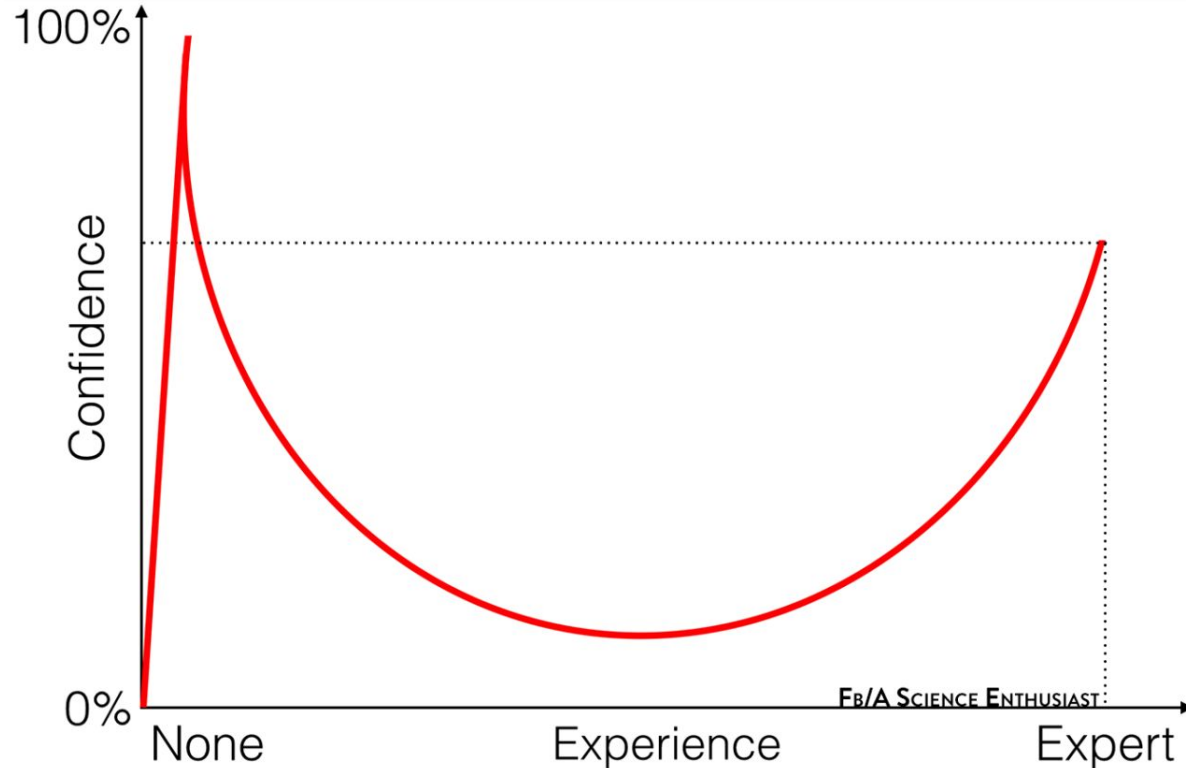


# I don't know what I'm doing

- I have no EE training
- Everything I've done with PCBs comes from:
  - Talking to people who know more
  - Books
  - Youtube videos
  - Doing it wrong
  - Getting lucky

# THE FIRST RULE OF DUNNING-KRUGER CLUB IS



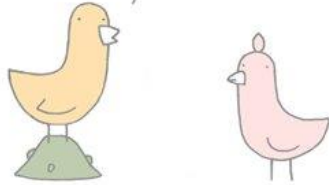
**YOU DO NOT KNOW YOU'RE IN  
DUNNING-KRUGER CLUB**

# Keep it simple

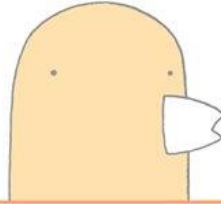
- Keep it as simple as possible
- Plenty of time to get fancy on future projects
- Nothing wrong with doing a thing, and doing it well

## Trash Bird

I have a simple problem.



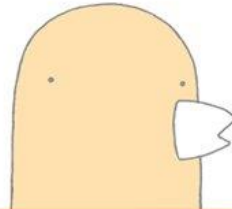
Should I make it complicated?



Is there another option?



I guess I could make it *extremely* complicated.



True.

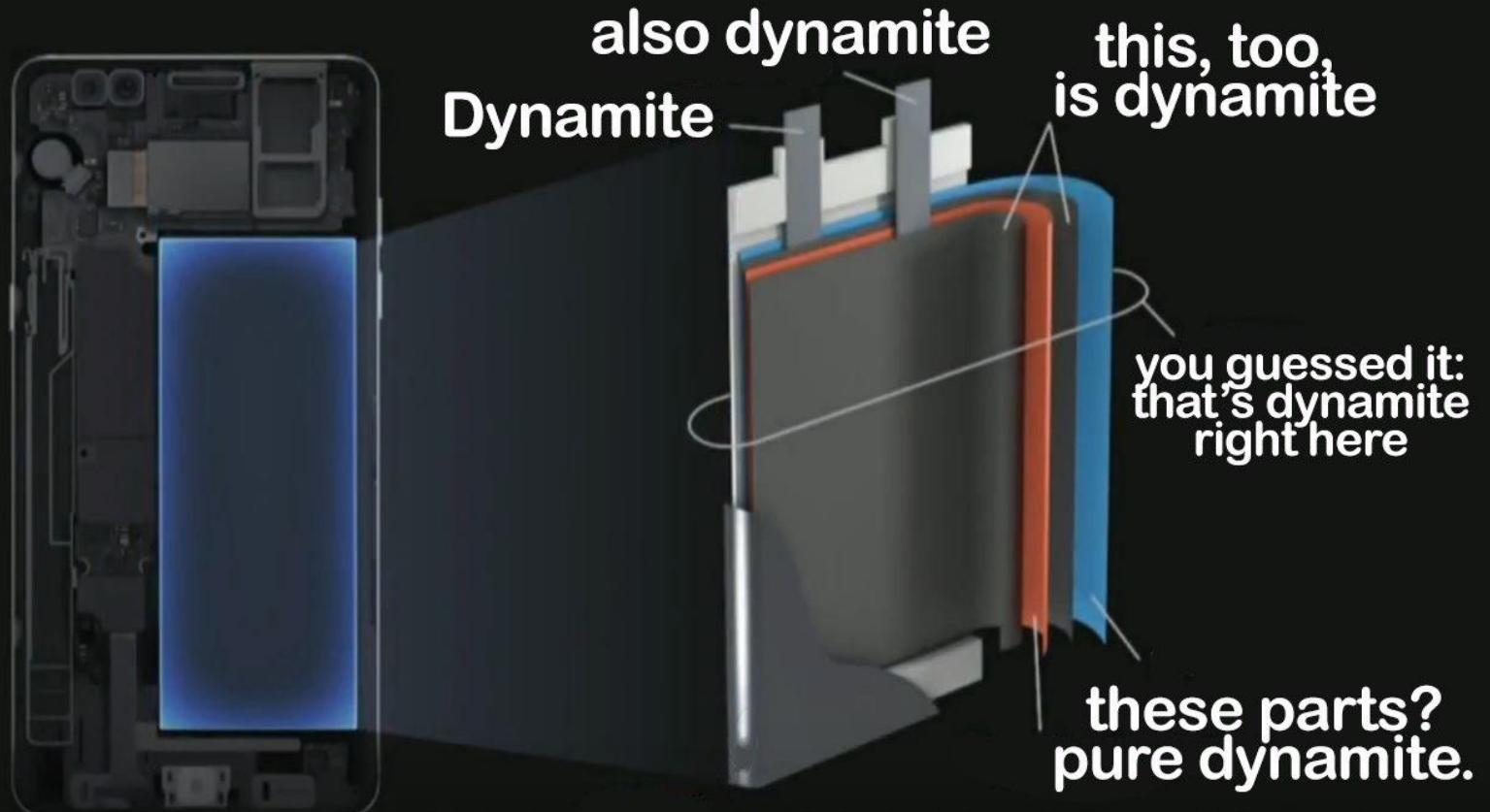
# Failure will happen

- I'm not going to tell you it's a learning experience - I *hate* that phrase
- But...
- It's probably going to fail at least once
- Don't make your first project something:
  - You can't afford to replace
  - You have a strict timeline on
  - The most complex thing you can imagine

# Things to have a healthy fear of

- Line voltage (110V/220V)
- Battery charging
- Batteries in general

# Lithium-ion Battery Structure



# Look for existing hardware

- Look for existing solutions
- Look for existing *partial* solutions, too
- Many sites (sparkfun, adafruit, etc) publish schematics and PCBs of their modules
- Need to build something that combines several existing OSHW projects? Look for how each is built already!
- Open licenses + giving credit for what you use & there's 100s of designs out there to copy^H^H model on

# Modules are awesome

- Modules make complexity Someone Else's Problem
- Large scale - arduino, rpi
- Smaller scale - LIPO charging module
- RF modules can be a godsend
- Modules can add safety - offload dangerous finicky operations to known designs
- ESP8266, LORA, XBee all good examples of modules that abstract the very difficult RF stuff

# Downsides of modules

- Modules will ALWAYS be more expensive than components
- Manufacturers & fabs often hate modules because they can't be easily machine assembled
- Sometimes, unavoidable and still worth it - ESP8266 for instance... but even the ESP comes as a chip if you design the rest around it
- Not machine assembling? You don't care!



# Prototype vs DFM

- You can get away with *anything* for prototype quantities
- < 50 boards, it's almost irrelevant what your process is
- If you expect to make boards commercially, you really need to care
- You need to talk to a manufacturer *before* you define your BOM or you're going to be redoing a lot of work, and losing a lot of money!
- Proto vs Manuf is the valley of death for many kickstarters

# Finding components

- ‘Jellybean’ components (resistors, caps, LEDs, etc) usually don’t matter much
- Otherwise, buy from somewhere trustworthy
- Digikey, Mouser, Element14 all good
- Maybe don’t go to aliexpress as your first orders, until you learn how to spot sketchy devices

# Module types and terms

- PTH - Plated Through Hole; think old electronics kits
- SMT / SMD - Surface Mount Technology, Surface Mount Device, Surface Mount Diode; modern components directly mounted to the PCB

# Parametric searching

- How do you find components?
- Parametric searching! Available on almost all the parts supply sites...
- Search by category, voltage, brand, size, number of pins, etc
- Aka... “parameters”

# The most important parameter

View Prices At: 

## Stock Status

- ☒ In Stock
- ☐ Normally Stocking
- ☐ New Products

## Media Available

- ☐ Datasheet
- ☐ Photo
- ☐ EDA / CAD Models

## Environmental

- ☐ RoHS Compliant
- ☐ Non-RoHS Compliant

Clear All Selections

Apply Filters

0 Remaining

# Look for pricing and price breaks

Description		Quantity Available ?		Unit Price USD ?		Minimum Quantity ?		Packaging		Series	
▲	▼	▲	▼	▲	▼	▲	▼	▲	▼	▲	▼
1.00MM R/A								<a href="#">Alternate Packaging</a>			
CONN FFC FPC 16POS 0.50MM R/A		27,000 - Immediate		\$0.59891		3,000		Tape & Reel (TR) ? <a href="#">Alternate Packaging</a>		<a href="#">BackFlip, Easy-On 503480</a>	
CONN FFC FPC 16POS 0.50MM R/A		29,115 - Immediate		\$1.38000		1		Cut Tape (CT) ? <a href="#">Alternate Packaging</a>		<a href="#">BackFlip, Easy-On 503480</a>	

# Pricing and price breaks

- Look for the price breakdown for components
- Some components - especially jellybean passives - can have significant price breaks
- Sometimes it's cheaper to buy 10,000 than 100!
- If they don't have to send someone to touch the parts, you get them cheaper
- Be prepared to potentially buy more than you need

# Breakdown

		<a href="#">RMCF0201FT10K0TR-ND</a>  Tariff Eligible 	<a href="#">RMCF0201FT10K0</a>	<a href="#">Stackpole Electronics Inc</a>	RES 10K OHM 1% 1/20W 0201	480,000 - Immediate	\$0.00290	10,000
		<a href="#">RMCF0201FT10K0CT-ND</a>  Tariff Eligible 	<a href="#">RMCF0201FT10K0</a>	<a href="#">Stackpole Electronics Inc</a>	RES 10K OHM 1% 1/20W 0201	484,713 - Immediate	\$0.10000	1

200 resistors - \$20

10,000 resistors - \$29

# EOL

- Beware parts that are EOL!
- Sing it with me: “If you’re making a prototype, this doesn’t matter”; buy what you need and you’ll be fine.
- Think you’ll ever make this in large quantity? Never start with a part that’s EOL or marked for obsolescence!

# Lead times

- Beware lead times!
- May be weeks to *months... or more*.
- If you're trying to make a product - or fulfill a kickstarter deadline, make a badge for a con, etc...
- Sure would suck if some company came in and bought all the parts you need and you've got an 8 month wait for more
- Plan for alternatives for everything you can
- Look at lead times, quantity in stock, etc

# Manufacturing quantities

- No process is perfect
- Expect dead components, dropped components, mis-soldered components
- Your manufacturer will tell you how many extra you should order; certain extremely high value components can be marked for special care, but it will cost
- *Never* order the exact amount you need!

# Schematics and footprints

- Many vendors now supply schematics, cad footprints, and even 3d models of the parts
- Many parts sites link them directly
- Digikey has a github repo of kicad parts for popular components they sell

# Datasheets

- Vendor datasheet is the final say-so on how a part works
- Comes with pinouts, voltages, known bugs in the hardware
- Look for mechanical drawings of the part layout if you have to make your own components
- Look for things like thermal requirements, grounding requirements, etc
- Learning to read these is key!

# Pin assignments

## 1.1 Pinout - PDIP/TQFP/VQFN/QFN/MLF for ATmega164A/164PA/324A/324PA/644A/644PA/1284/1284P

Figure 1-1. Pinout

(PCINT8/XCK0/T0) PB0	1	40	PA0 (ADC0/PCINT0)
(PCINT9/CLKO/T1) PB1	2	39	PA1 (ADC1/PCINT1)
(PCINT10/INT2/AIN0) PB2	3	38	PA2 (ADC2/PCINT2)
(PCINT11/OC0A/AIN1) PB3	4	37	PA3 (ADC3/PCINT3)
(PCINT12/OC0B/SS) PB4	5	36	PA4 (ADC4/PCINT4)
(PCINT13/ICP3/MOSI) PB5	6	35	PA5 (ADC5/PCINT5)
(PCINT14/OC3A/MISO) PB6	7	34	PA6 (ADC6/PCINT6)
(PCINT15/OC3B/SCK) PB7	8	33	PA7 (ADC7/PCINT7)
RESET	9	32	AREF
VCC	10	31	GND
GND	11	30	AVCC
XTAL2	12	29	PC7 (TOSC2/PCINT23)
XTAL1	13	28	PC6 (TOSC1/PCINT22)
(PCINT24/RXD0/T3*) PD0	14	27	PC5 (TDI/PCINT21)
(PCINT25/TXD0) PD1	15	26	PC4 (TDO/PCINT20)
(PCINT26/RXD1/INT0) PD2	16	25	PC3 (TMS/PCINT19)
(PCINT27/TXD1/INT1) PD3	17	24	PC2 (TCK/PCINT18)
(PCINT28/XCK1/OC1B) PD4	18	23	PC1 (SDA/PCINT17)
(PCINT29/OC1A) PD5	19	22	PC0 (SCL/PCINT16)
(PCINT30/OC2B/ICP) PD6	20	21	PD7 (OC2A/PCINT31)

# Pin descriptions

## 2.3.4 Port B (PB7:PB0)

Port B is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port B output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port B pins that are externally pulled low will source current if the pull-up resistors are activated. The Port B pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port B also serves the functions of various special features of the ATmega164A/164PA/324A/324PA/644A/644PA/1284/1284P as listed on [page 88](#).

## 2.3.5 Port C (PC7:PC0)

Port C is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port C output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port C pins that are externally pulled low will source current if the pull-up resistors are activated. The Port C pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port C also serves the functions of the JTAG interface, along with special features of the ATmega164A/164PA/324A/324PA/644A/644PA/1284/1284P as listed on [page 91](#).

## 2.3.6 Port D (PD7:PD0)

Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port D output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port D pins that are externally pulled low will source current if the pull-up resistors are activated. The Port D pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port D also serves the functions of various special features of the ATmega164A/164PA/324A/324PA/644A/644PA/1284/1284P as listed on [page 94](#).

## 2.3.7 RESET

Reset input. A low level on this pin for longer than the minimum pulse length will generate a reset, even if the clock is not running. The minimum pulse length is given in "[System and reset characteristics](#)" on [page 334](#). Shorter pulses are not guaranteed to generate a reset.

# Active low vs active high

- What “enables” the function of a pin? A one? Or a zero?
- The bar symbol in the pin name tells you!

**$\overline{2.3.7}$     $\overline{\text{RESET}}$**

The --- means to *reset the chip* this is set to 0, so you need to pull it to 1 normally!

- We'll discuss pulling soon

# Things to look for

- Max power requirements
- Voltages - many complex chips take *many* voltages!
- Pull-up and pull-down requirements (forget to pull your reset pin and you're going to have a bad time)

# The power of skimming

---

The flat flex jumpers are terminated to Zero Insertion Force (ZIF), non-ZIF or Low Insertion Force (LIF) FFC connectors, available from Molex. Premo-Flex standard flat flex jumpers are now available in extra flexible 0.12mm cable, ideal for complex board-to-board interconnections in confined spaces.

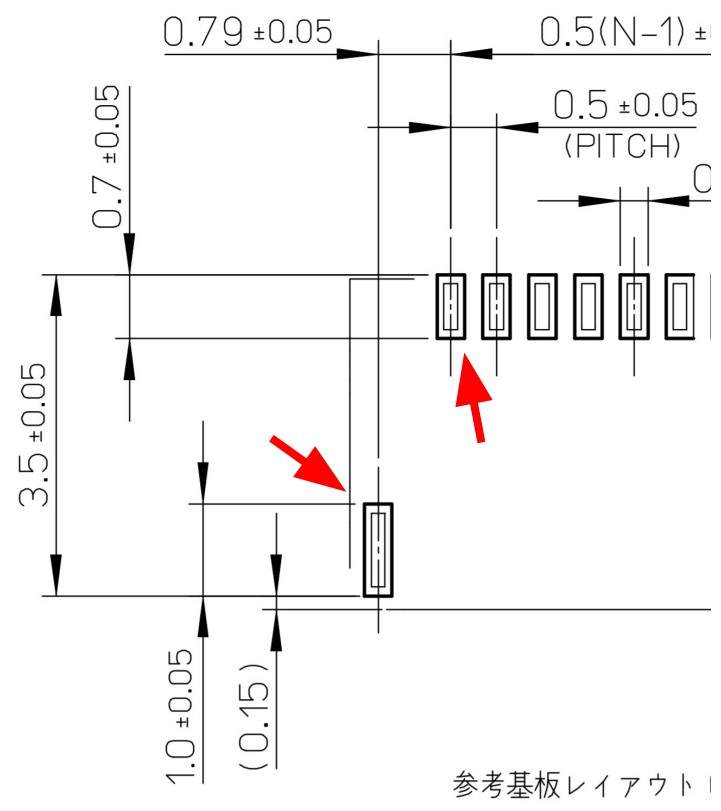
Molex offers an extensive range of FFC connectors and is able to design customized FFC connectors to customer requirements. Type A (same-side) and Type D (opposite-side) contact layouts allow for mirrored contacts in top- and bottom-mount ZIF applications. For additional information visit: [www.molex.com/product/premoflex\\_ffc-fpc.html](http://www.molex.com/product/premoflex_ffc-fpc.html)

---

# Datasheet gotchas

- Often for many sub-parts - *make sure you're looking at the part you think you're looking at*
- Check the measurement flavor (metric? imperial?)!
- **Double-check** the measurements and offsets!
- Use standard library parts whenever you can

FFFFffffff



# Picking a package

- Through-hole still a option...
- Some surface mount components are easy to solder at home
- Some are difficult
- Some are almost impossible
- Same goes for manufacturing, really - smaller components make it much harder for manufacturers, which make it more expensive for you

# come to computers



we got turn tables



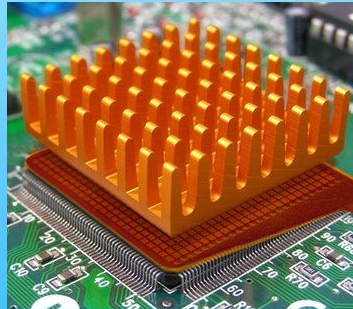
twistos



the hydra of lerna



hoverboards



pokepokepoke



cold ones

# Through-hole components

- Nothing wrong with PTH but it's getting more expensive and more rare than SMT because it's harder to make and fabricate
- Can't handle higher-frequency, because the wires act as antennas
- Fine for hobby or kit, not fine for product design

# Common passives

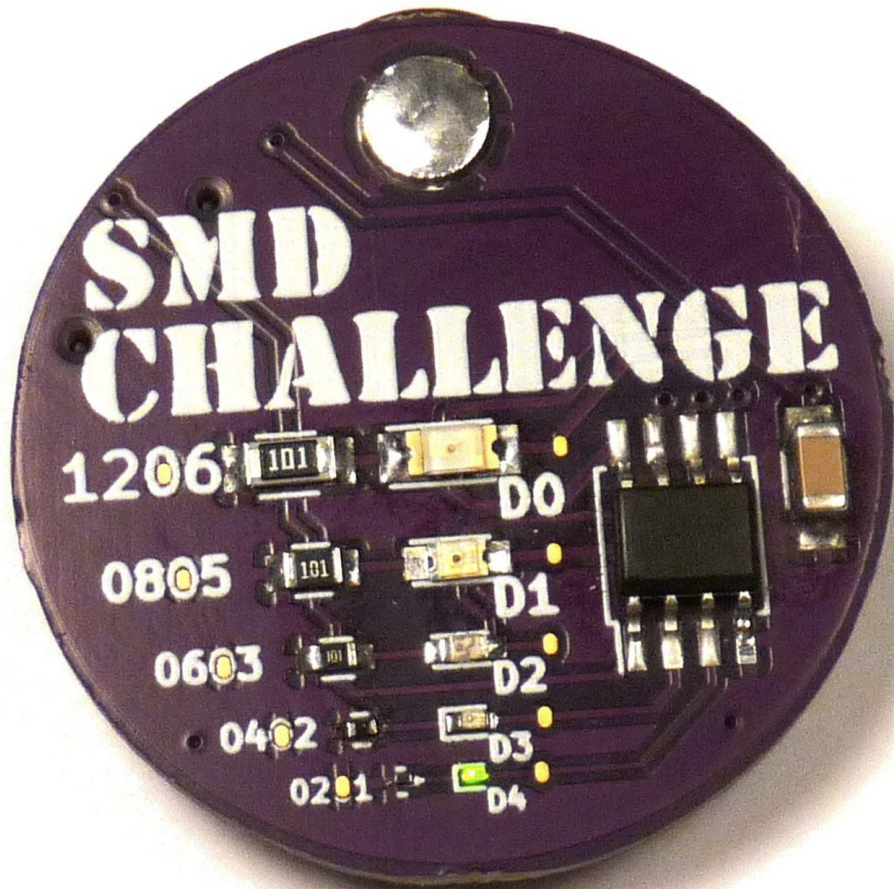
- Passives don't do computing - they're things like resistors, diodes, capacitors
- Usually come in rectangular, regularly sized packages
- Package name denotes size, like 0603 would be 0.06 by 0.03 inches
- Buuuuutttt...

# Butts.

- Wait, why was 0603 in imperial?
- Because reasons, that's why.
- 0603 is 0201 in metric.
- But 0201 is also an imperial size for an ultra ultra tiny component.
- That's embarrassing.
- *Be careful when ordering sizes!*

# Reasonable passive sizes

- Avoid anything below 0402 imperial
- 0402 is still pretty small. It would be difficult to solder by hand, but totally doable. If fabbing, make sure your fab company can handle them!
- 0603 is “standard”.
- Larger sizes are usually found only in capacitors for power systems, fuses, large resistors, but are fine, too





# 0402 vs USB and Micro USB



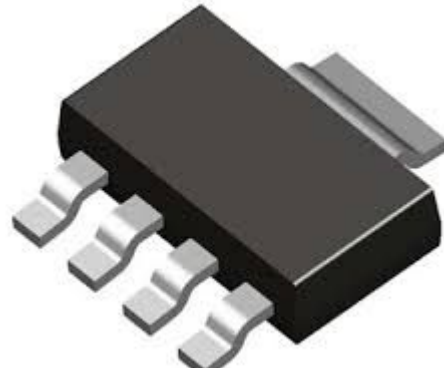
# SOIC

- Looks like the “traditional” microchip, but surface mount
- Generally easy to work with
- Be careful - there are ‘wide’ and ‘narrow’ versions!
- Fine for hand assembly and fab



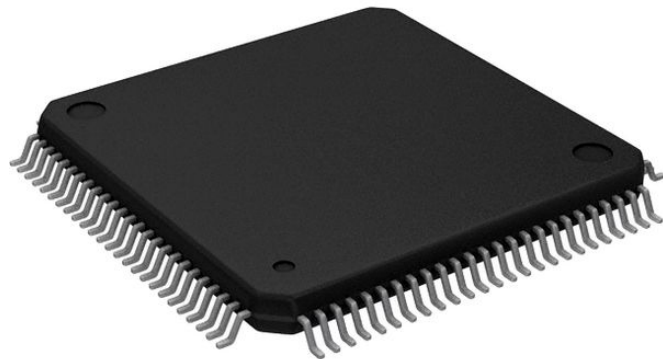
# SOT-23

- Usually found for transistors and power converters
- Fine for hand assembly and factory
- Transistors are often very sensitive to static; be kind to them!
- Often found in 3, 5, or 6 pin flavors



# QFP

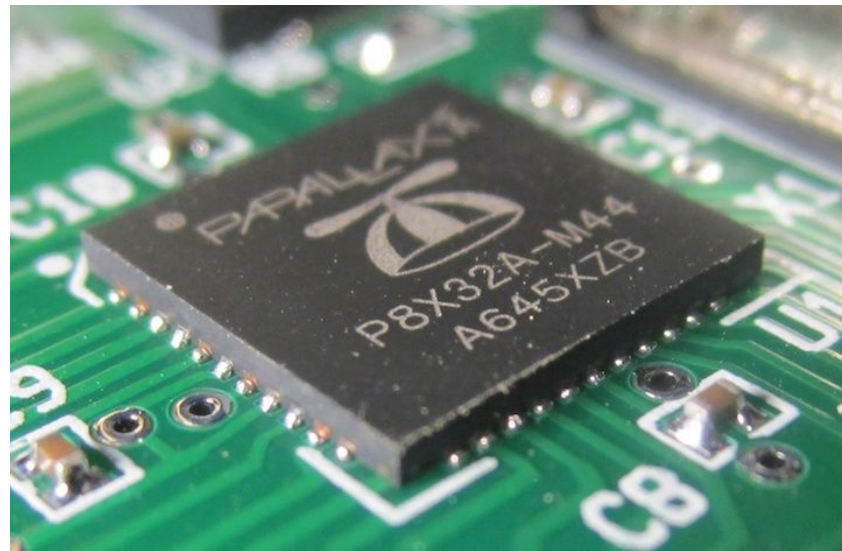
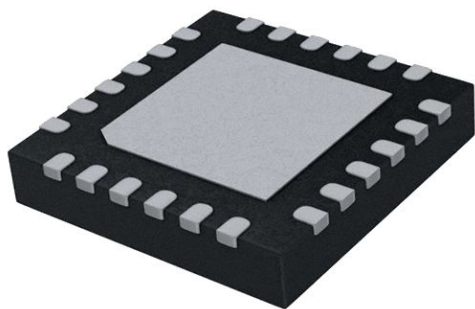
- Quad Flat Package - pins on all 4 sides of a square or rectangular chip
- Fine for home or fab assembly
- Very high pin count QFPs are a real pain though
- QFP-32? Easy! QFP-128? Less easy!



# QFN

- Quad Flat No-Lead
- Like a QFP... but no legs!
- The pins are on the *bottom*.
- This is much trickier to hand solder - you **MUST** reflow.
- Fine for fab assembly
- Becoming very common for radio and space saving

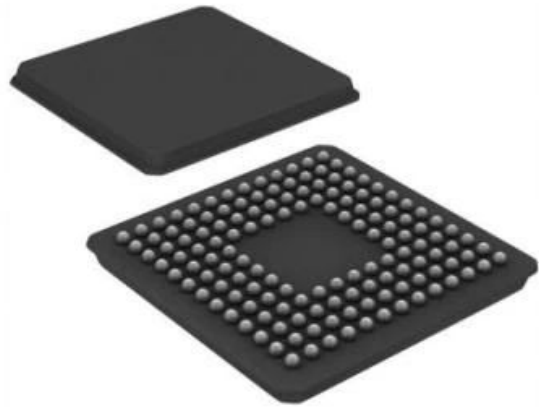
# QFN



# BGA

- Ball Grid Array
- All the connections are under the chip
- Must be reflowed
- In general, avoid if you can
- Very hard to be sure you got it right
- Very easy to exceed the capabilities of your board fab or your assembly house
- Often inspected via x-ray to make sure they soldered properly

# BGA



# Application circuits / application notes

- Suggested layout and schematics for a part
- Often part of the datasheet or an additional document from the manufacturer
- Shows the exact passives you need to use complex chips
- Often shows gotchas and pitfalls
- Always look for an example application circuit!

## Browse Application Notes

### Show results for

- All Application Notes
- + 8-bit MCU
- + 16-bit MCU & DSC
- + 32-bit MCU
- + Algorithms (Building Blocks)
- + Analog Simulation
- + ARCNET-CircLink® Controllers
- + Audio & Speech
- + Automotive
- + Battery Management
- + Consumer
- + Display
- + Ethernet Devices
- + Functional Enablement
- + General Purpose
- + Home Appliance
- + Lighting
- + Linear Devices
- + Low Power
- + Medical

## App notes cont'd

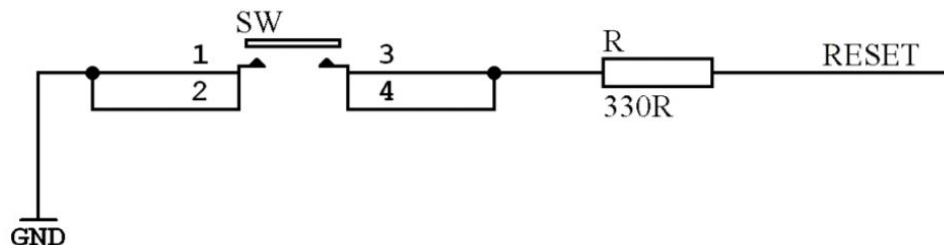
- Quality varies by manufacturer
- Most are pretty excellent
- Some provide schematic of complete system, some provide schematics of individual portions

### 3.1 External RESET Switch

If an external switch is connected to the RESET pin, it is important to add a series resistance. Whenever the switch is pressed it will short the capacitor, and the current (**I**) through the switch can have high peak values. This causes the switch to bounce and generate steep spikes in 2ms - 10ms (**t**) periods until the capacitor is discharged. The PCB tracks and the switch metal introduces a small inductance (**L**) and the high current through these tracks can generate high voltages up to  $V_L = L * di/dt$ .

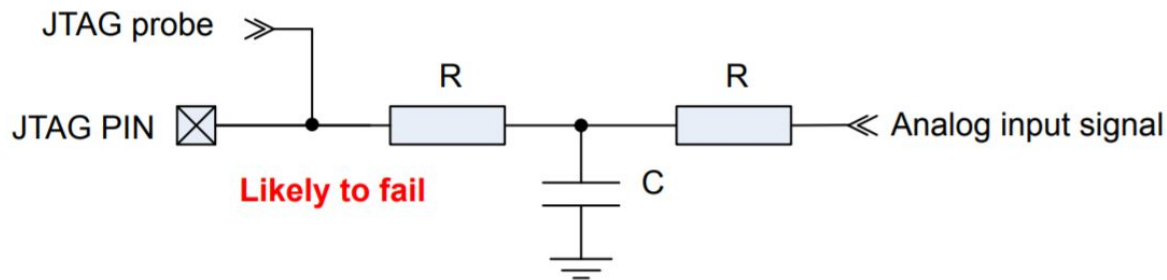
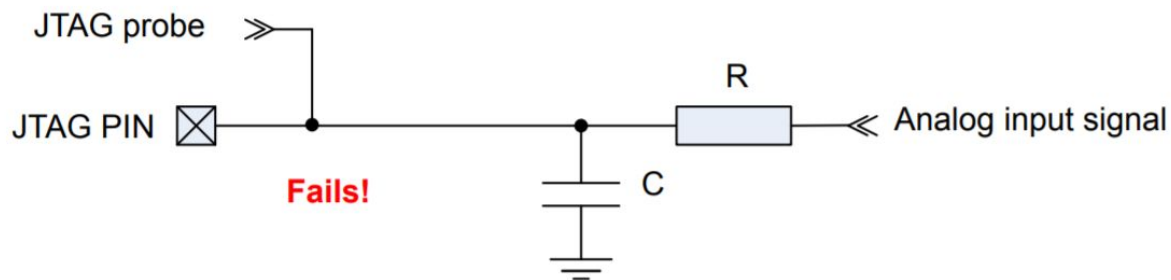
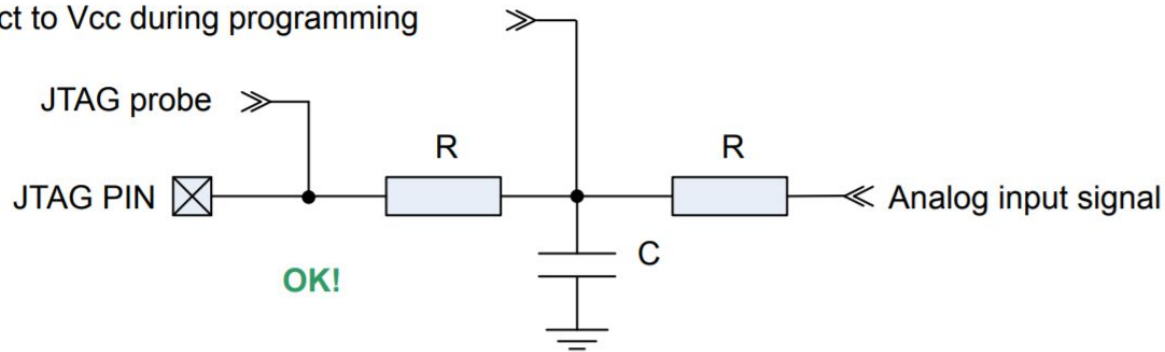
This spike voltage,  $V_L$ , is most likely outside the specification of the RESET pin. By adding a series resistor between the switch and the capacitor, the peak currents generated will be significantly low and it will not be large enough to generate high voltages at the RESET pin. An example connection is shown in the following diagram.

**Figure 3-2. Switch Connection for Reset Pin**



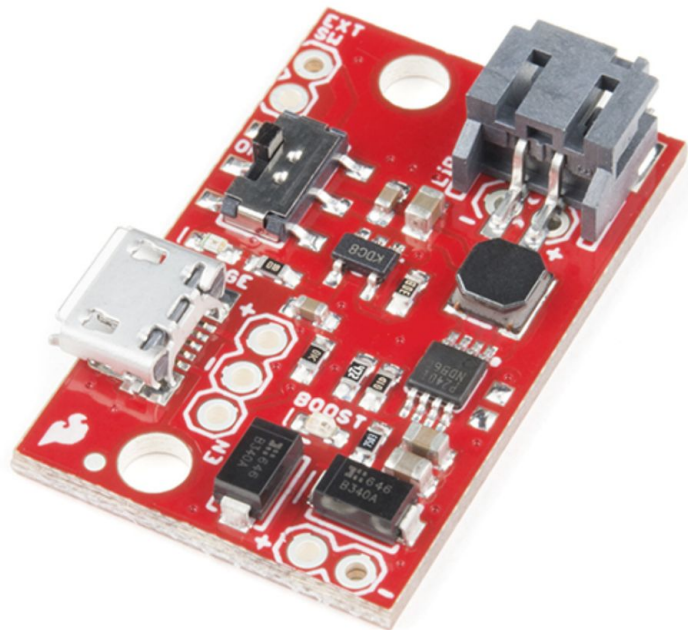
**Figure 4-5. JTAG Interface Connections – Correct and Incorrect Ways**

Connect to Vcc during programming



# Open implementations

- Also look for public implementations of the circuit you need
- Especially helpful if you're combining functionality which is available as a module
- Beware of edge cases and understand the design!  
Especially, for instance, with battery tech!
- Remember to credit according to the license!



# SparkFun LiPo Charger/Booster - 5V/1A

PRT-14411

\$15.95

Volume sales pricing

- 1 +

Quantity discounts available



Notice. This product requires other products in order to function properly.

[See essential products.](#)

ADD TO CART

DESCRIPTION

FEATURES

DOCUMENTS

- [Schematic](#)
- [Eagle Files](#)
- [Hookup Guide](#)
- [Datasheets](#)
  - [MCP73831](#)
  - [PAM2401](#)
- [GitHub](#)

## Tags

BATTERY

BOOSTER

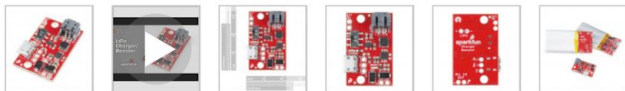
CHARGER

LIPO

LIPO CHARGER

POWER

PROTOTYPING



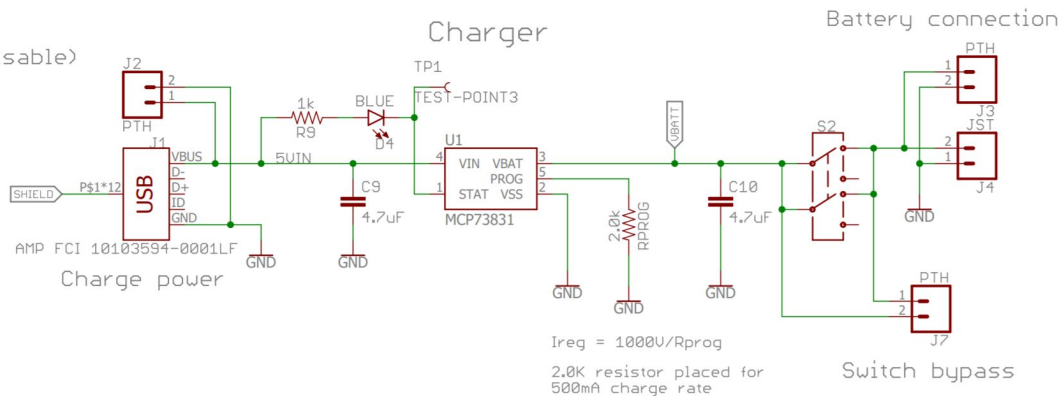
images are CC BY 2.0



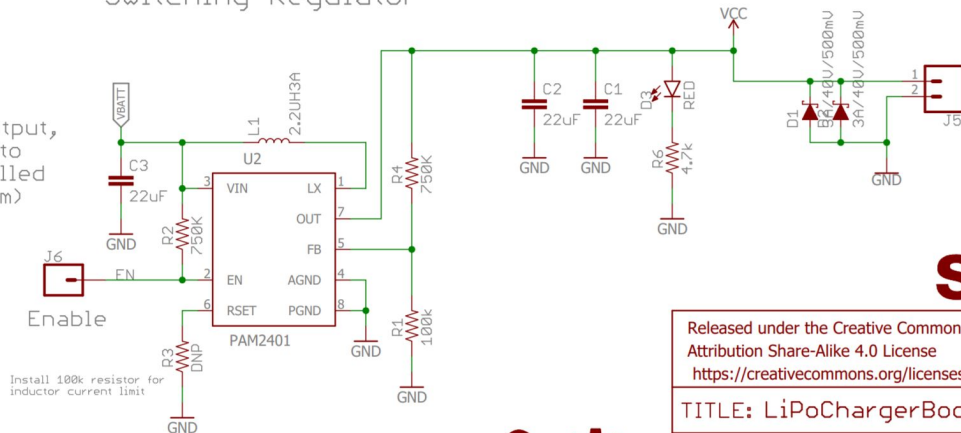
To charge battery,  
Minimize output load (or disable)  
Supply 3.75 to 6V, 500mA  
capable to USB or input  
voltage pins.

Output capacity:  
5V, 1A for 3.0V to 4.2V  
battery voltage.

For heavy duty use:  
Use 2A switch in switch  
bypass pins, or jump  
with wire.



Enable pin:  
To disable output,  
short EN pin to  
ground (is pulled  
up with 10kOhm)



Released under the Creative Commons

Attribution Share-Alike 4.0 License

<https://creativecommons.org/licenses/by-sa/4.0/>

TITLE: LiPoChargerBooster5V1A\_v10

Design by: Marshall Taylor

REV:  
v10

# General guidelines

- Use 10k resistors to pull pins high or low.
- Any pin not designated as internally pulled high or low *must be connected by you*
- Always use a 0.1uF capacitor on any power pin
- Put capacitors as close to their power pin as possible
- Use ground planes

# “Pulling” pins

- Disconnected pins can get random values based on ESD and environmentals
- Any pin which is used as an input to a chip should be configured to a known good state
- Typically done by “pulling” it to a 1 or 0 with a resistor
- 10k resistor to VCC or to ground as appropriate

## Other design requirements

- Some components expect grounding on center pads
- Some power-handling components require thermal pads to act as heatsinks
- RF is super fidgety in general
- Some components are just plain out of reach for homebrew designs - high density or small pin BGA for instance

# Types of caps matter

- Sing along again: “Always check the datasheet”
- Different cap chemistry/makeup changes how it behaves
- Power supply designs often use several cap types
- Usually the datasheets will list when an electrolytic or tantalum cap is required

## “More open” parts

- Some parts only release datasheets under NDA
- Some processors require commercial programmers and toolchains
- You *can* work with these, but probably avoid them when you're first starting
- Check for support for anything you plan to write code for, before you count on it working!

# Processor toolchains

- Many embedded processors are supported by GCC
- Avoid proprietary processor toolchains if you can
- Figure out what you need to do to program the system!
- Some use USB, some require serial, or JTAG

# Closed source example code

- Beware vendor example code
- Rarely licensed in an OSS-compatible way
- “Open” support libraries may embed licensed code you can't actually use

# Schematic capture

- The process of drawing the *logical* layout
- Follow application circuits whenever possible
- Denote your parts
- Kicad separates schematic components and board layouts
- Eagle combines schematic and board into a single part
- No True Path, plenty of dogmatists

# Schematic parts vs physical

- Often the pins for the *schematic representation* of a part are laid out differently than the *physical part*
- It makes sense to group ground, power, etc in ways that aren't representative of the physical restrictions
- Remember to consult the physical layout

# Physical layout

- Usually a separate tool or mode of your CAD tool
- Different ways of doing things, learn your tool!
- Lots of tutorials for all the popular CAD tools
- Keyboard shortcuts will be invaluable
- Follow your datasheets!

# App note example: Physical layout

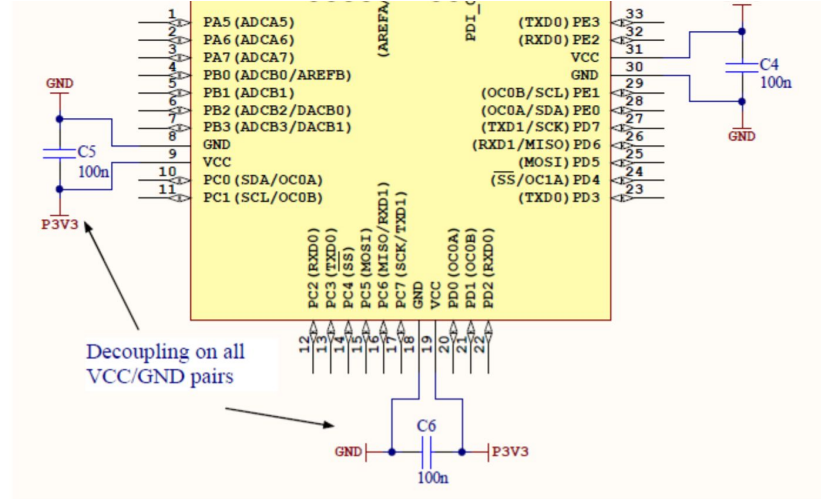
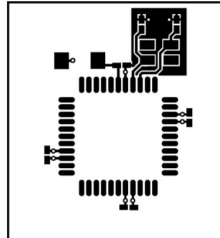


Figure 7-2. ATmega32A4 - Copper PCB Layout of Required/Recommended Connections



# Library vs Roll-your-own

- Two schools of thought:
- A: Always create every footprint manually from the datasheets
- B: Always use vendor-supplied libraries whenever possible.
- If you're new to design, I'd strongly suggest 'B', myself

# Follow your fab rules!

- Company making your PCB publishes the rules
- OSHPark, SEEED, MacroFAB, etc all have different minimum sizes for traces, vias, spacing, etc
- You can violate them - but you might get junk back
- Often they can do better - **but not reliably**. It might work once and not the next time.

# Watch your measurements!

- PCB design mixes imperial and metric!
- “6 mil trace”. Is that millimeters? **Nope.**
- “Mil” == Thousandth of an *inch*.
- Because reasons.
- $6\text{mil} = 0.006\text{ inches} = 0.1524\text{mm}$
- Why are pin pitches in metric, but factory tolerances usually in imperial? Reasons.

# Some things are still Really Hard

- Most BGA...
- If you see:
  - Via-in-pad
  - More than 4 layers
  - “Laser Via”
- You can still do it, but you’re going to pay, and pay a lot - \$5000/order often.

# Picking a tool

- Eagle? Kicad? Tinker? GEDA?
- Use what the videos you like to follow use
- Use what someone you know uses
- Once you know what you're doing, *then* you can try a tool you think you'll like more
- Plenty of tools to pick from, each with strengths and weaknesses

Putting it together

# Putting it together

- Through-hole
- Hand SMT
- Hot air
- Reflow

# How soldering works

- Solder + Flux wants to flow and stick to metal
- The green (or purple, or whatever) layer on your PCB is called Solder Mask; solder doesn't want to stick to it.
- Solder with no flux is a goopy mess that won't flow at all
- The smoke you see when you melt solder? That's your flux burning off!

# Where it goes wrong

- Too much heat burns off all your flux
- Too much time burns off all your flux
- Both leave you with a goopy mess - add fresh solder to bring in more flux, or add more flux on its own
- Often caused by too big an iron or too high a temperature

Does your iron look like this?



Does your iron look like this?



## But seriously

- You don't need to spend a lot of money
- Uncontrolled irons aren't going to do you any favors though
- Almost anyone who thinks they can't solder is using the wrong equipment
- The equipment matters, but fortunately, the equipment is cheap

# Fine

## Weller WLC100 40-Watt Soldering Station

by [Weller](#)



1,355 customer reviews | 143 answered questions

Amazon's Choice

for "soldering station"

List Price: ~~\$55.63~~

Price: **\$39.97** ✓prime

You Save: \$15.66 (28%)

Pay ~~\$39.97~~ \$0.00 after using available Amazon Rewards Visa Card Points.

Size: **1 Pack**

- High performance analog soldering station produces up to 900° F to handle soldering projects
- Variable power control dial adjusts power from 5 watts to 40 watts for accurate soldering
- Quality, lightweight pencil iron with cushioned foam grip provides extended comfort during long-term soldering projects
- Includes: a Weller certified ST3 iron-plated tip for long life and consistent performance, a built-in soldering holder to safely rest your pencil, and a cleaning sponge to remove unwanted residue from soldering for next time use
- UL-Listed: Tested and meets independent safety standards

› [See more product details](#)

[Compare with similar items](#)

**Used & new** (69) from **\$37.17** ✓prime



# A little better



## Hakko FX888D-23BY Digital Soldering Station FX-888D FX-888 (blue & yellow)

by [Hakko](#)



[467 customer reviews](#) | [78 answered questions](#)

**Amazon's Choice**

for "hakko soldering iron"

List Price: ~~\$110.47~~

Price: **\$99.42** ✓prime

You Save: **\$11.05 (10%)**

**Pay \$16.57/month for 6 months with your Amazon Prime Rewards Visa Card**

- Digital soldering station end safe
- Comes with fx-888d, fx-8801 soldering iron, t18-d16 tip, Fh800 iron holder, A1559 sponge, A1561 cleaning wire, manual
- Adjustable temperature control

### Specifications for this item

Part Number	FX888D
Measurement System	US
UPC	787721750666 , 641328061764 , 013161034173 732454169452

Model Number	FX888D
Number of Items	1
Power Source	corded-electric
UNSPSC Code	23271800

# Also fine, and portable

results



## UY CHAN Upgraded Original TS100 Digital OLED Programmable Pocket-size Smart Mini Outdoor Portable Soldering Iron Station Kit Embedded Interface DC5525 Acceleration Sensors STM32 Chip Fast Heat (B2)

by UY CHAN










266 customer reviews

58 answered questions

Price: **\$67.98** ✓prime

**Pay \$11.33/month for 6 months with your Amazon Prime Rewards Visa Card**  
Free Amazon tech support included

Color: **TS100 With B2 Tip**

 <b>\$67.98</b> ✓prime	 \$79.98 ✓prime	 \$67.98 ✓prime	 \$67.98 ✓prime
 \$109.98 ✓prime	 \$104.98	 \$107.98 ✓prime	

- **【Fast Heating】** This portable soldering iron heats up in seconds. The temperature is displayed on OLED screen, which can be accurately and easily adjusted from 212°F to 752°F (100°C to 400°C)
- **【Smart & Safe】** It has dual-temperature sensors and accelerated sensors with STM32 chip. And it also has sleep mode and automatic over-heating warning.
- **【External power supply】** DC5525 power port is compatible with DC 12-24V AC adapter/power bank. It's convenient for both home repairing and filed repairing.
- **【Reprogrammable】** Connecting to the computer, you can reset your own temperature rising curves and custom functions

# Excellent, but overkill for beginning

by [AMERICAN HAKKO PRODUCTS INC](#)

## Hakko Soldering Station, FX-951-66

★★★★☆ ▾ [87 customer reviews](#) | [39 answered questions](#)

List Price: ~~\$269.77~~

Price: **\$242.79** ✓prime | FREE One-Day

You Save: ~~\$26.98~~ (10%)

**New** (11) from **\$242.79** ✓prime



### Specifications for this item

Part Number	FX951-66
Number of Items	1
UPC	641328007229
Brand Name	AMERICAN HAKKO PRODUCTS INC
EAN	4962615023385 , 0641328007229
Item Weight	2.6 pounds

Model Number	FX-951
Power Source	corded-electric
UNSPSC Code	23271800
Voltage	120 volts
Wattage	65 watts

[See more product details](#)

# Good vs Bad irons

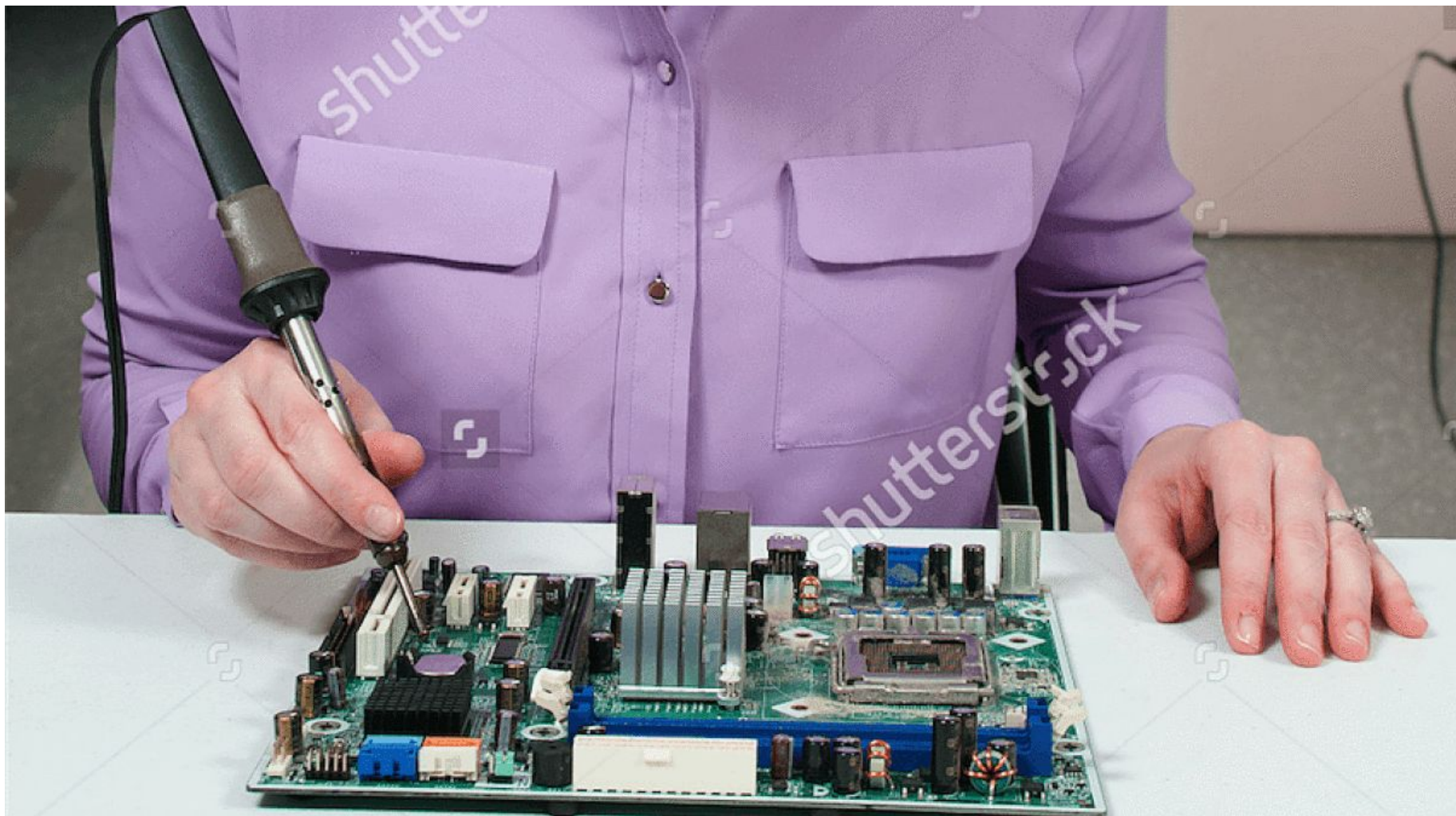
- Good: Thermal control, knowing what temp it is, being able to limit the temp
- Bad: Indiscriminate over-heating
- Good: Thermal mass that keeps the iron at temperature while soldering
- Bad: Insufficient mass causing the iron to get cold

# Differences in expensive irons

- Why spend more than the minimum?
- Better heat control
- Different tip availability
- Different tip heating technologies

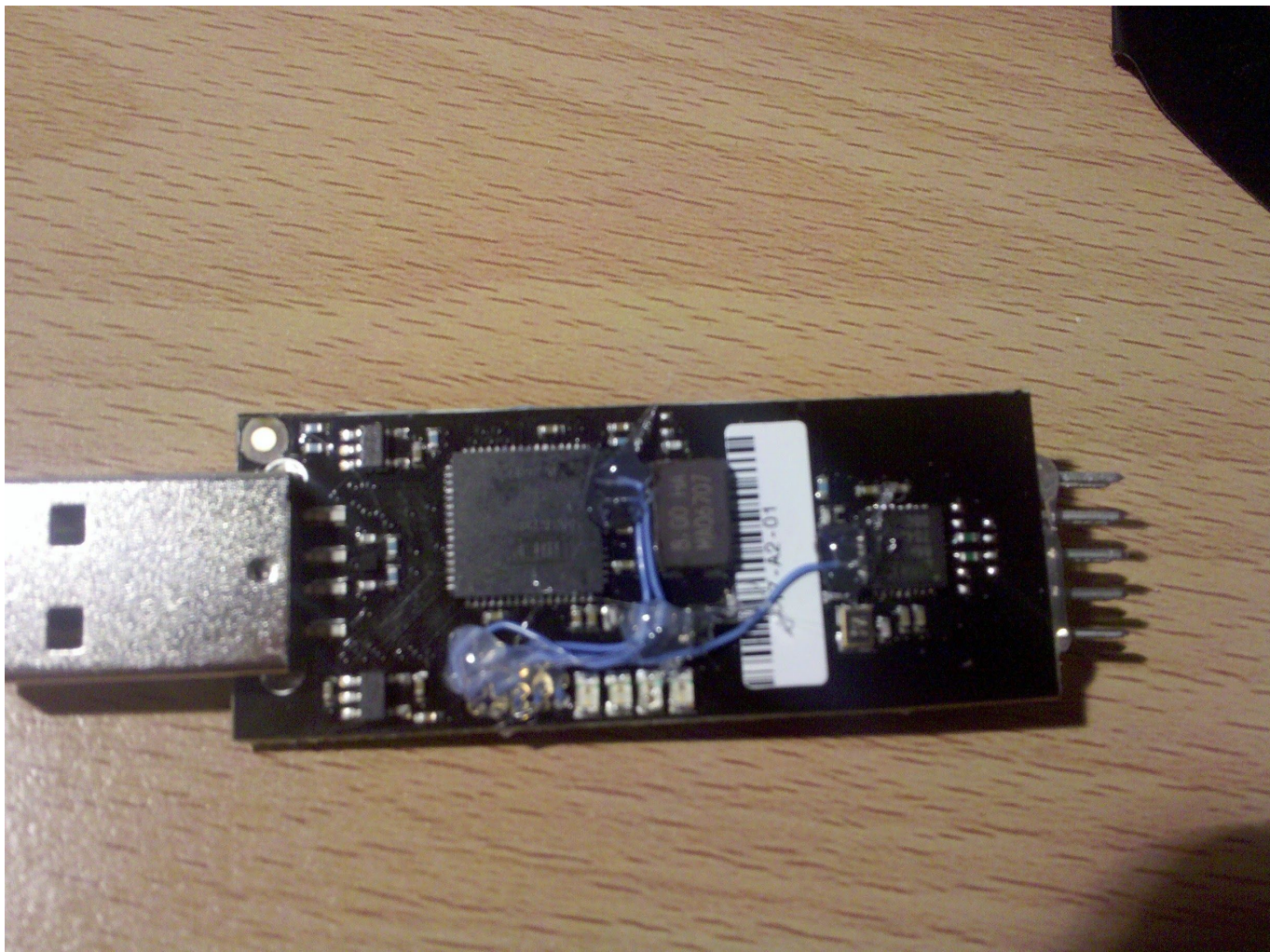
# Soldering techniques

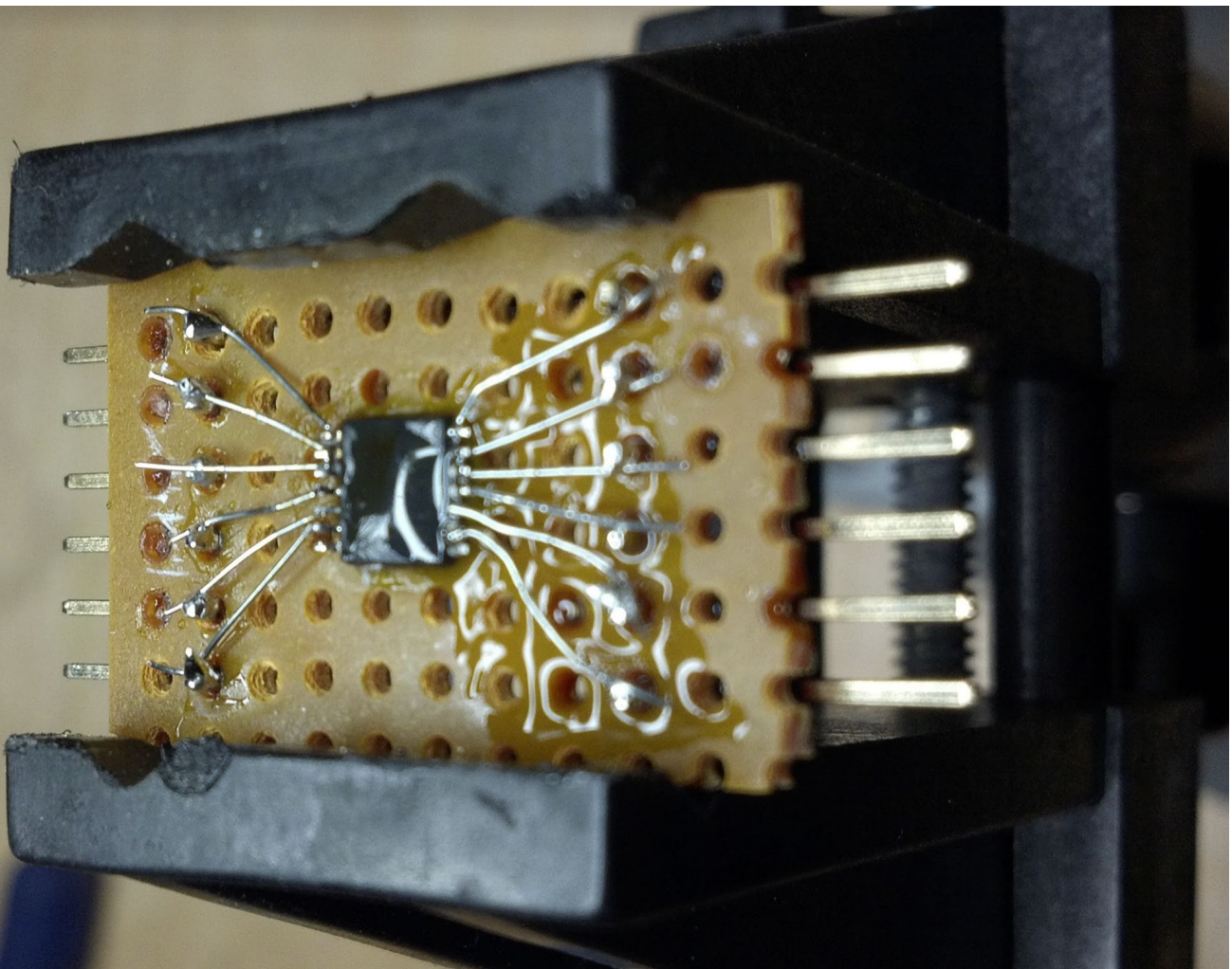
- Different techniques for different methods
- Once you know the tricks it's a lot simpler than you might fear



# General tricks

- Tape, clamps, third-hand tools, etc are all fantastic
- Have good light
- Form “tripods” with your hands - brace elbows on the table, or even wrists, etc
- With decent tools and bracing your hands, you can accomplish more than you think





# Through hole

- AKA PTH (Plated Through Hole)
- Like old radioshack kits
- Easiest for people to put together
- Hard (and likely impossibly expensive at the hobby level) for machines to put together

# Soldering PTH

- Put component through holes
- Bend wires to hold in place
- Put iron in the groove between the wire and the PCB
- Add solder
- Don't put solder on the iron and then carry it to the PCB!

# Image from Sparkfun How To Solder Through-hole

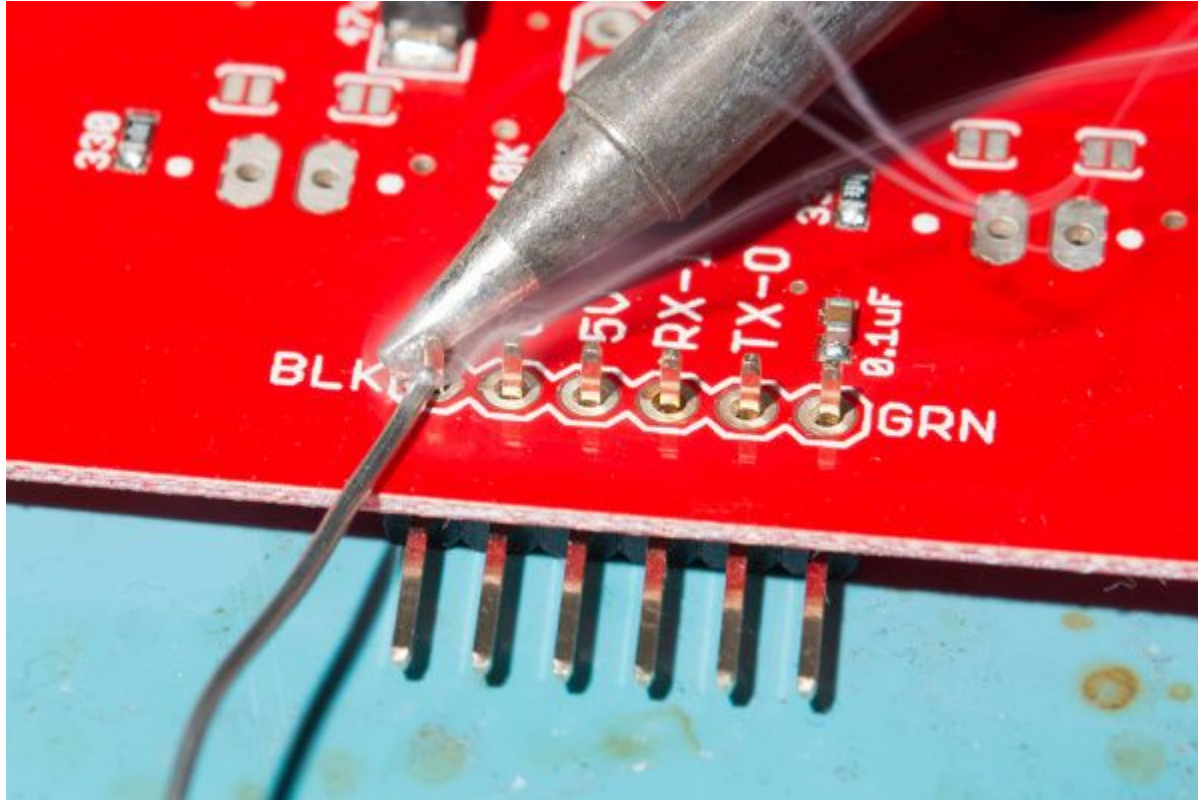
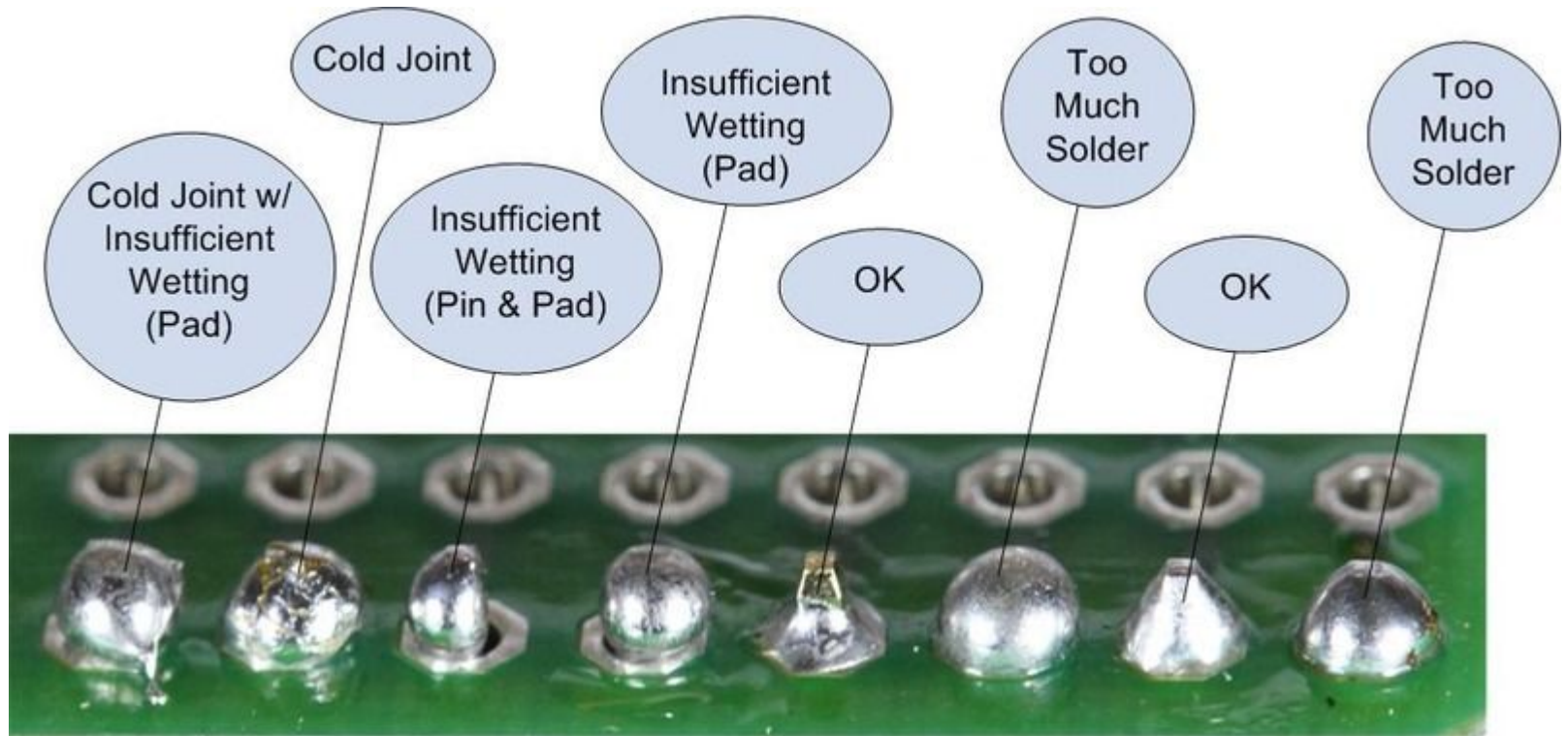


Image from [circuitrework.com](http://circuitrework.com)



# Doing it wrong (image from AVR Freaks)



# SMT by hand

- Exact opposite of PTH...
- Get *non corrosive non clean gel flux*
- Put flux on the PCB
- Stick component in flux
- Hold with tweezers
- Put solder on iron
- Bring solder to PCB

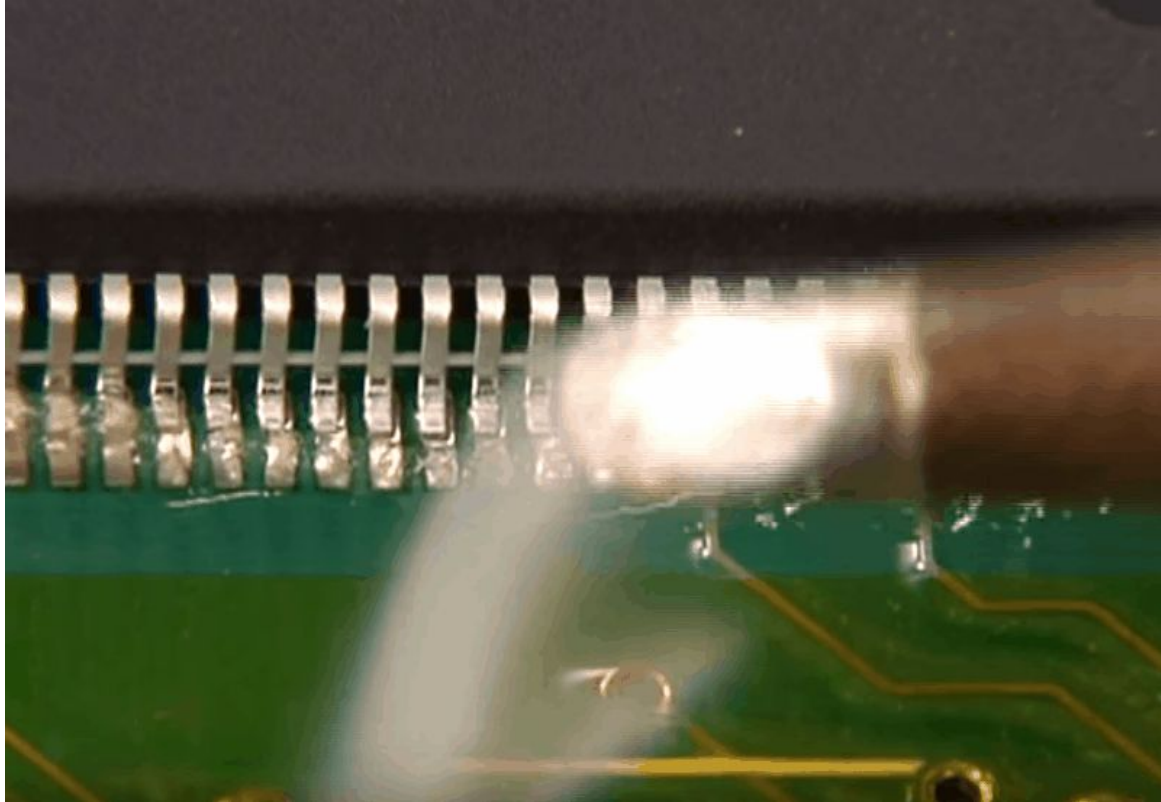
# Why does this work?

- Flux makes solder runny
- By bringing our own flux, we replace the flux burned off by the iron
- Flux makes the solder want to flow and stick to metal
- This helps prevent bridges

# This works so well..

- Solder + flux wants to stick to metal so much...
- You can drag a ball of solder over all the pins...
- And it will just stick to the parts it needs to!

Video from “Professional SMT soldering methods”



# Hand-soldering passives

- Put a blob of solder down on one side on PCB
- Pick up passive in tweezers
- Put soldering iron on blob to make it melt
- Slide passive into molten blob
- Solder other side
- Return to first side and add a little more solder+flux

# Soldering with hot air

- A hot air gun is almost a must-have for surface mount work... Fortunately...



## BACOENG 110V Digital 858D SMD Hot Air Rework Station Solder Blower Heat Gun

by BACOENG

★★★★★ 5 customer reviews

Price: \$46.99 ✓prime

Pay \$46.99 \$0.00 after using available Amazon Rewards Visa Card Points.

Free Amazon tech support included

- 110V, 700W, Temperature range: 212-896°F(100-480 °C), Noise: ≤50dB
- Closed Circuit Sensor, microcomputer zero-crossing soft touch temperature control, LED visual display, high power, rapid rise of temperature, accurate and stable temperature, little influence of soldering without lead.
- Adjustable air flow, large and soft air flow, easy adjustment of temperature, suitable for multiple usages.
- Hand handle with sensor switch, the system will turn into the working mode while the handle is held and the system will standby while the handle is put on the holder, which is very convenient for

## Useful (and vital) for...

- Removing surface mount components
- Soldering QFN and sometimes even BGA
- Soldering many components at once
- Home-brew reflow

# Gotchas

- Gets hot FAST
- *Learn on a scrap board, you will almost definitely ruin the first thing you try*
- Easy to damage PCB (see point B)

# Solder paste

- Needed for soldering qfn, etc
- Little solder balls suspended in flux
- Comes in syringes or pots
- Sensitive to temperature, air, etc
- Must be stored sealed, refrigerated
- Still only good for a limited time

# Reflow

- Solder paste and a stencil
- All the parts are put on the board at once
- Whole board is heated up to melt all the solder
- This is how boards are fabbed

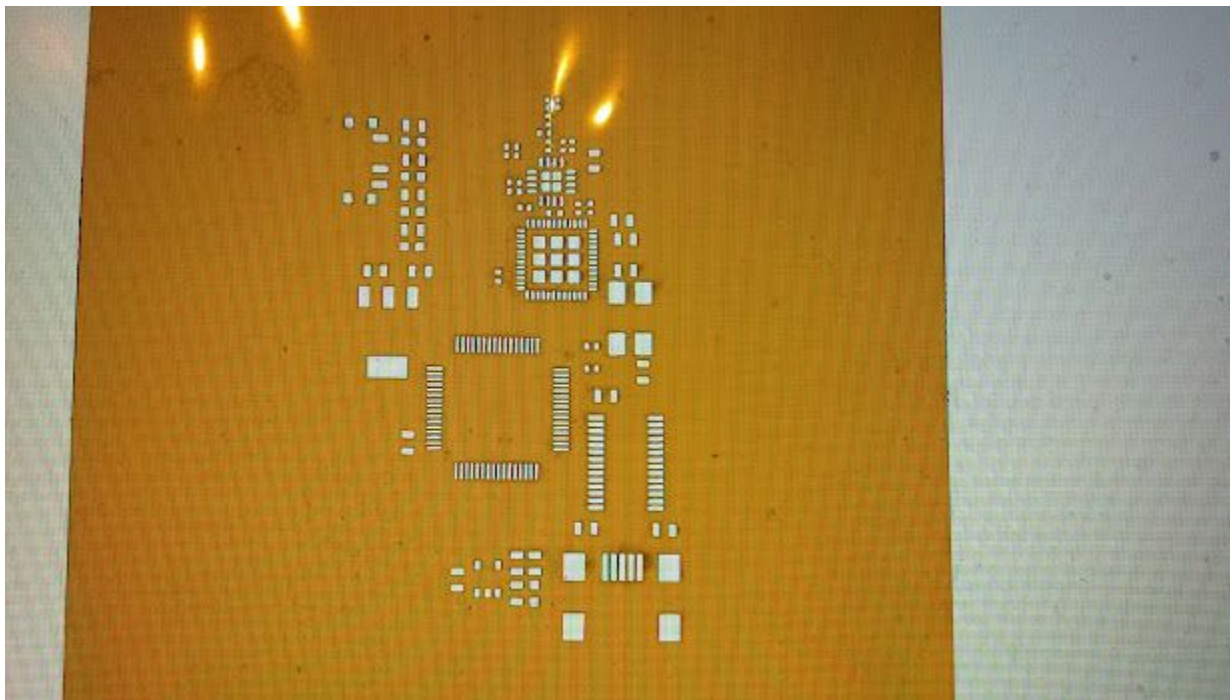
# Getting a stencil

- Affordable hobby-scale stencils now available
- OSHStencils, SEED, others
- Laser cut out of kapton plastic (disposable) or steel (more professional)

# Home reflow options

- Electric griddle
- Electric burner *with thick aluminum plate to spread out the heat*
- Toaster oven
- Toaster oven with external reflow controller
- Hot air gun

# Stencils



# Hotplate reflow



# The goal

- Solder paste has a “reflow profile”
- Warm to temp A for N minutes
- Increase to melting temp B, and soak for some amount of time
- Cool at some specified rate

# The reality


- Watch it melt
- Make sure all the components reflowed
- Let it sit briefly at temperature
- Turn it off
- Sure, it's hand-wavy
- OK for home made prototypes!

# The pitfalls

- Design for manufacture is huge here
- Minor variances can cause vastly different results
- Large amounts of copper near a pad can cause uneven heating and “tombstoning” where one end lifts up
- You really should work with your manufacturer if you’re going to go into production

# Find a good manufacturer

- It's important to find a manufacturer who will *work with you*
- Many will do what you ask...
- And *only* what you ask
- If you don't know to ask for something, or how to ask for it, you won't get it.

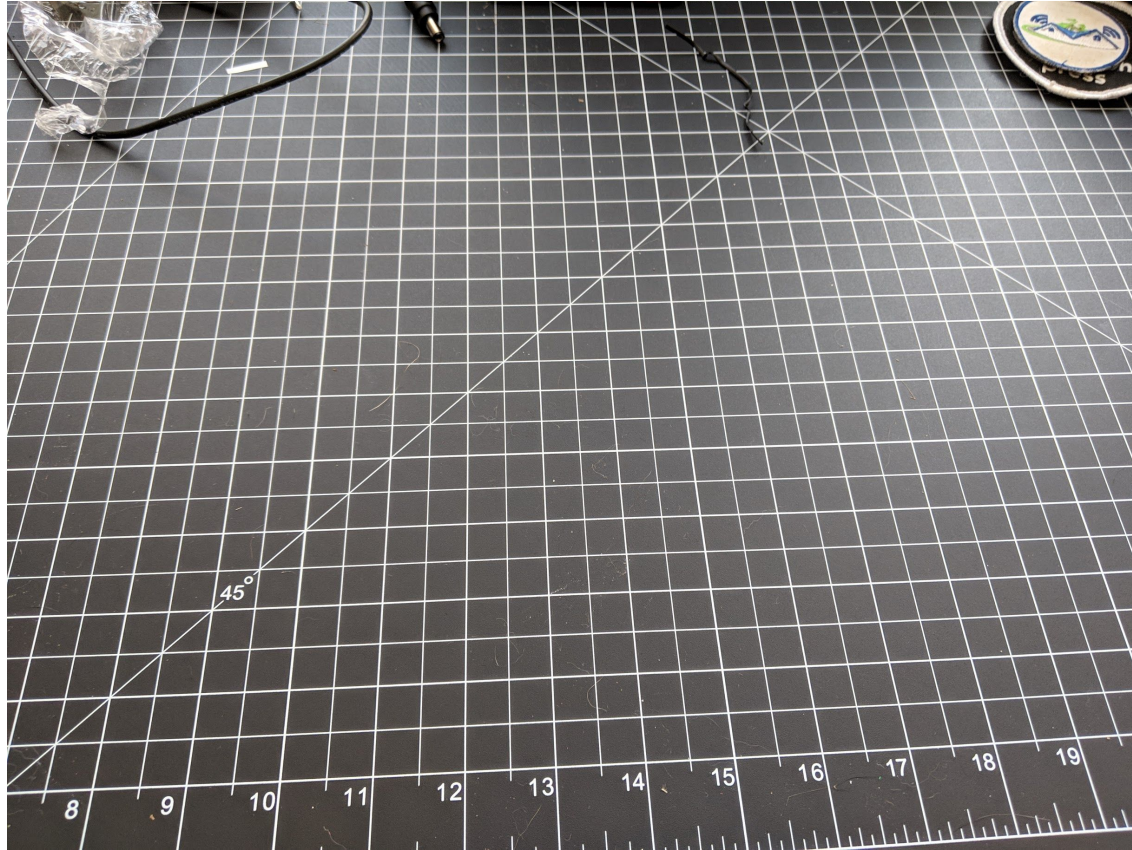


I DO NOT WANT ANY ENGRAVING  
JUST LEAVE THE METAL PLATE BLANK  
NO ENGRAVING

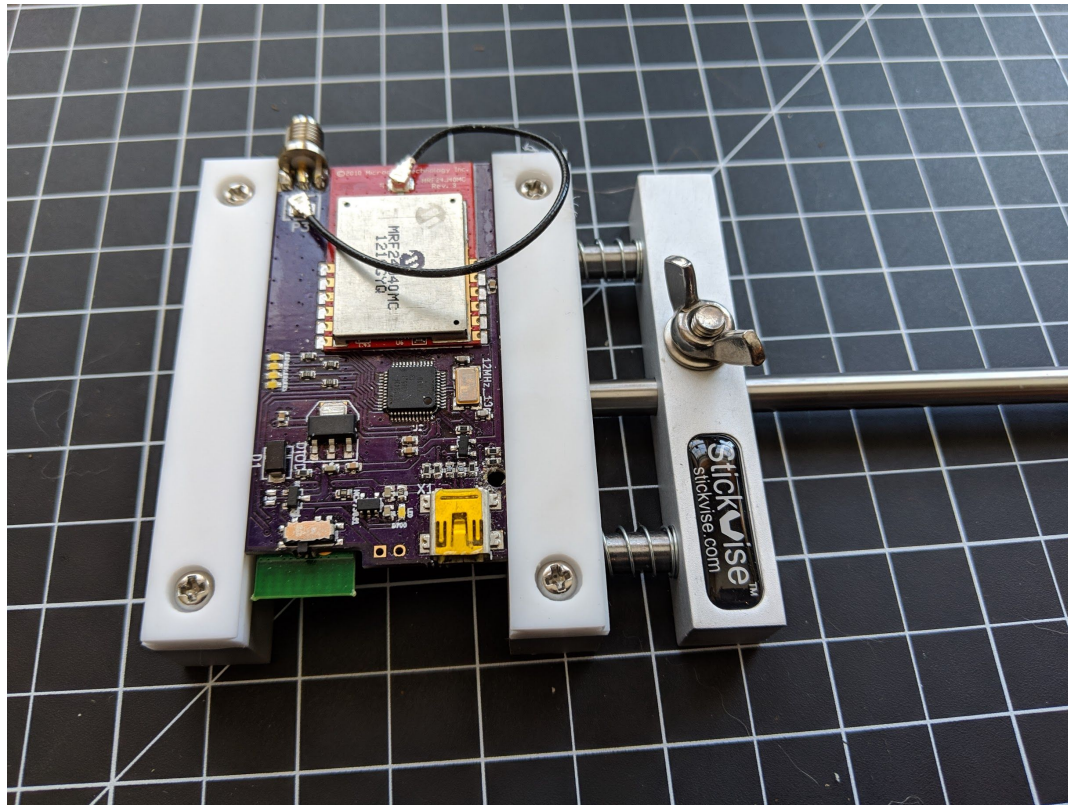
## Other useful gear

- Not vital, but improves quality of life...

# Self-healing cutting + thermal mat

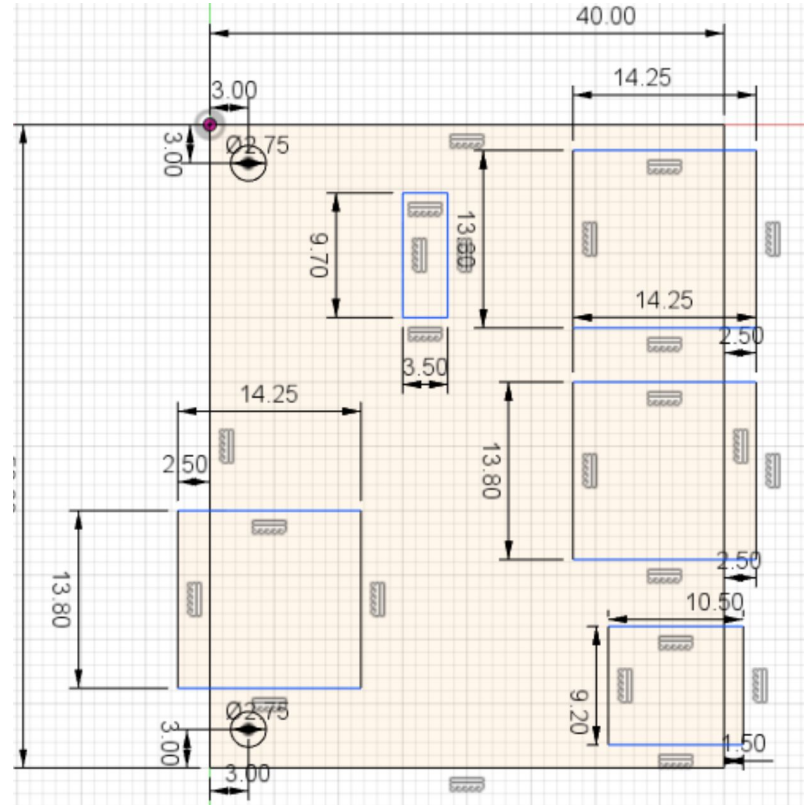
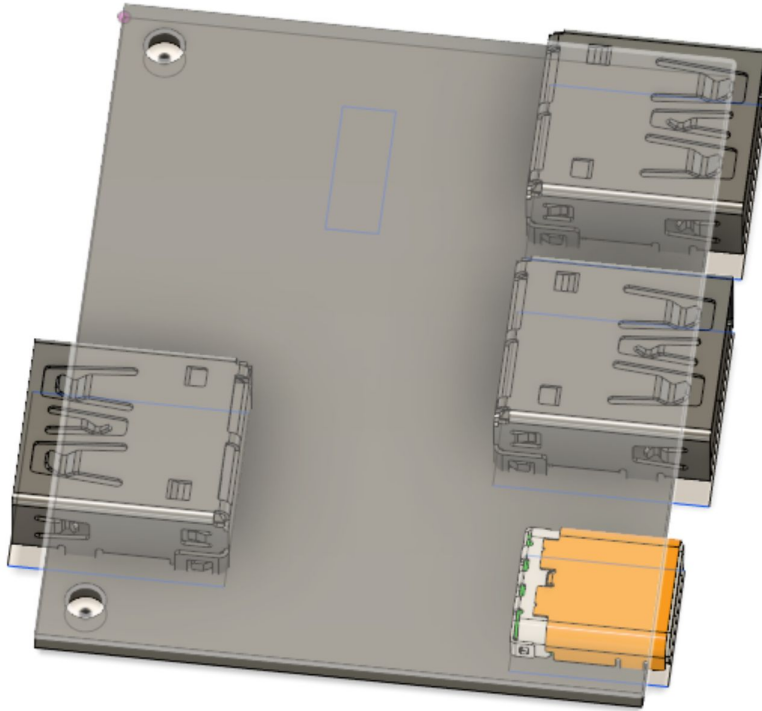


Stickvice - \$30 on amazon



Some other fun tricks

# Parametric design with manuf models



## Different tools...

- Kicad is good for PCBs
- Kicad isn't so good at parametric layout
- This is generally true of other PCB tools too
- Fusion360 is though...

# Load DXF into Kicad

Import DXF File ✕

File:  Browse

Place DXF Origin (0,0) Point:

☒ Center of page

☐ Upper left corner of page

☐ Center left side of page

☐ Lower left corner of page

☐ User defined position

User defined position:

X:

Y:

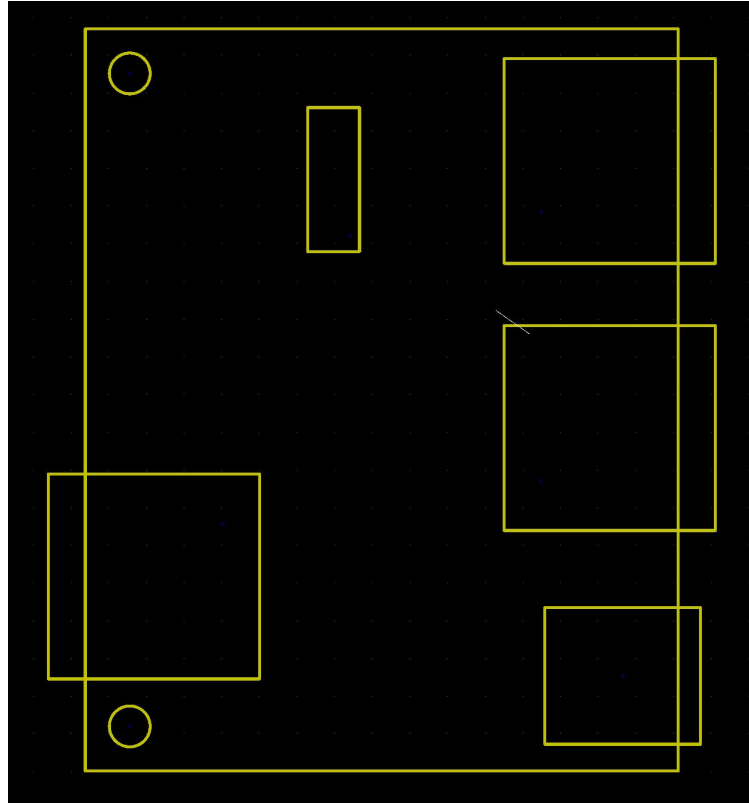
Units:

Import parameters:

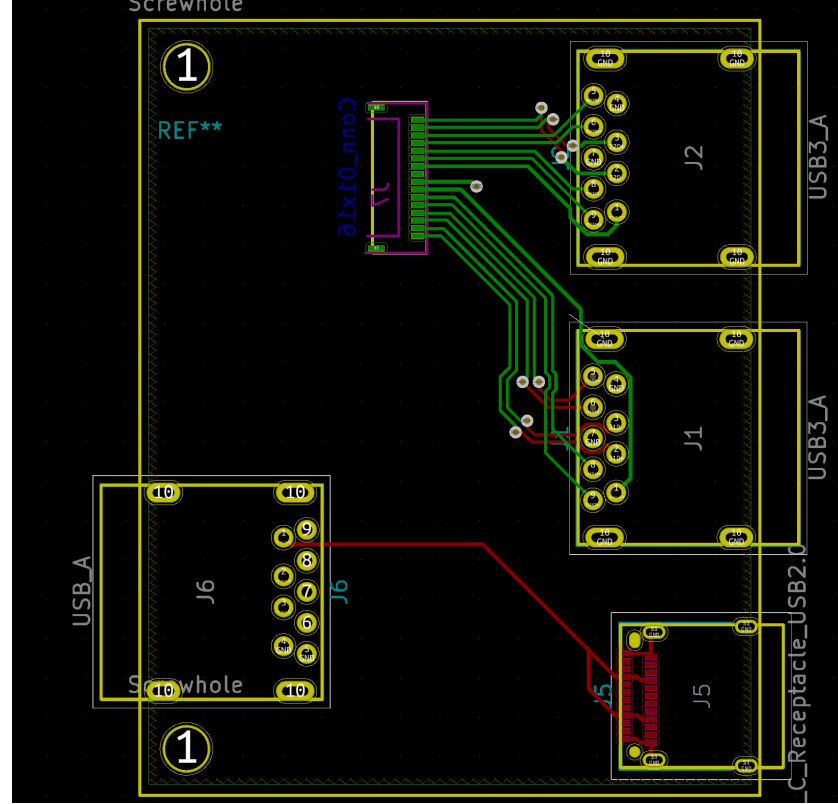
Default line width:  mm

Graphic layer:

OK Cancel

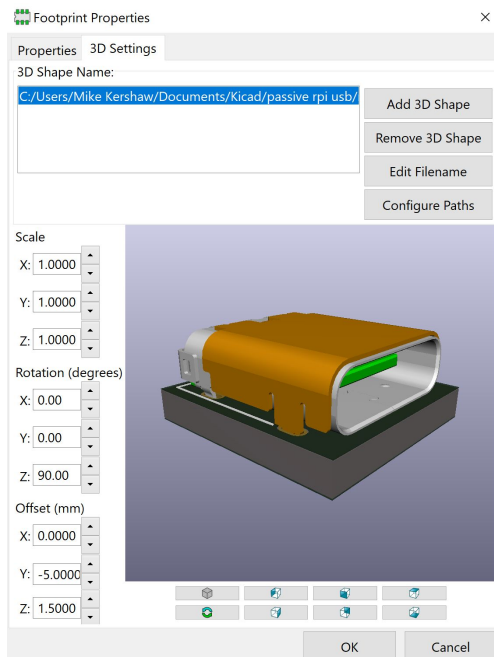
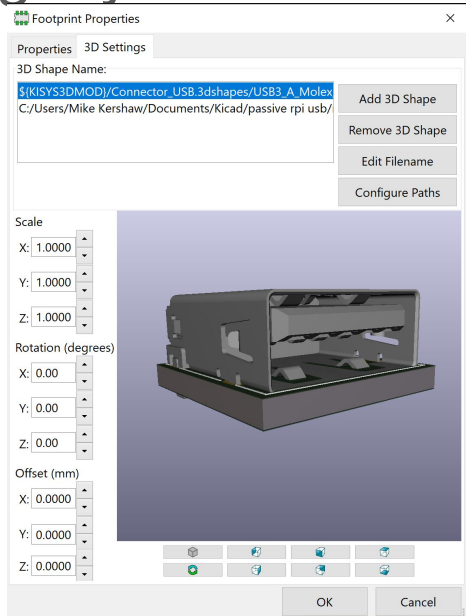


# Layout on top of DXF



# Kicad and 3d

- Kicad can read the manuf 3d files
- Slightly tedious to associate them all...



But the end result...

