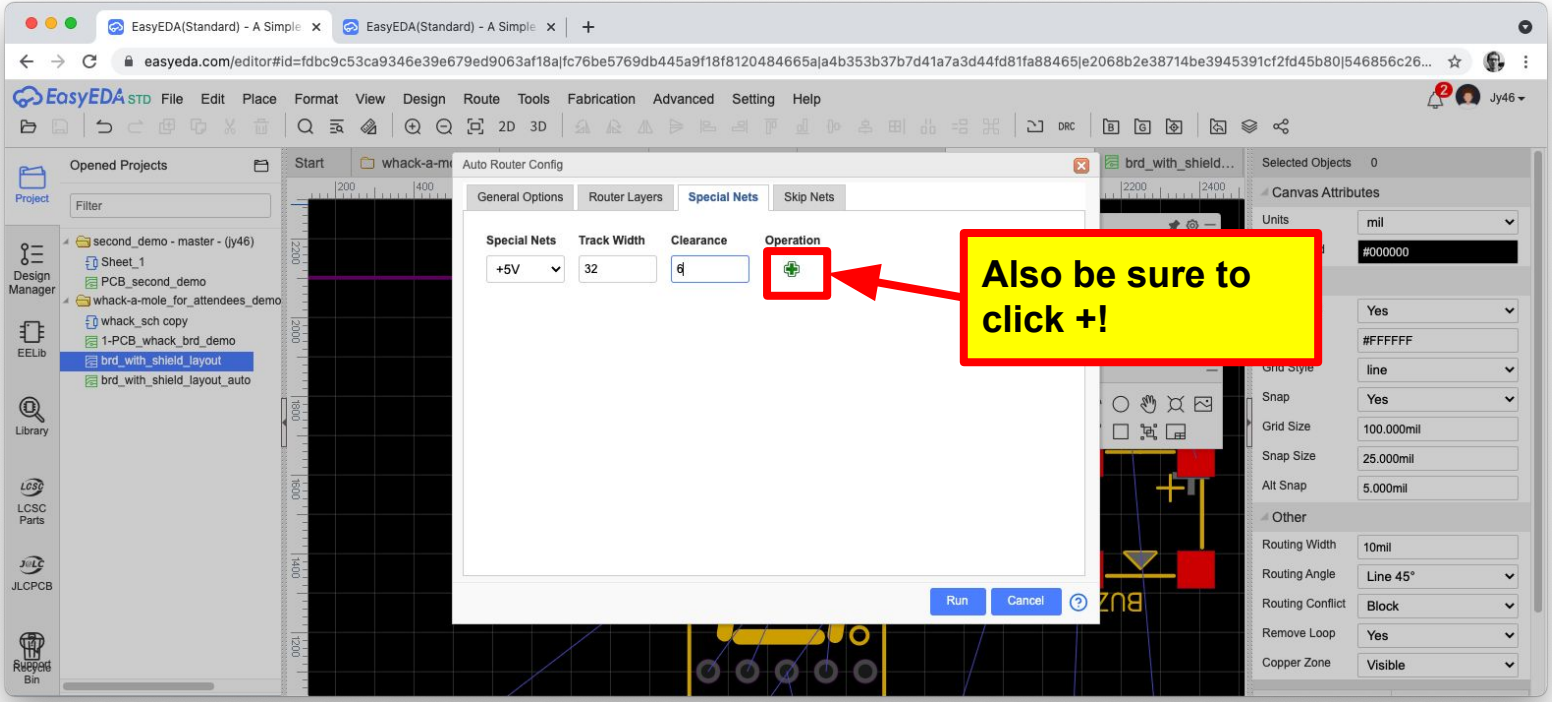
Copper Pour for GND



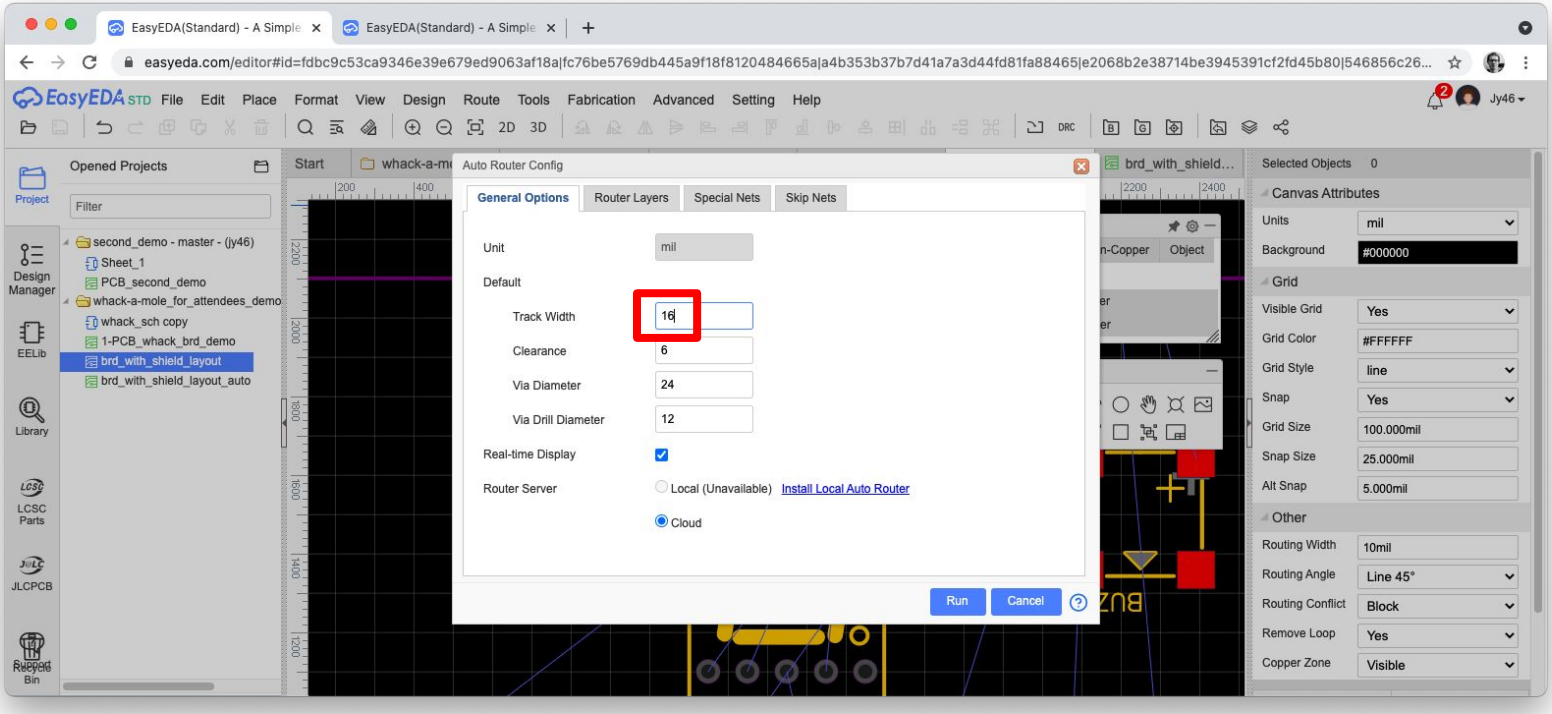
Then Could Just Auto Route



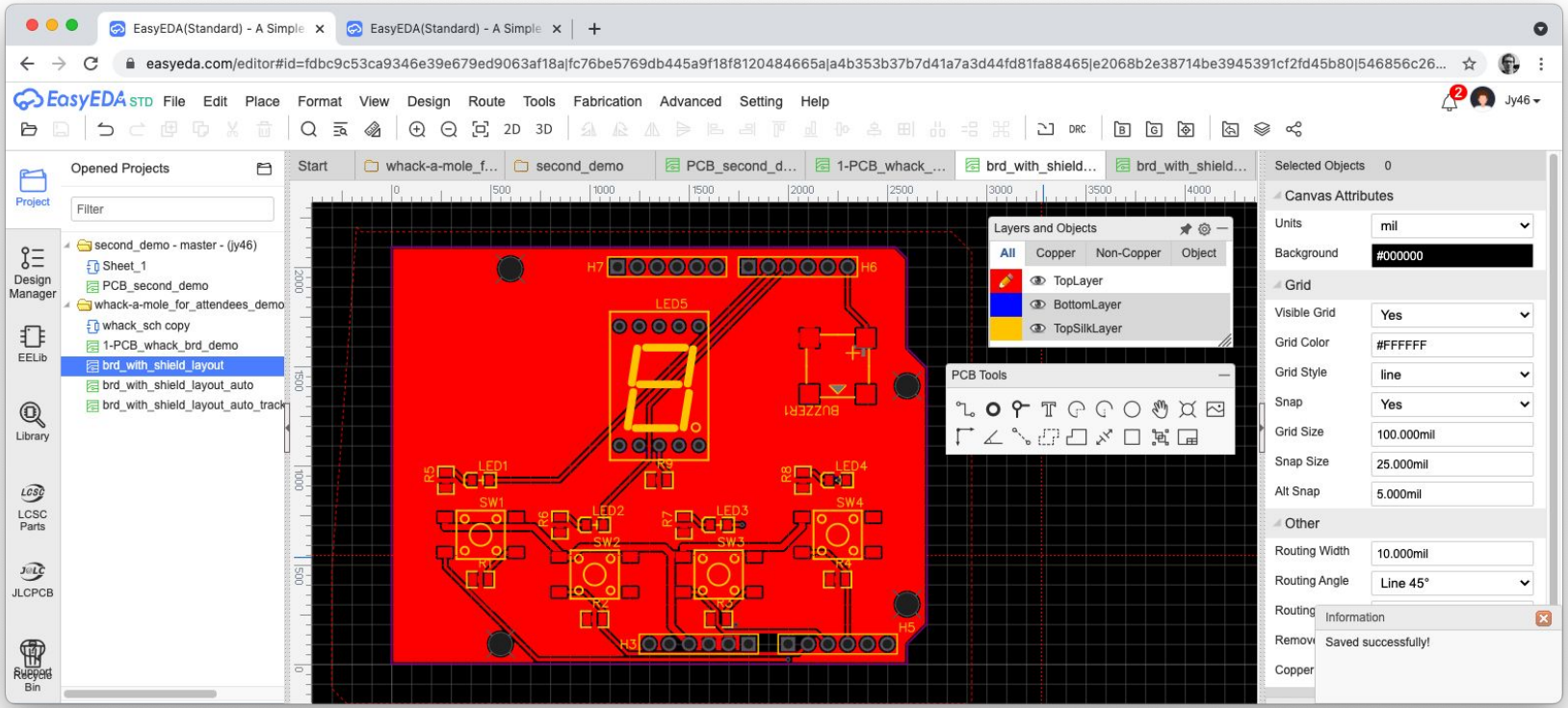
Make Sure +5 V Net is Wider: 32 mil



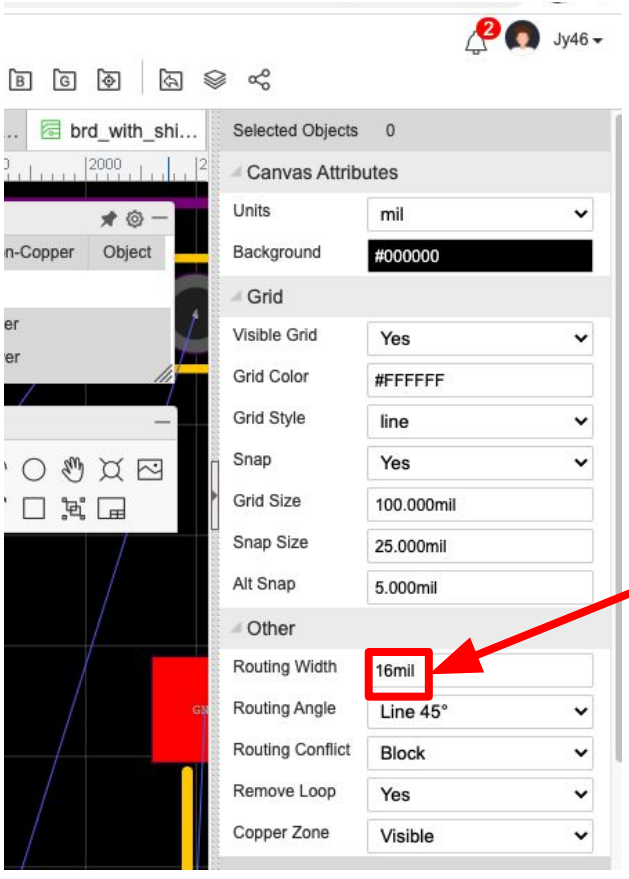
Set Other Track Widths to 16 mil



Auto Routing Result

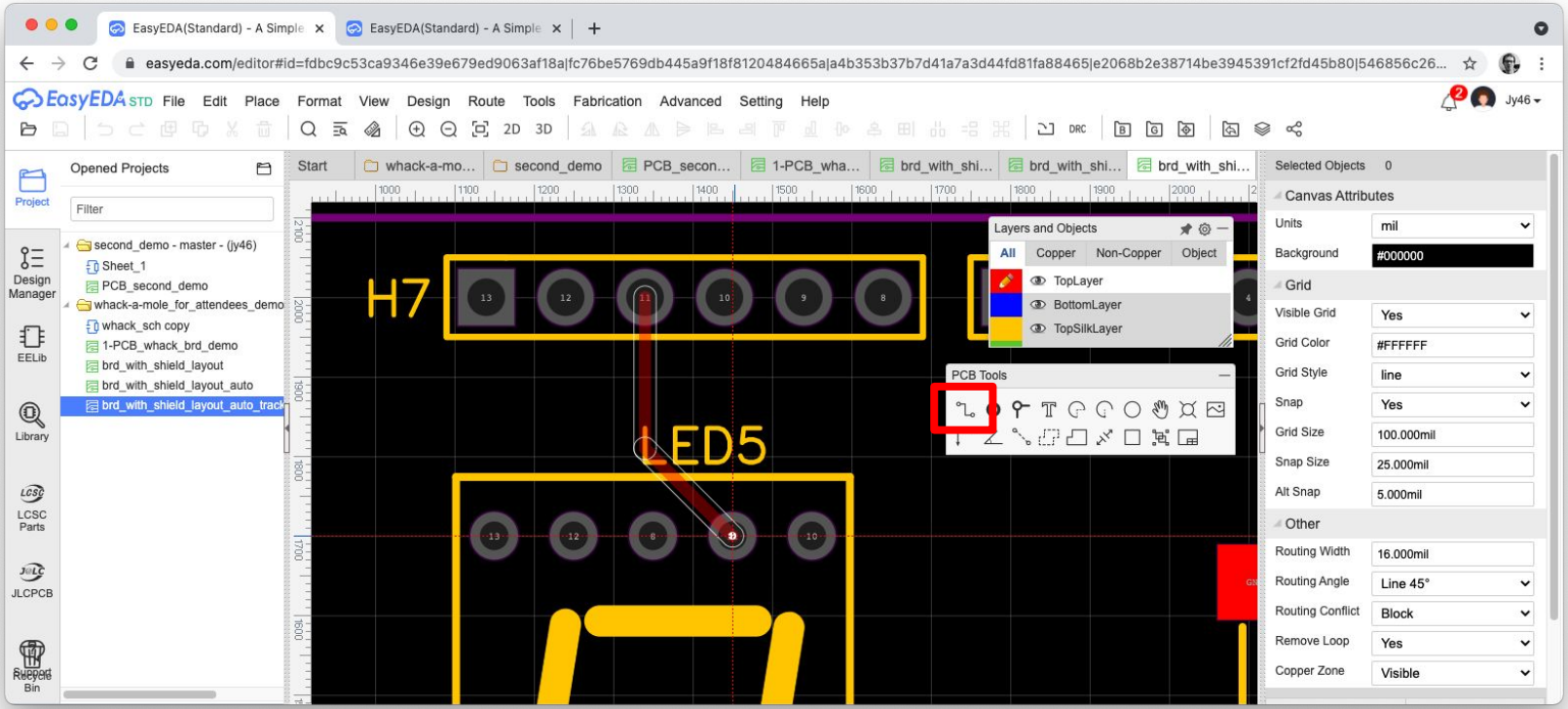


Final Comment: Can do manual routing instead

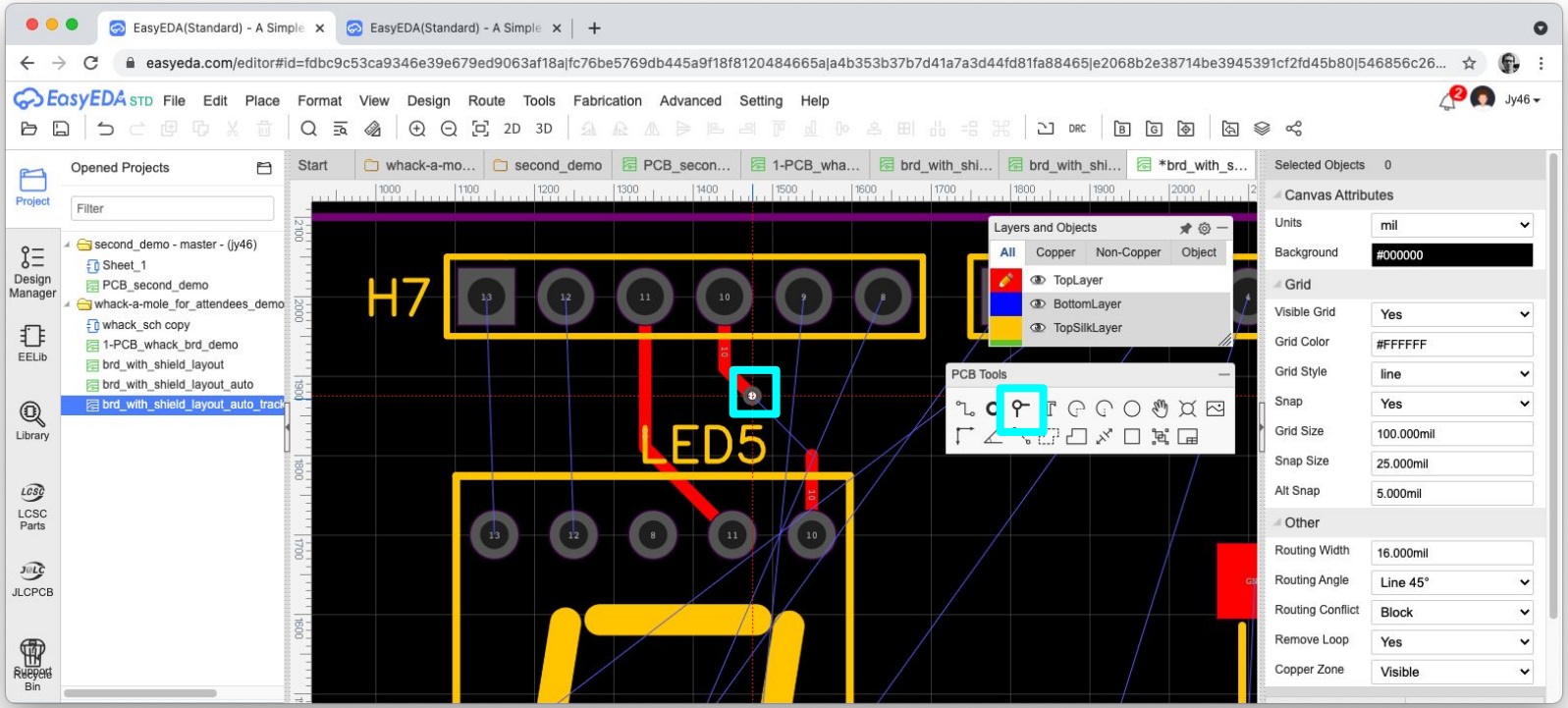


Be sure to set routing width appropriately

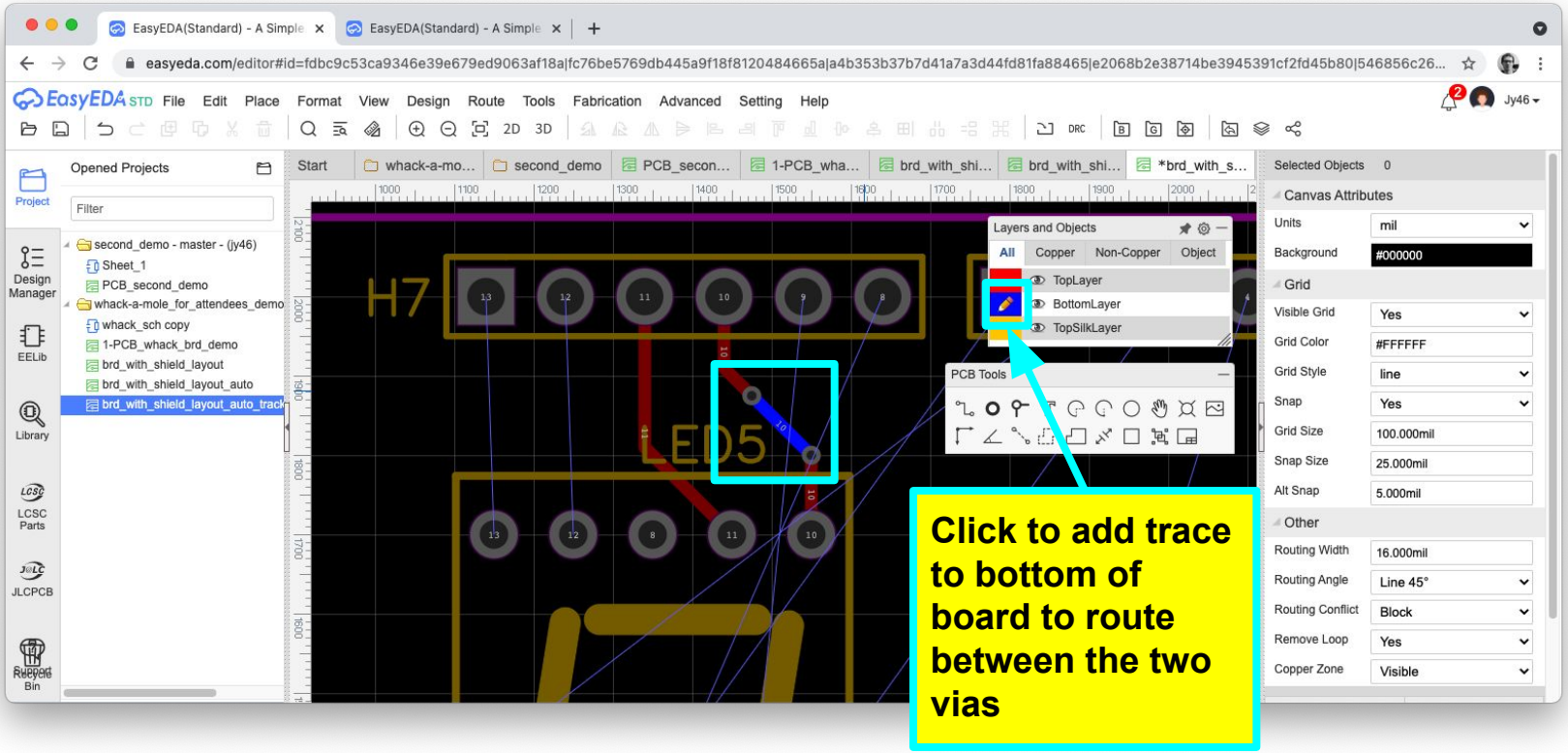
Final Comment 1: Can do manual routing instead



Final Comment 2: Can do manual via placement



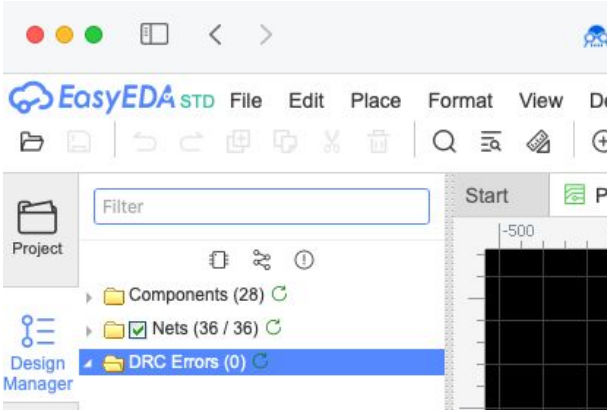
Final Comment 2: Can do manual via placement

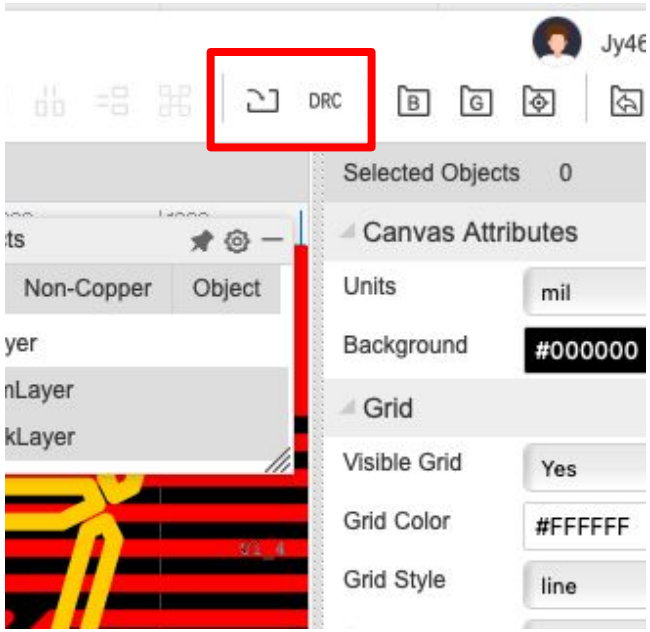


Design Rules Check (DRC)

Perform design rules check (DRC)

- Can the fab make the PCB?
- Space between traces
- Keep out zones for components
- Space from edges



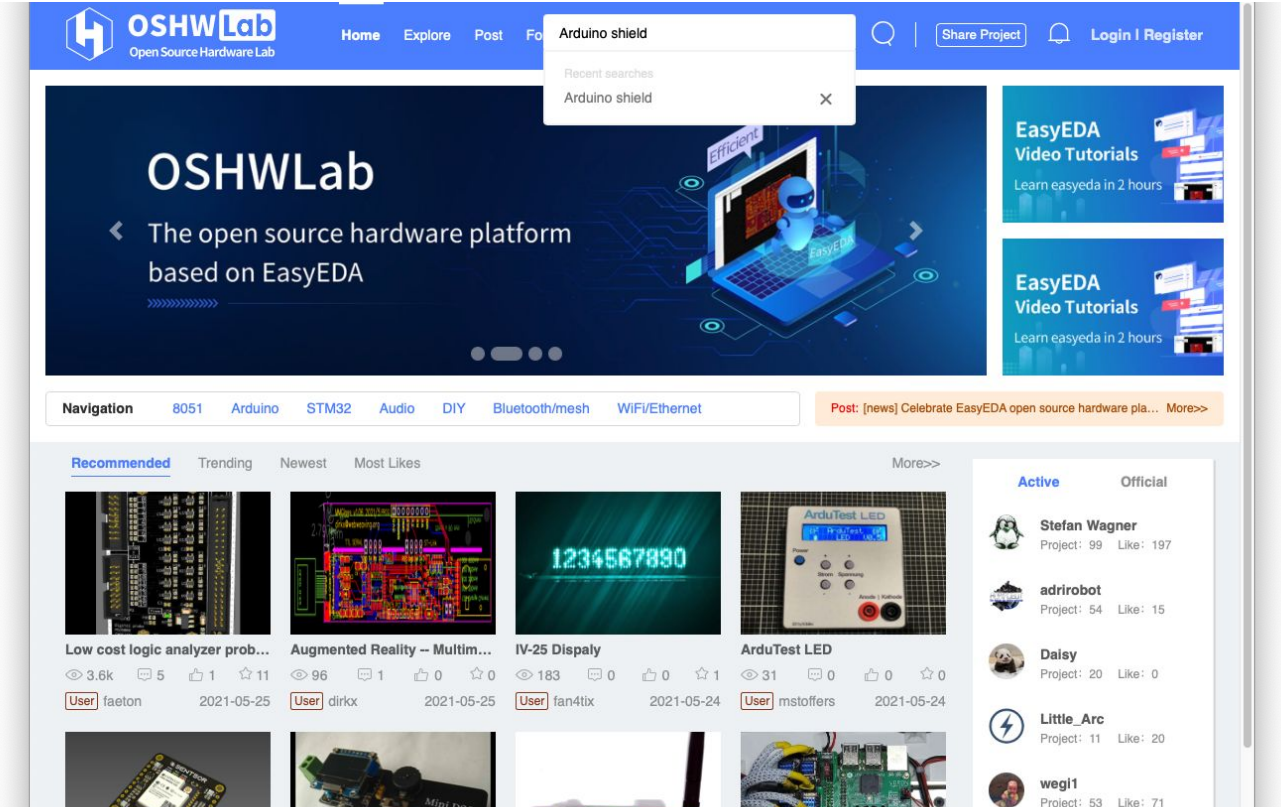


Feedback & Scheduling Follow-up

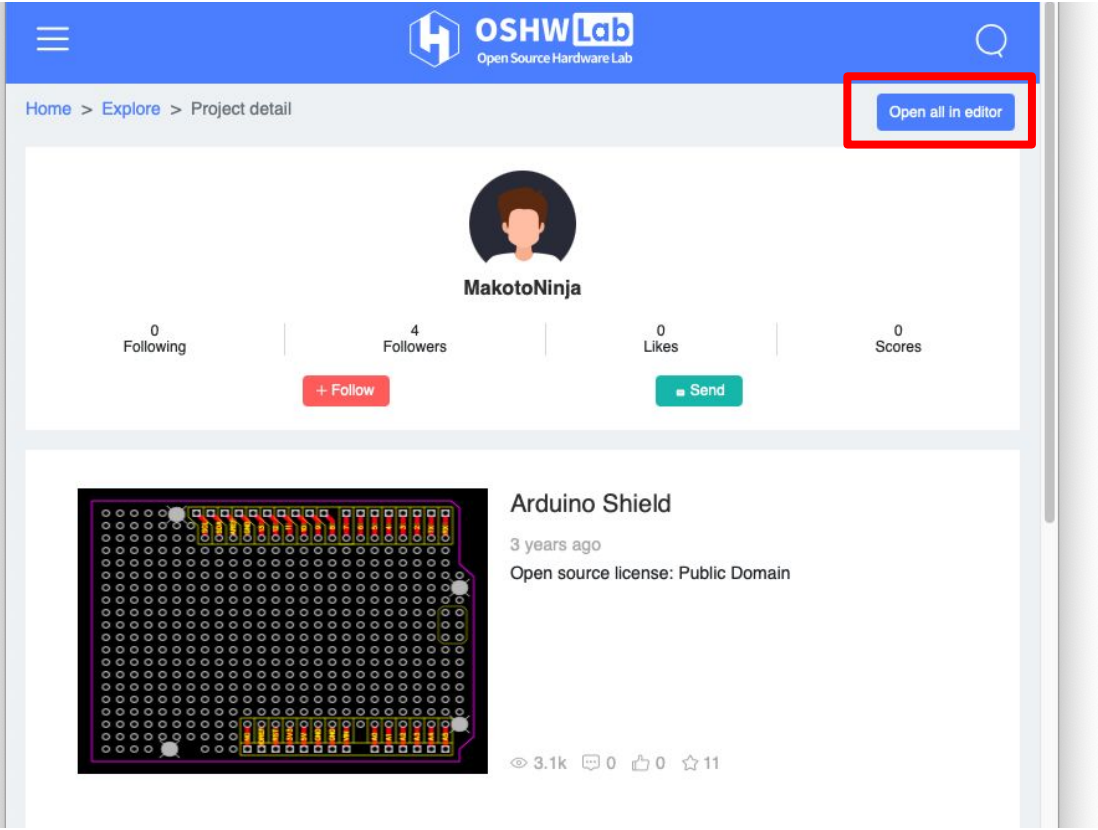
Please spend a few minutes providing feedback on your experience today using this form

Email me now or later at jy46@rice.edu if you want to schedule a follow-up

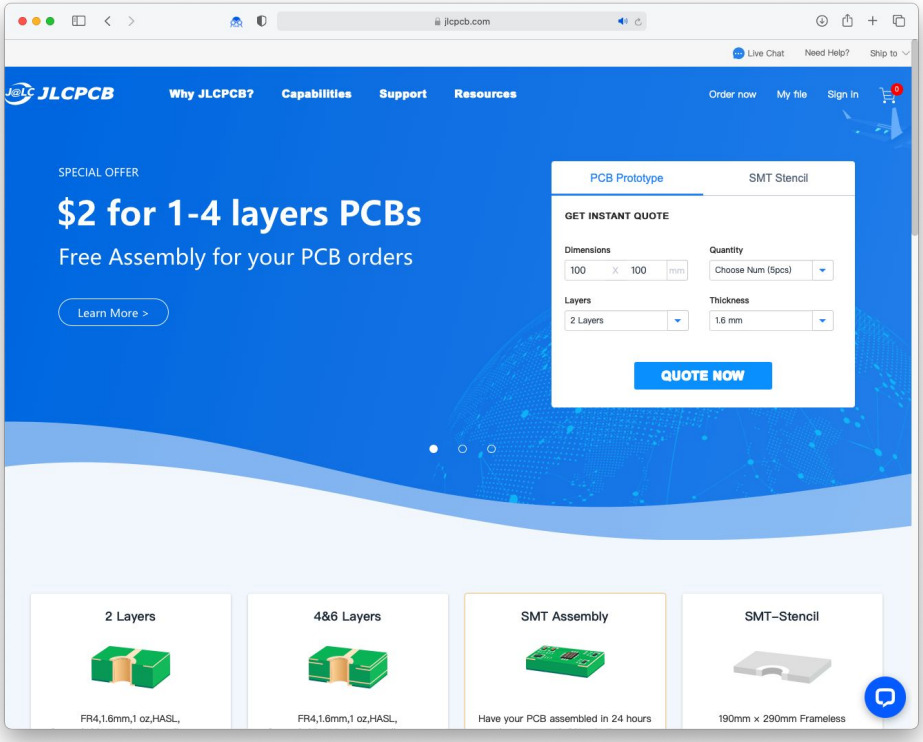
Start with a Design from OSHWLab: https://oshwlab.com



Arduino Shield: https://oshwlab.com/MakotoNinja/arduino-shield



Manufacture: JLCPCB - https://jlcpcb.com

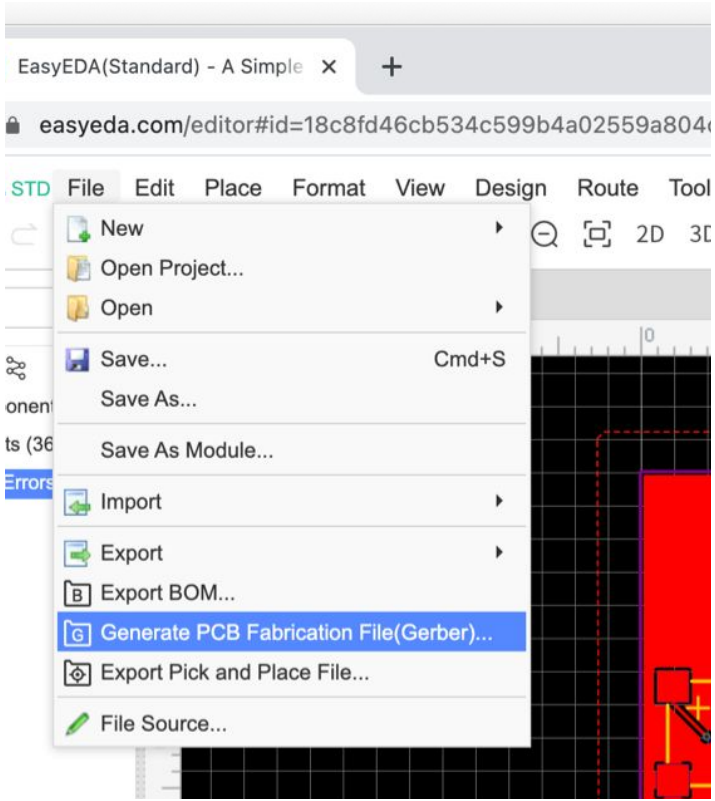


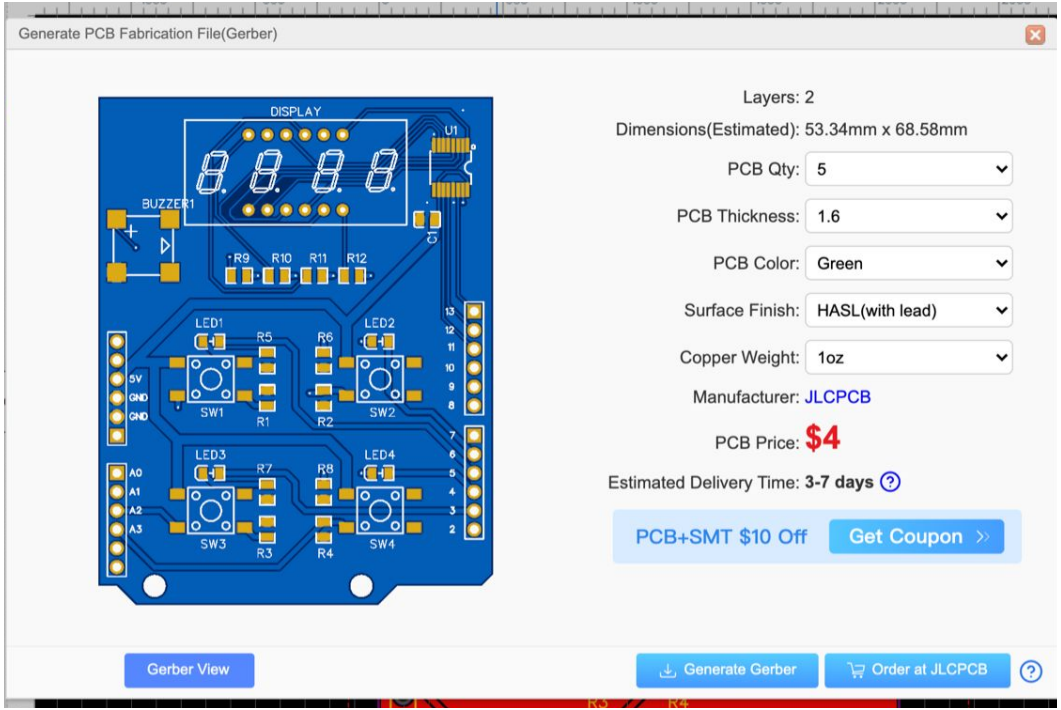
Low cost

Integrated with EasyEDA

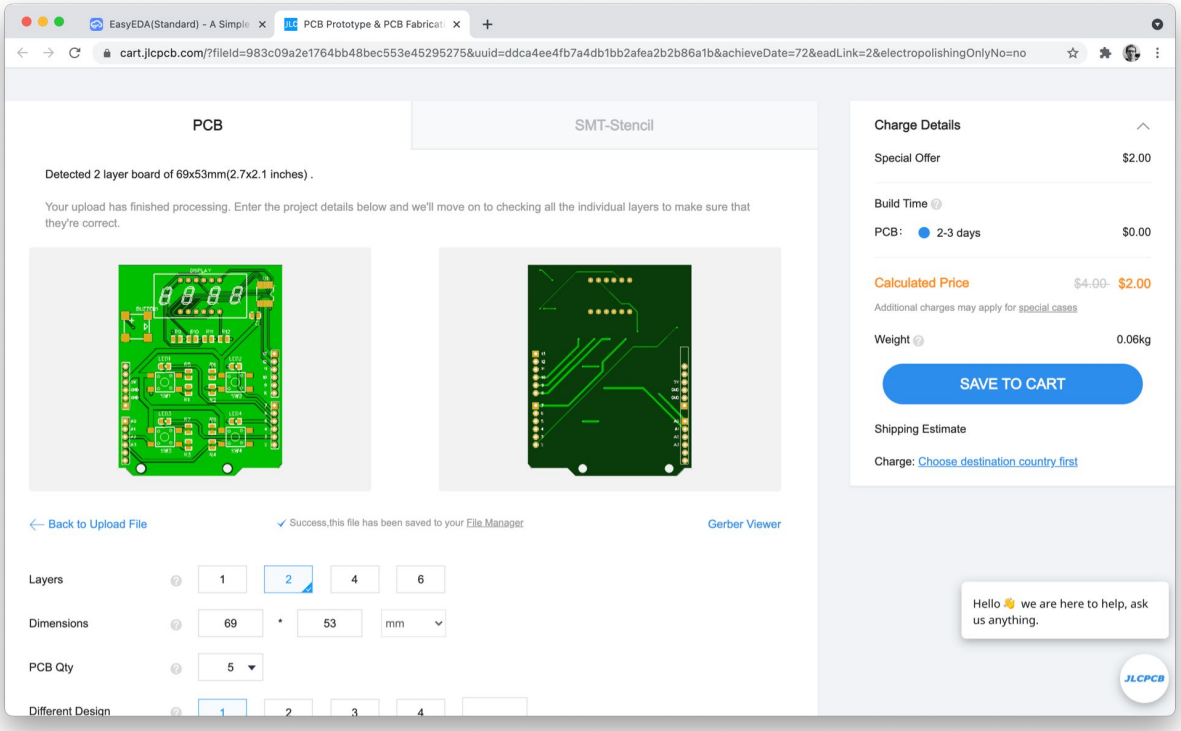
Can pay for assembly

Ordering: Start with generating Gerber files

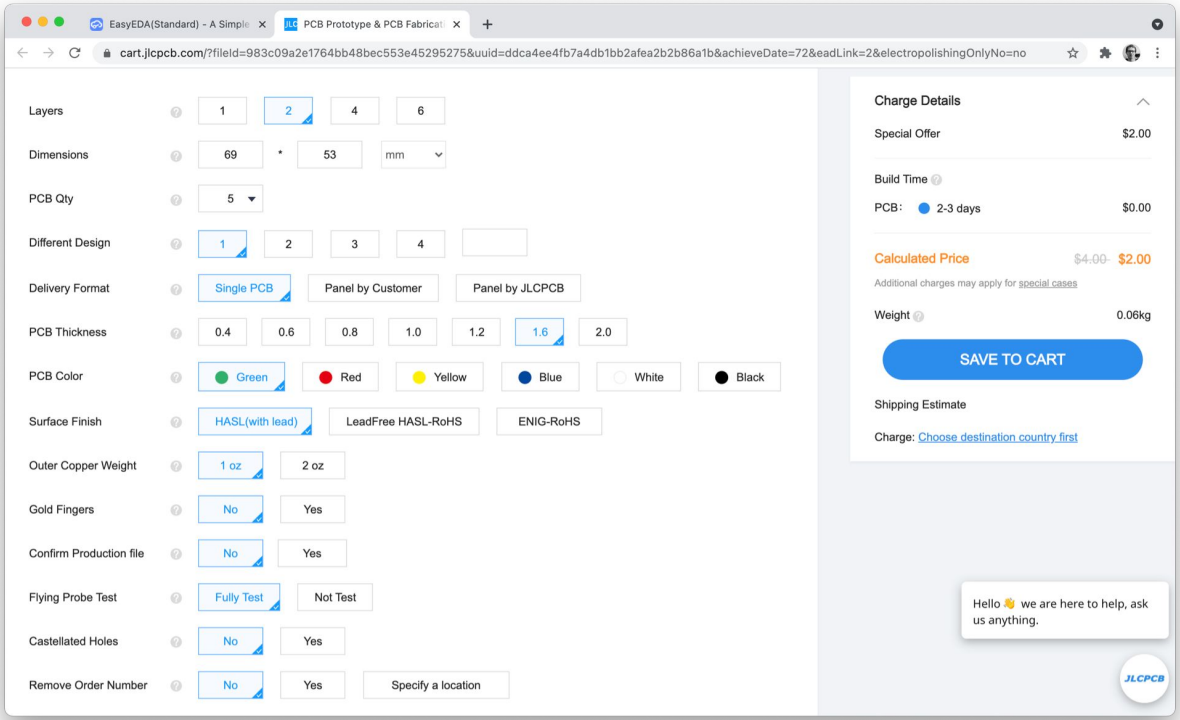




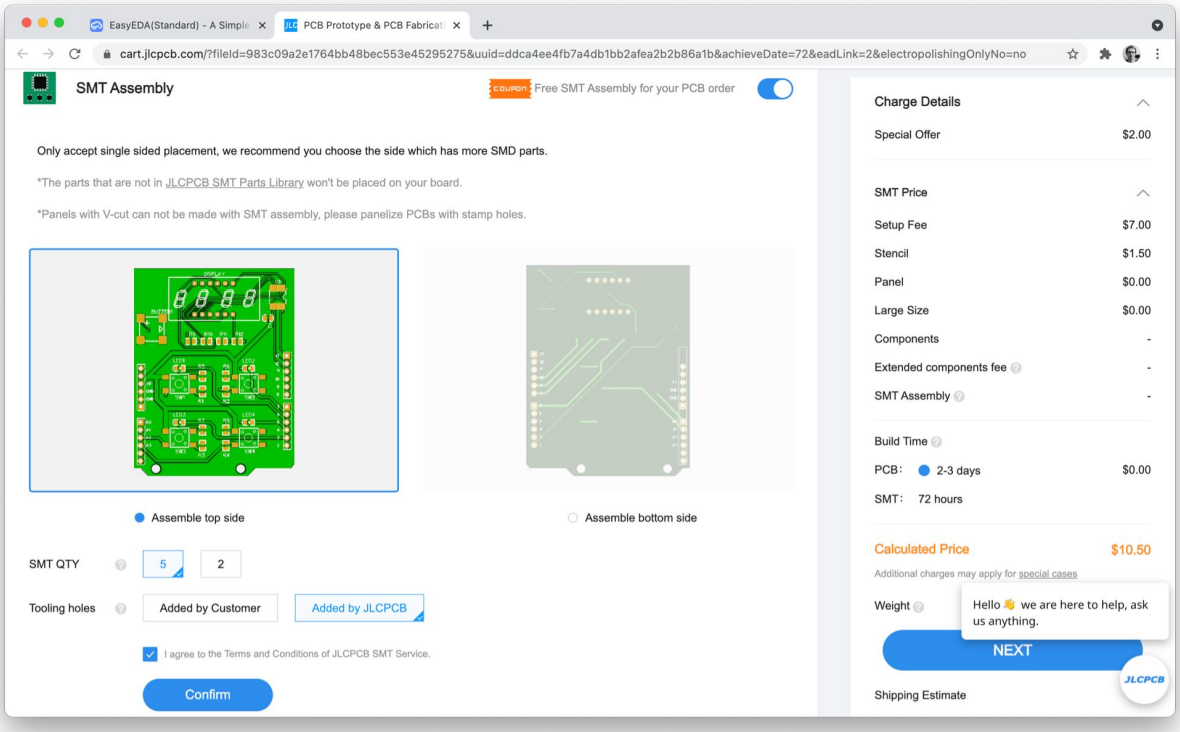
Ordering: JLCPCB site



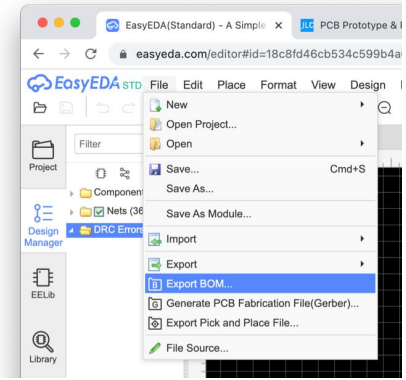
Ordering: Options

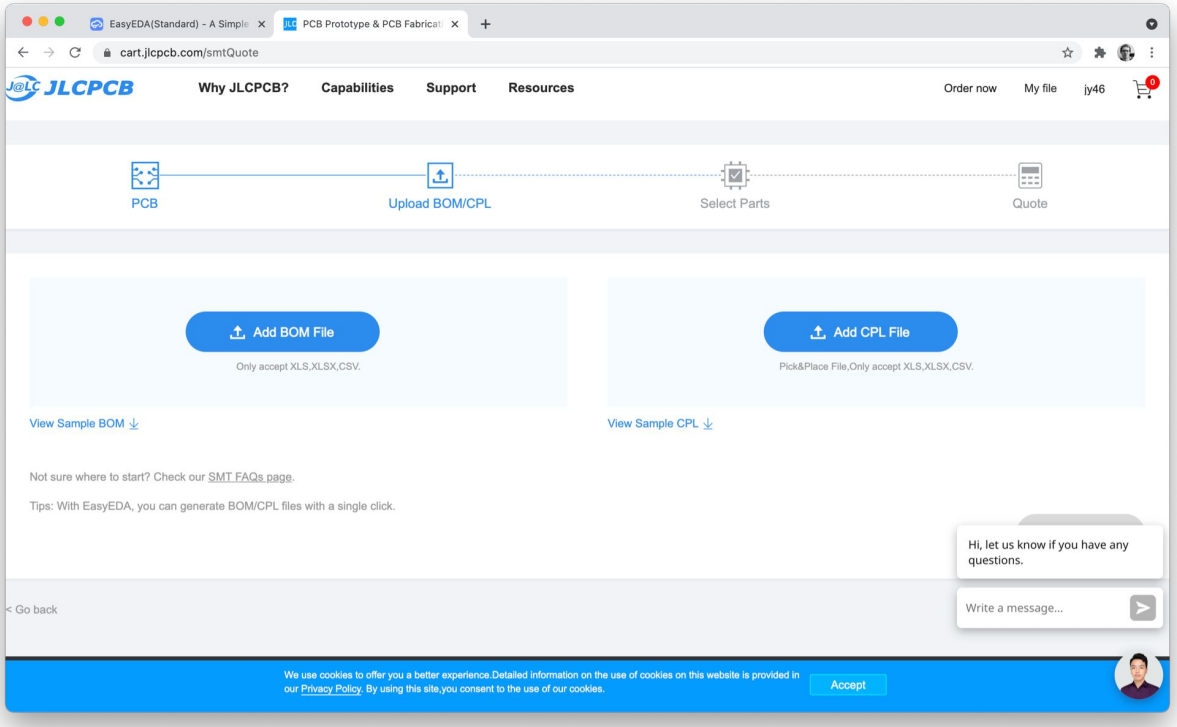


Ordering: SMT Assembly

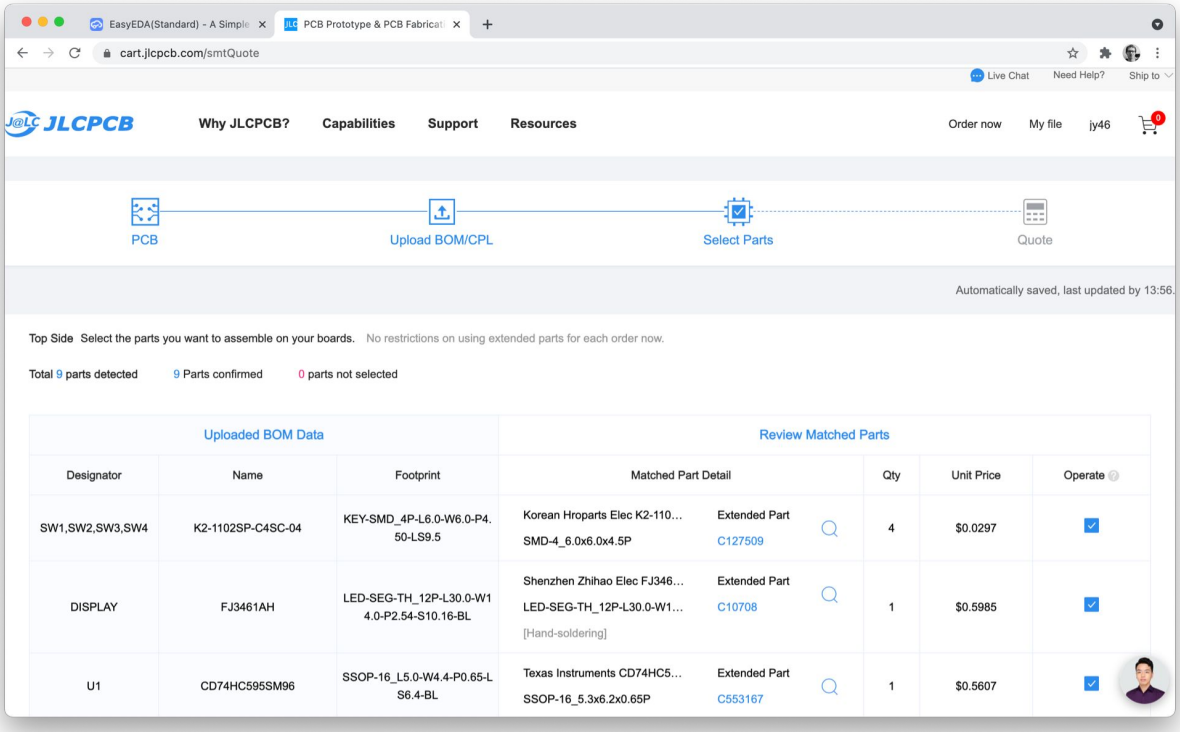


Ordering: Uploading Other Files

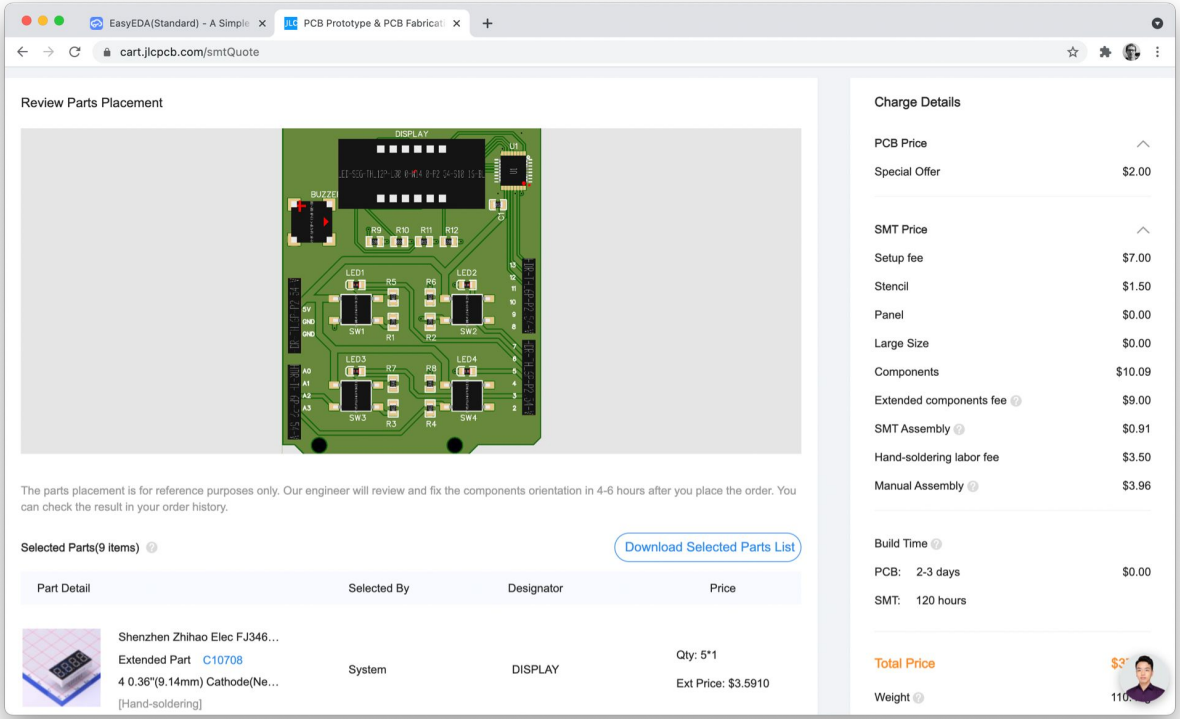




Ordering: JLC recognizes parts



Ordering: Parts Placement



Ordering: Checkout