

R2CON BADGE

— *r2con 2017* —

Jaime Peñalba Estébanez
@NighterMan

About



JAIME PEÑALBA ESTÉBANEZ
@NighterMan

jpenalba@member.fsf.org

Linux kernel researcher at COSEINC
WhiskeyCON Superstar
The most useless RadareCore member

Short long story

This is the story of how to go from potato to designing a basic badge in a limited amount of time.

I started doing electronics this year and didn't have any prior knoledge on it, so don't expect me to be a professional on the subject.

If I was able to do it, anyone can do it.

Short long story



Timeline

- 12th of July talk to pancake about badge
- 15th of July first working prototype
- 14th - 17th of July order components
- 17th of July schematics and board layout
- 21st of July first working prototype PCB
- 25th of July order PCBs
- 7th of August PCBs arrive
- 8th of August all components arrived
- 18th of August Assemble badges
- 31st of August write the software
- 5th of September fix and flash

Remarks

I'm really sorry for not being able to manufacture badges for everybody ☹

But you have to keep some things in mind:

- I had zero experience on manufacturing neither on design
- A bit more than one month to do everythithing
- Times when working with china range between 10 and 30 days (no time for fixes)
- It had to be cheap
- I had no help neither anyone to ask for help

Prototyping

In order to save time on shiping from china, I had to design something which can be built from the heap of componentes I had been collecting since the start of the year.

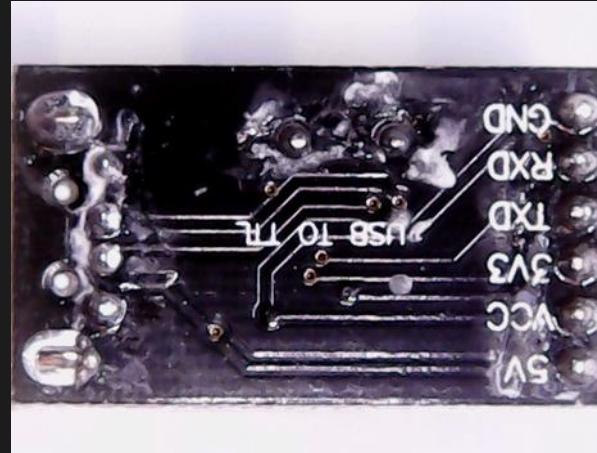
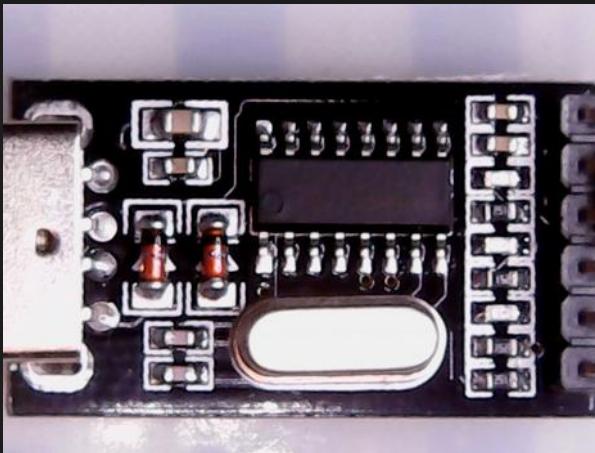
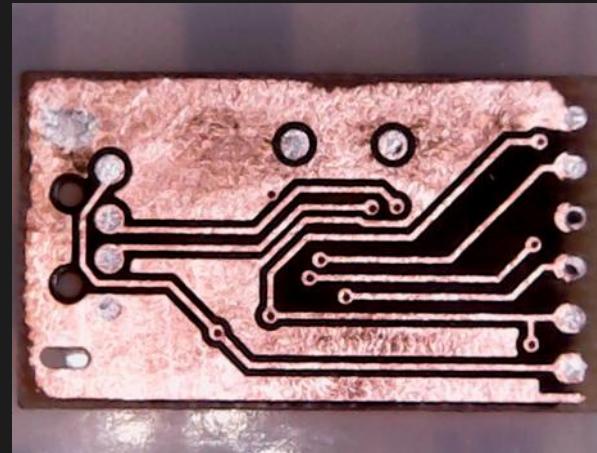
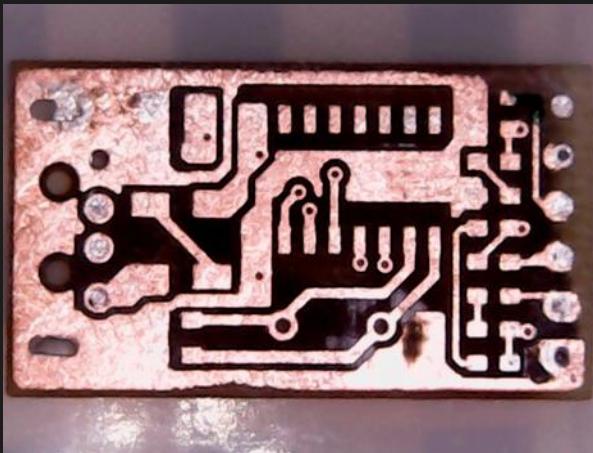
Prototyping

Some of the components had to be scavenged. One of the victims, a cheap usb to UART adapter based on CH340G



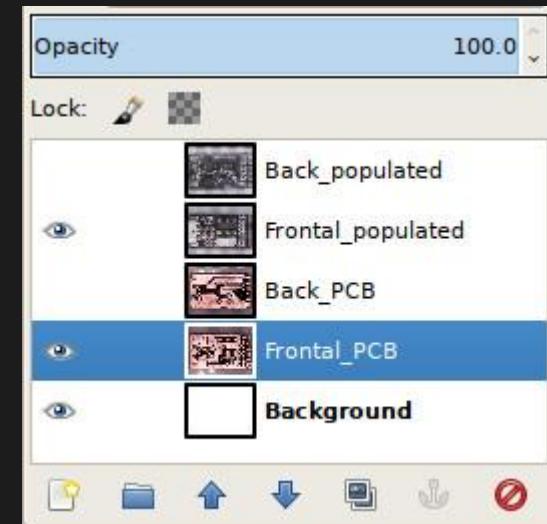
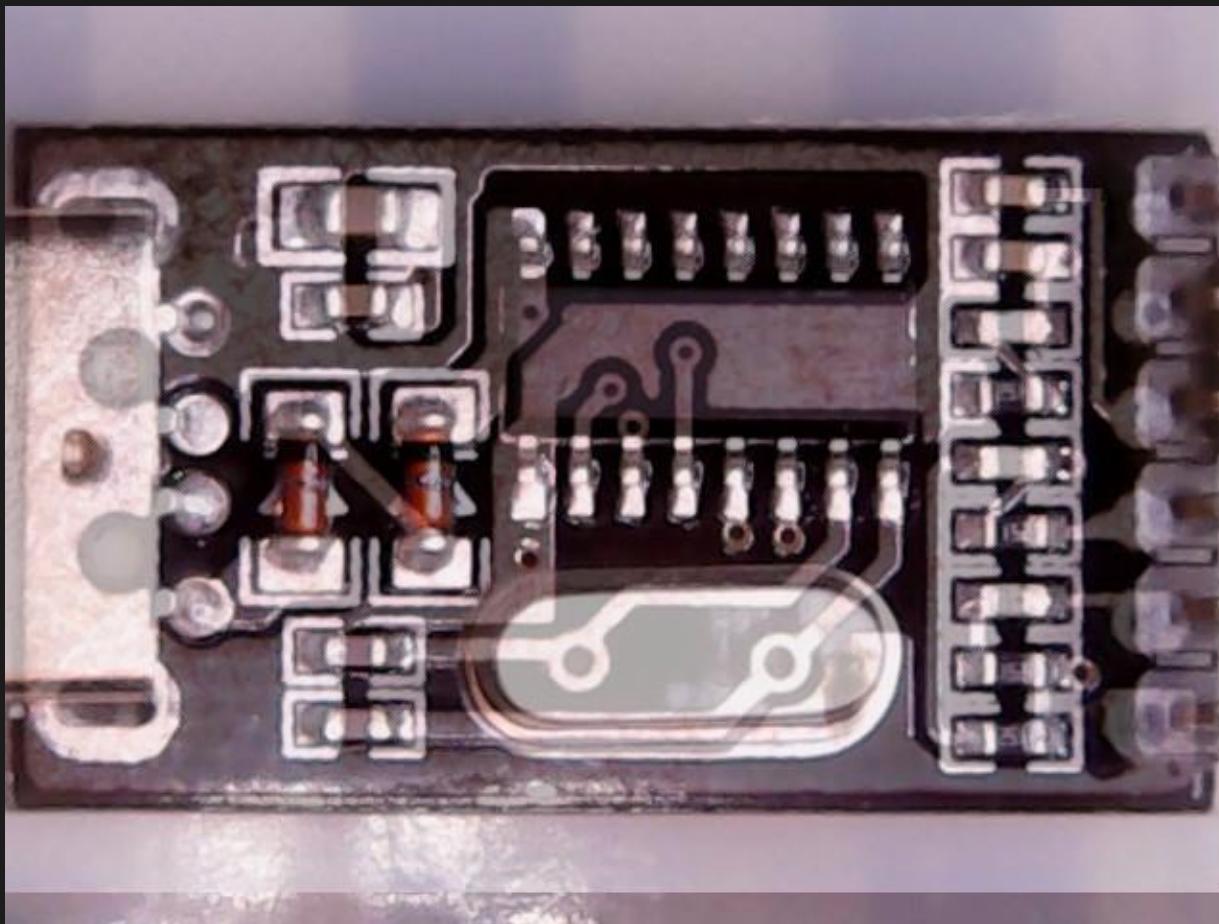
Prototyping

Datasheets on chinese components, are sometimes limited or even non existent.



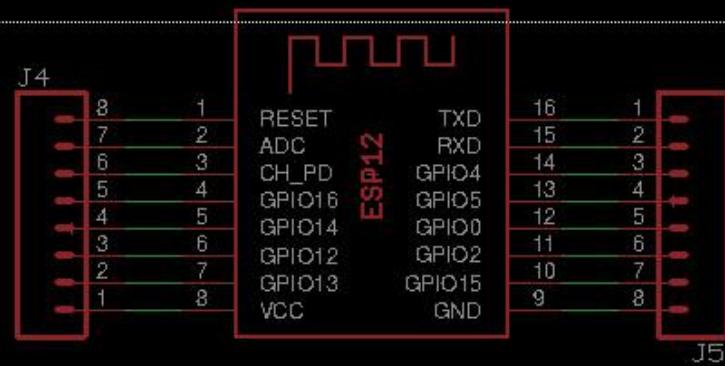
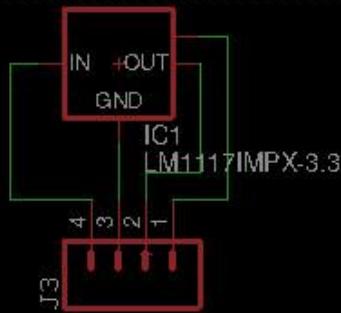
Prototyping

With those images you can create an overlay



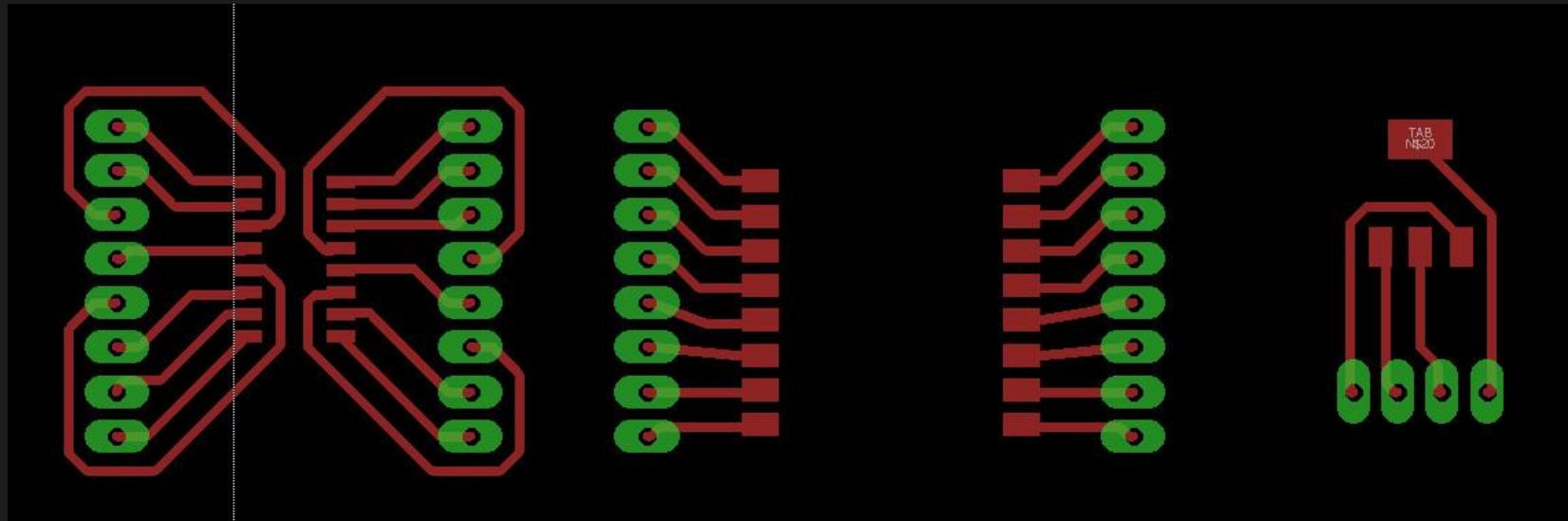
Prototyping

Started by designing some adapters



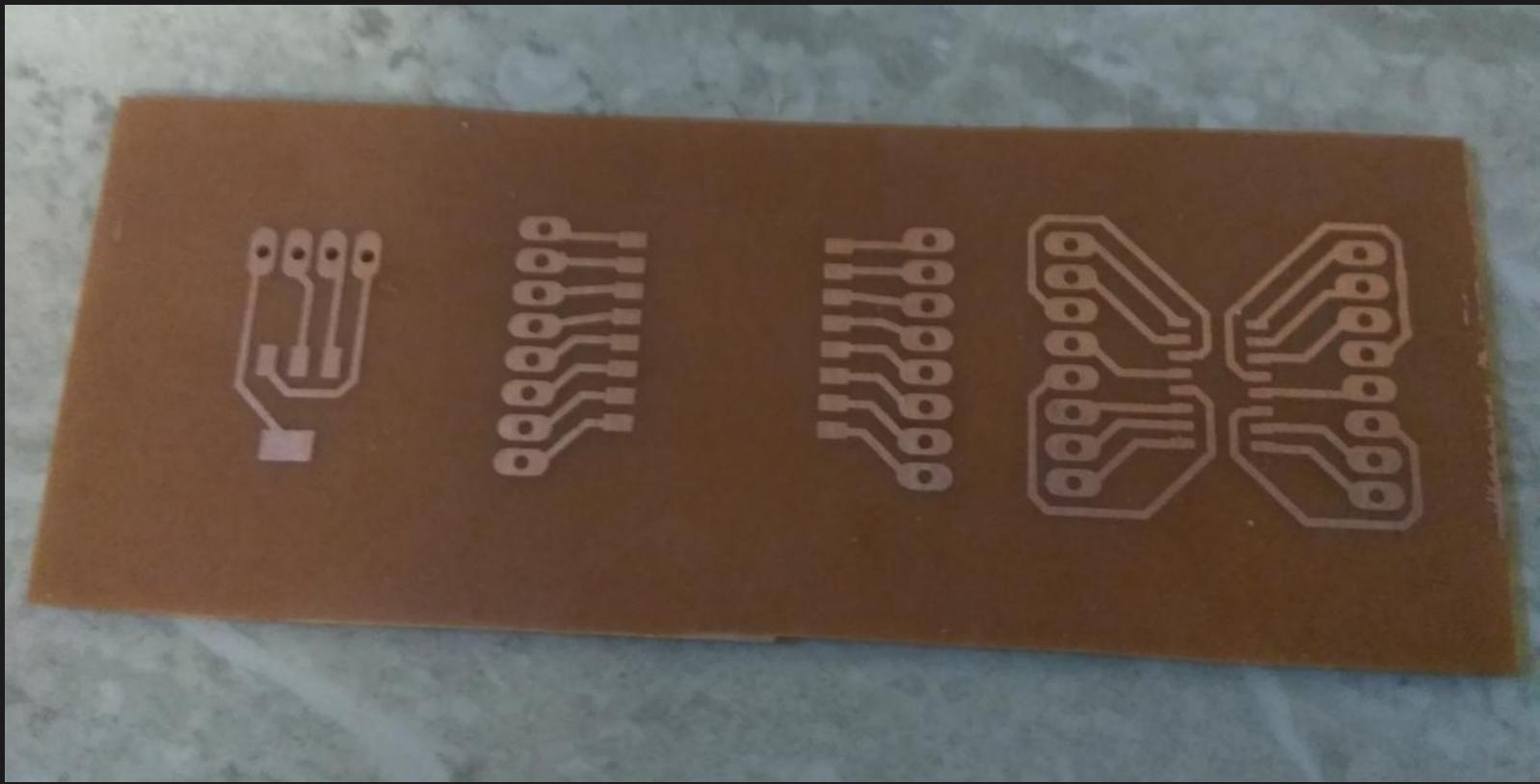
Prototyping

Started by designing some adapters



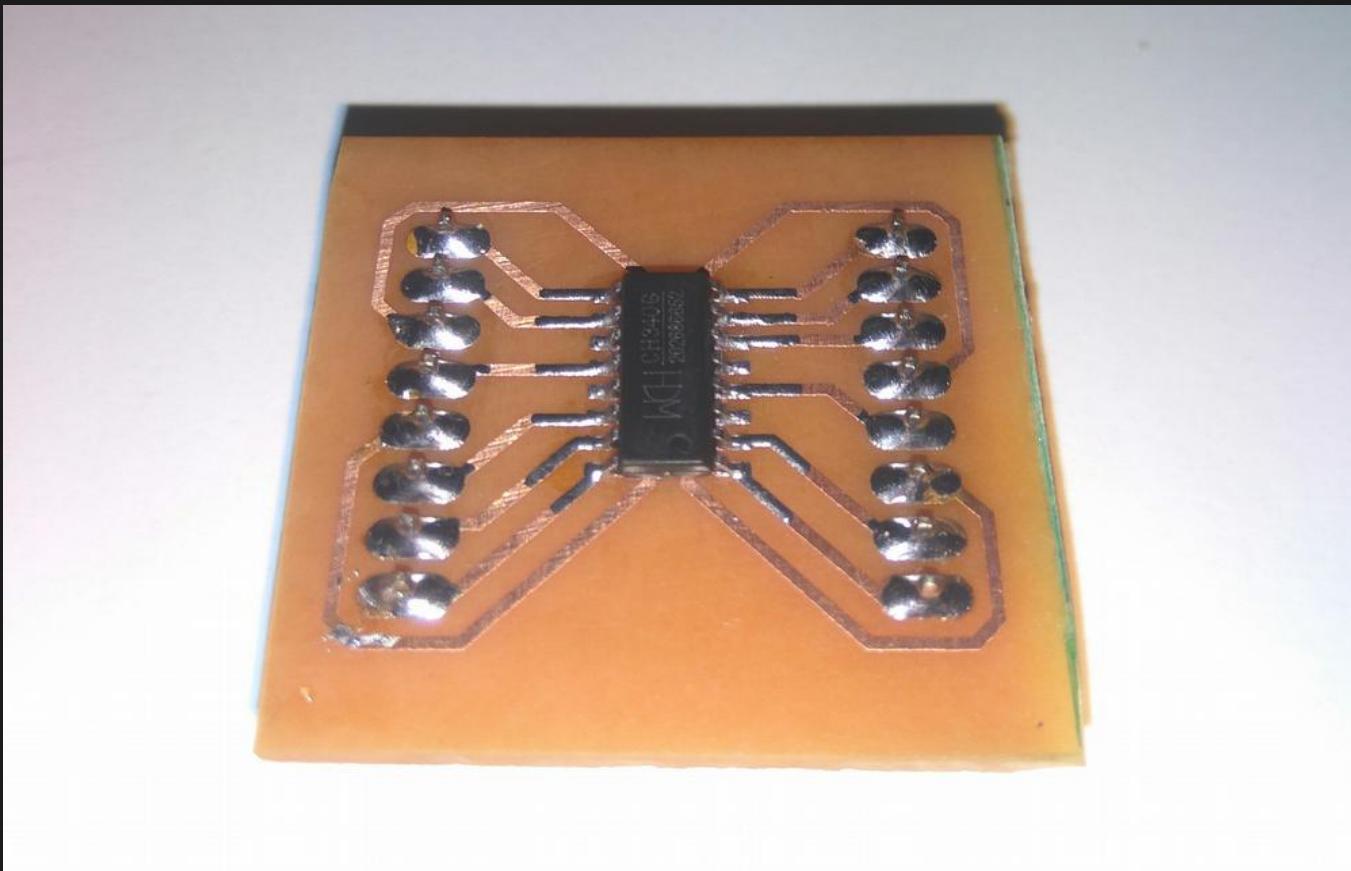
Prototyping

And etching them



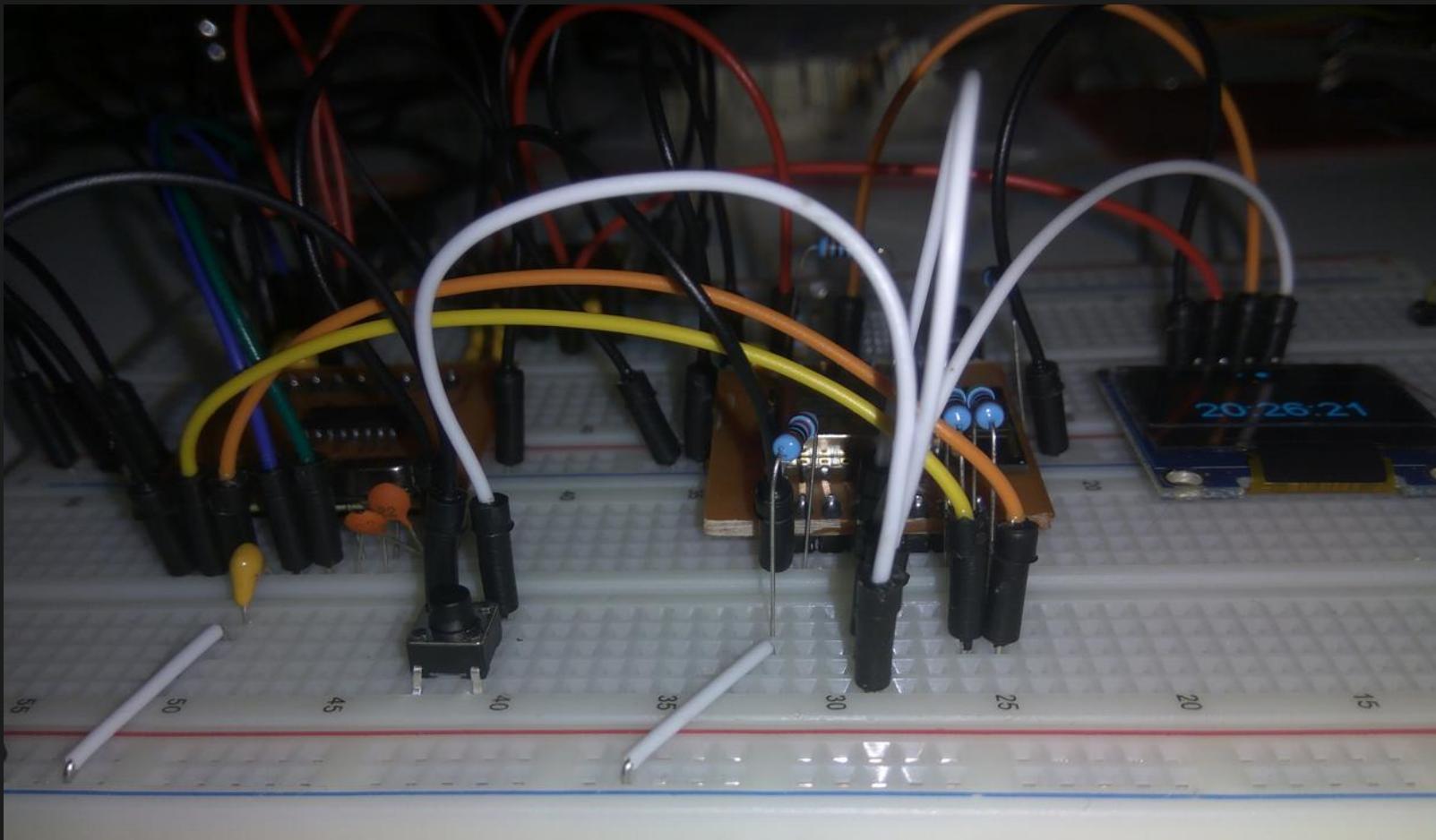
Prototyping

Assemble adapter with the ICs

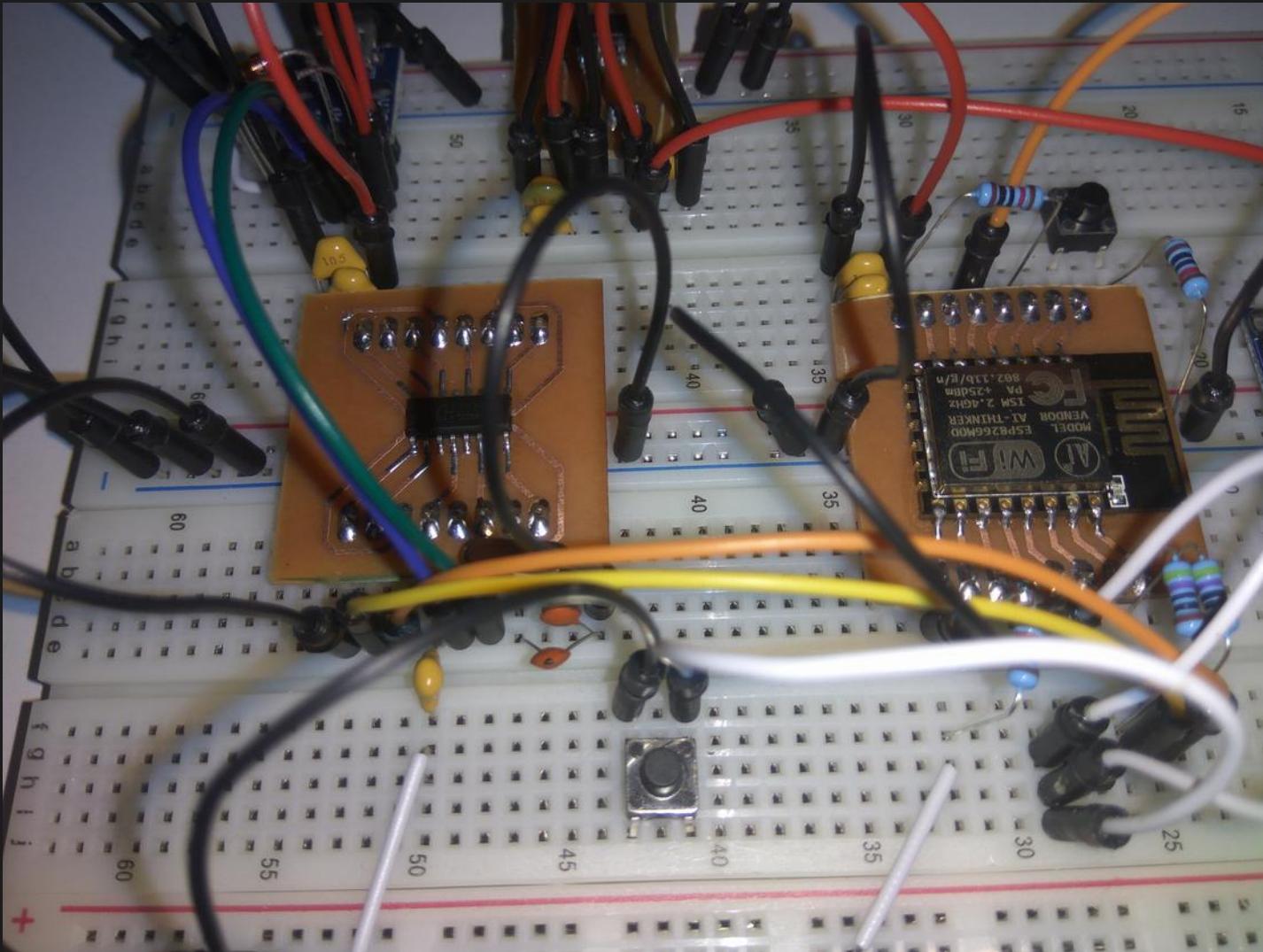


Prototyping

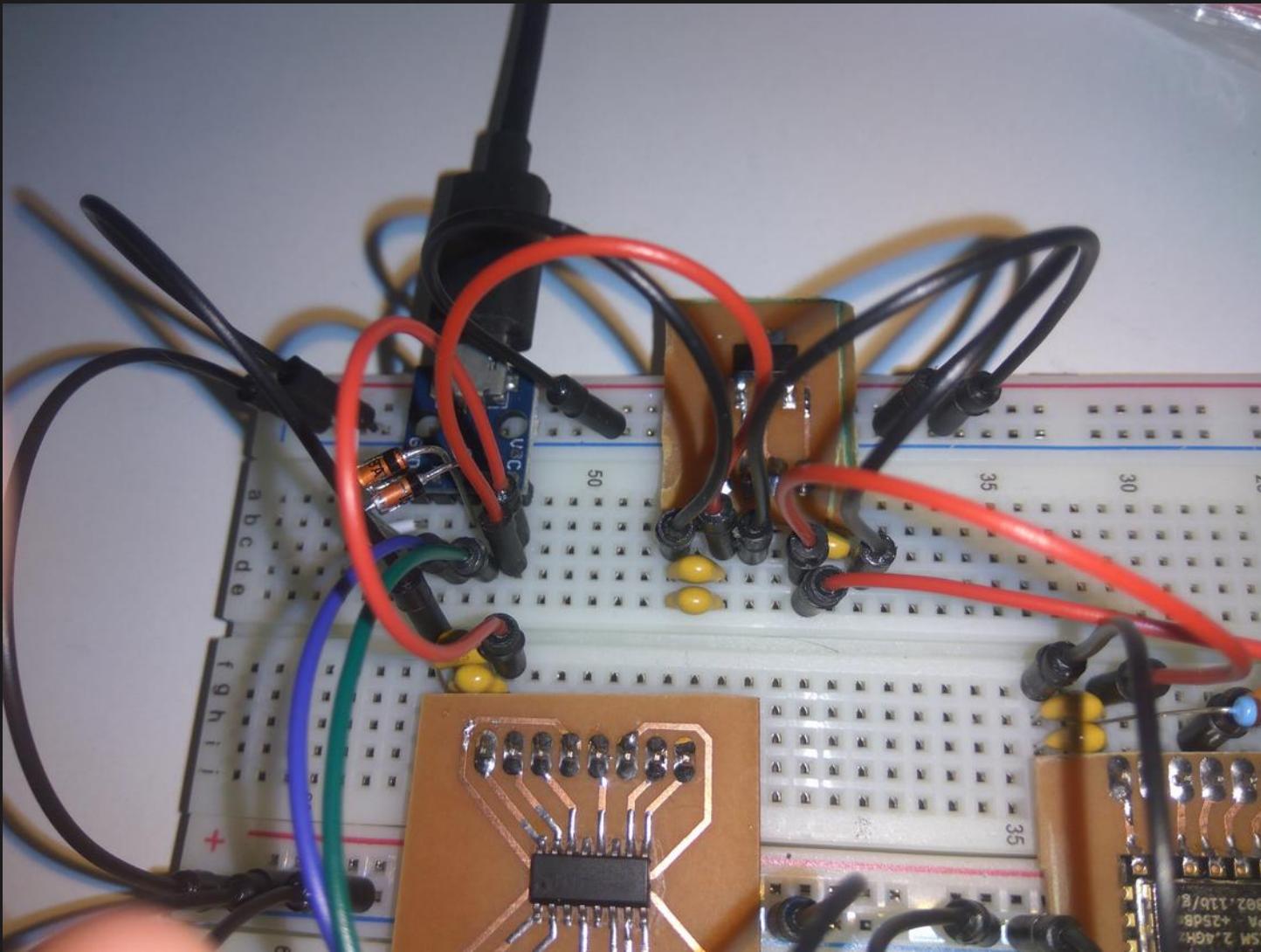
Try to put everything together



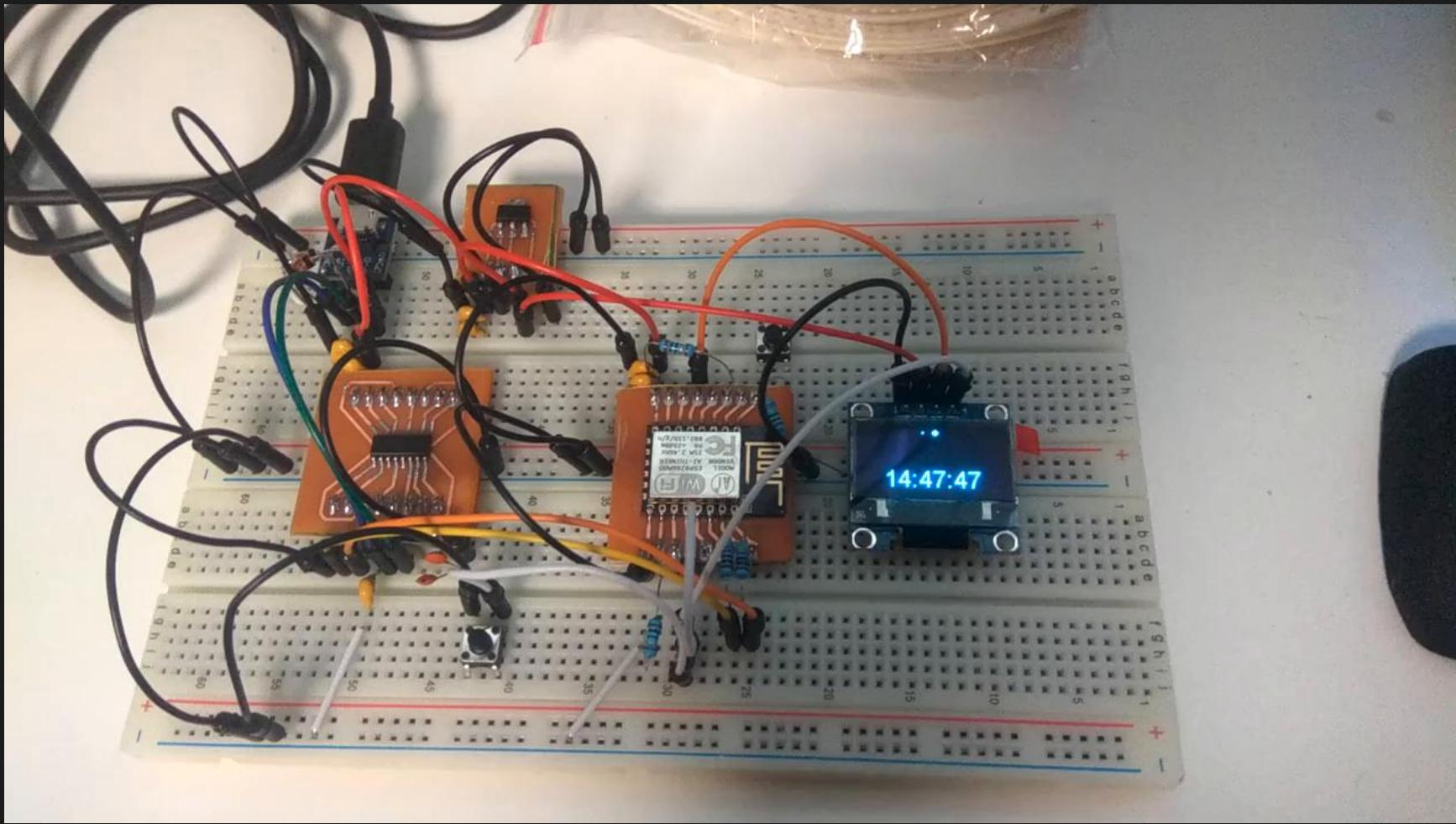
Prototyping



Prototyping



Prototyping



Prototyping

CH340G was supposed to work on 5 or 3.3 volts, but I wasn't able to get it working stable on 3.3V



So I had to use some clamping diodes...

Design

When designing circuits, there are many options available, some of the more common ones are:

- Eagle (now property of autocad)
- Altium Designer
- KiCad (open source)

I chose eagle which comes with lifetime license when you are a r2 user ☺

Design

Not choosing open source.

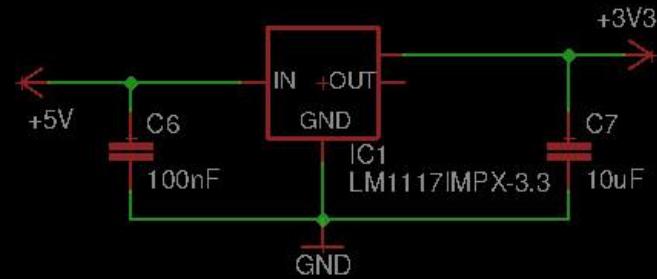
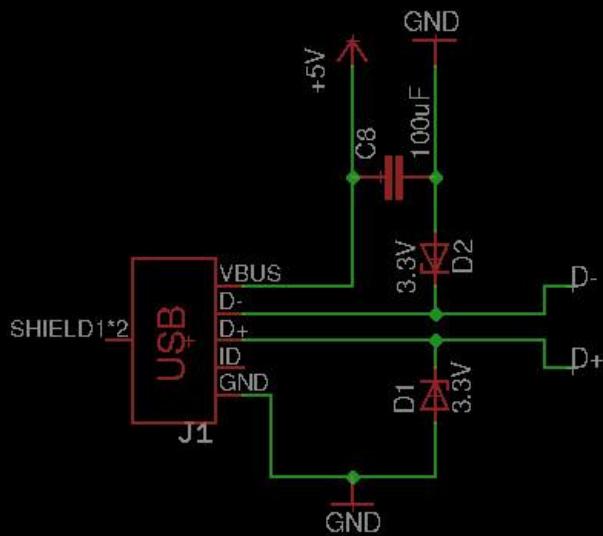


SHAME. SHAME. SHAME.

Design: Schematics

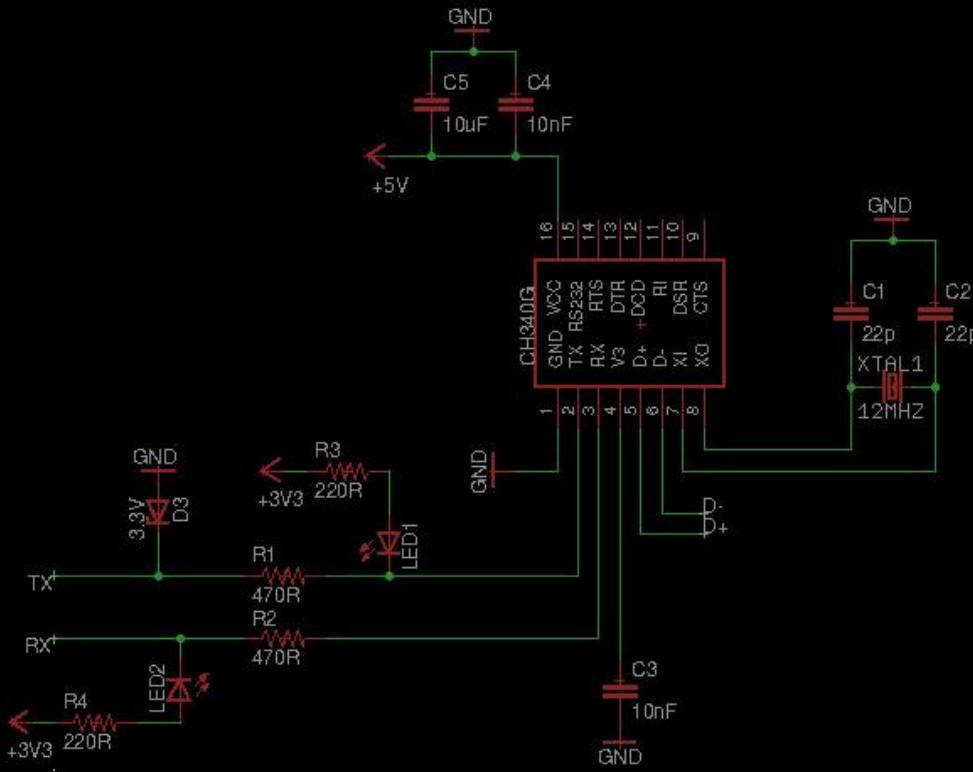
First of all we have to translate our breadboard prototype into schematics.

USB AND POWER



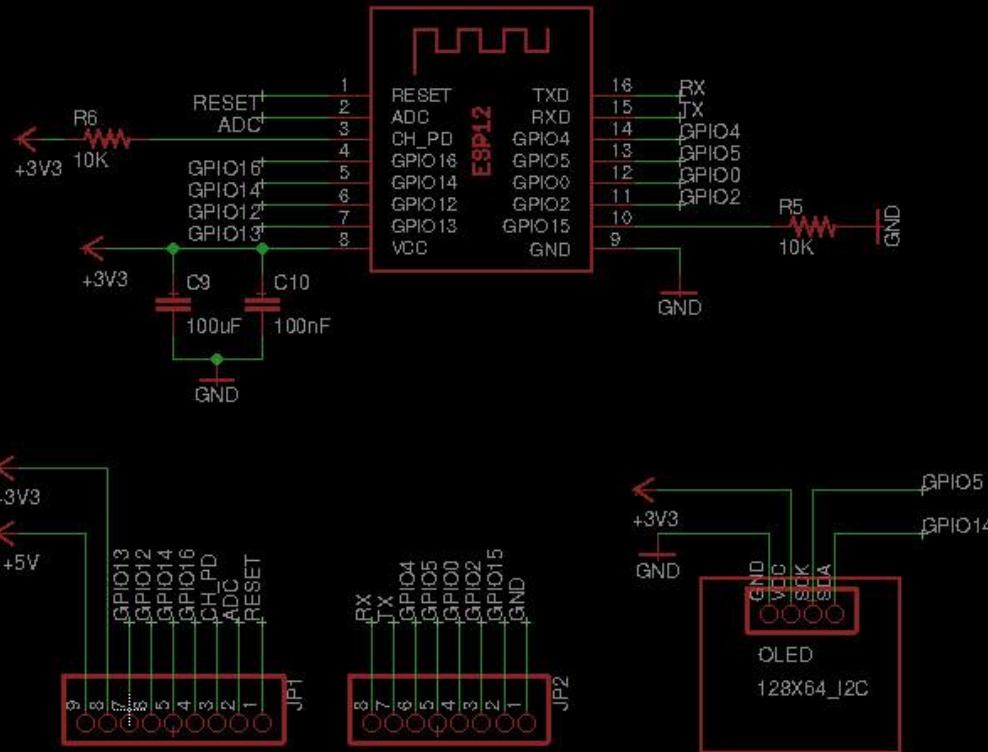
Design: Schematics

USB TO SERIAL CONVERTER



Design: Schematics

ESP CORE, SCREEN AND HEADERS



Board Layout

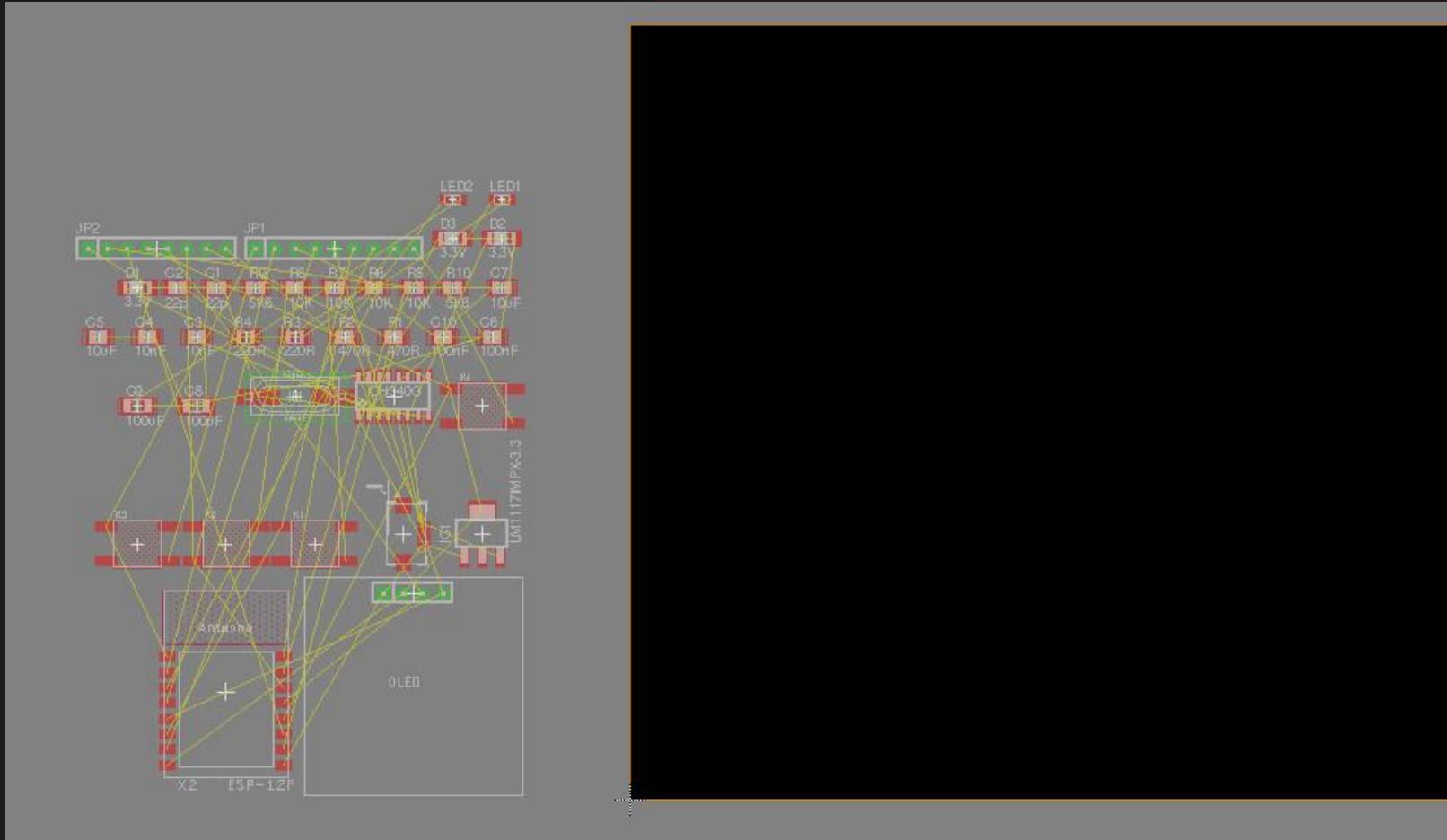
Once you have the schematics you have to layout the board by moving every component into place and connecting everything without crossing traces.

Depending on the number of layers you can use bias to reroute signals into other layers.

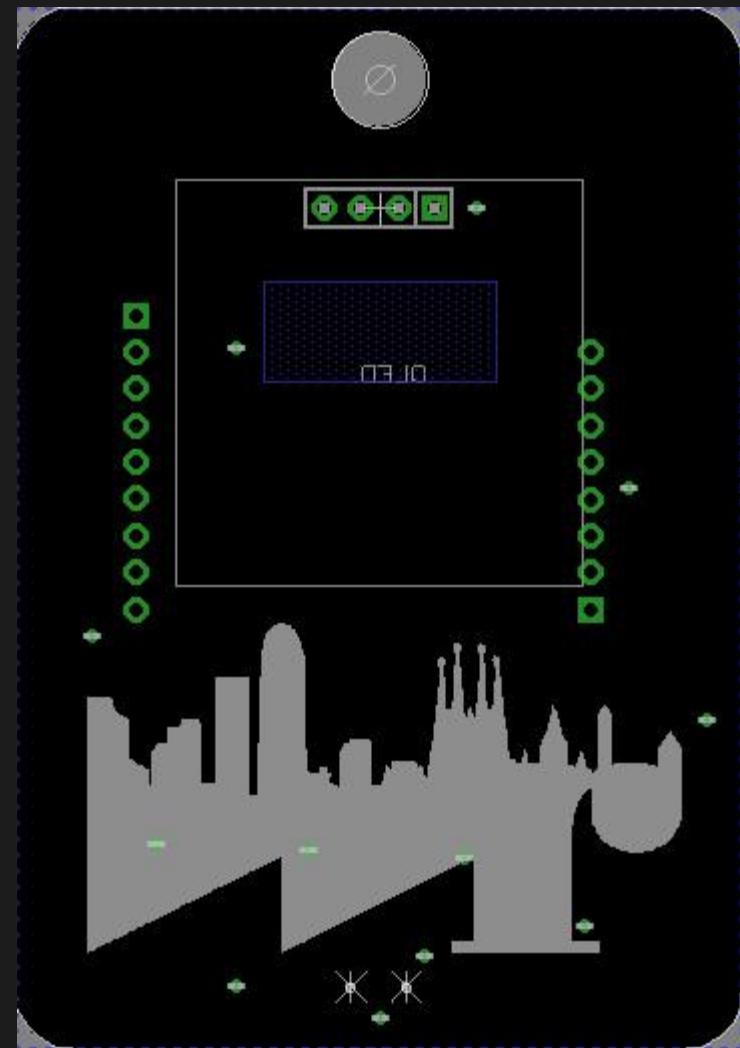
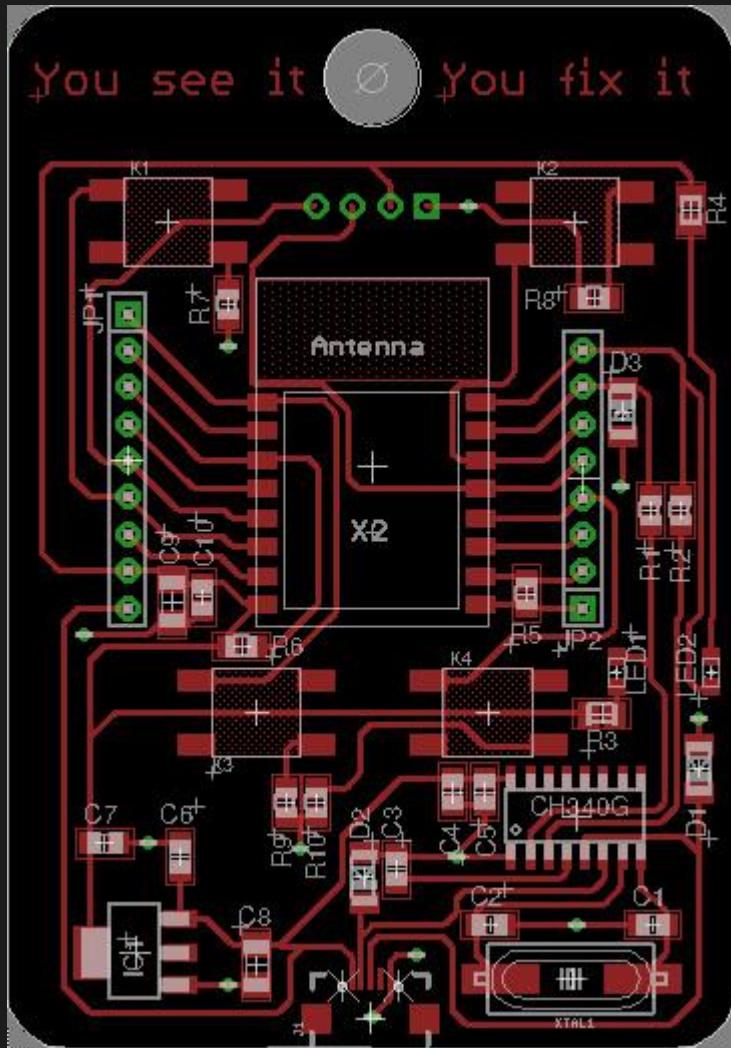
This is basically like solving a puzzle.

Board Layout

This is what it looks like at start



Board Layout

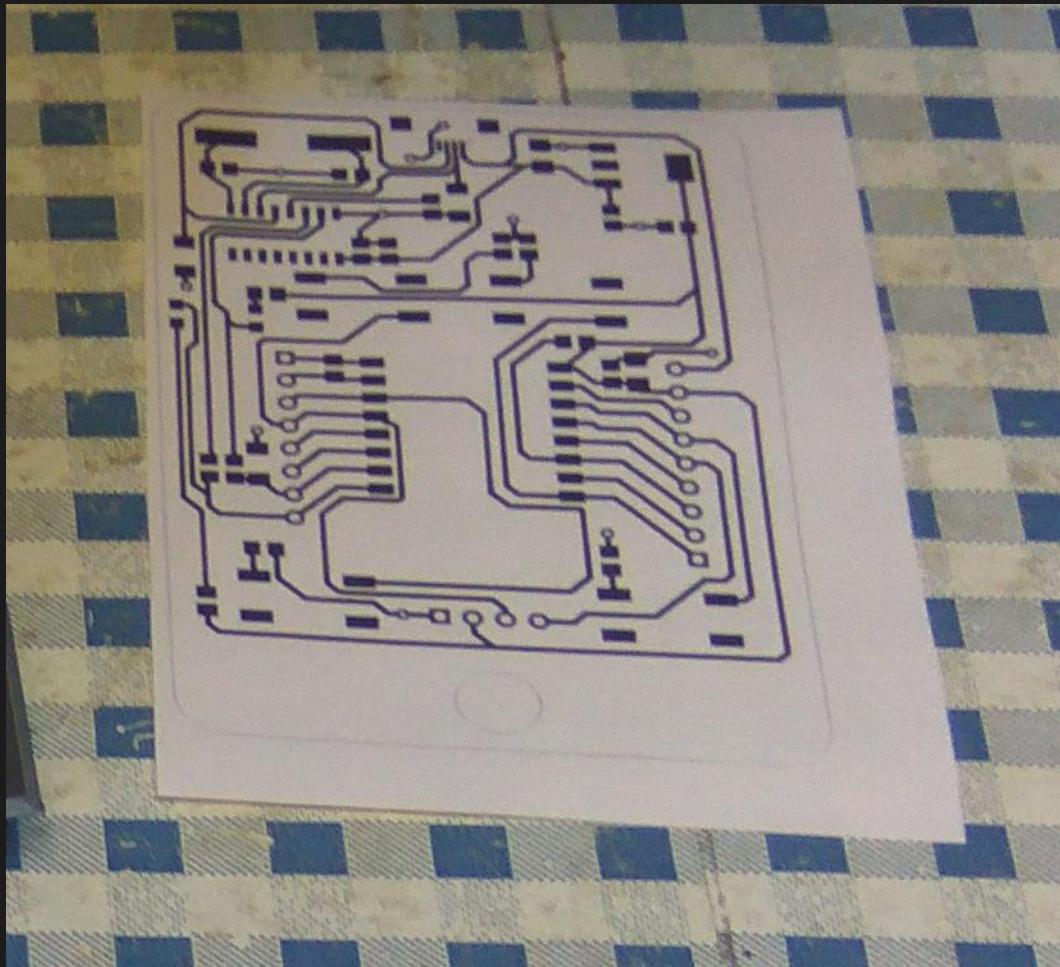


Testing Design

In order to test the PCB design prior sending into production, I tested it by making home PCBs using the toner transfer technique and soldering components by hand.

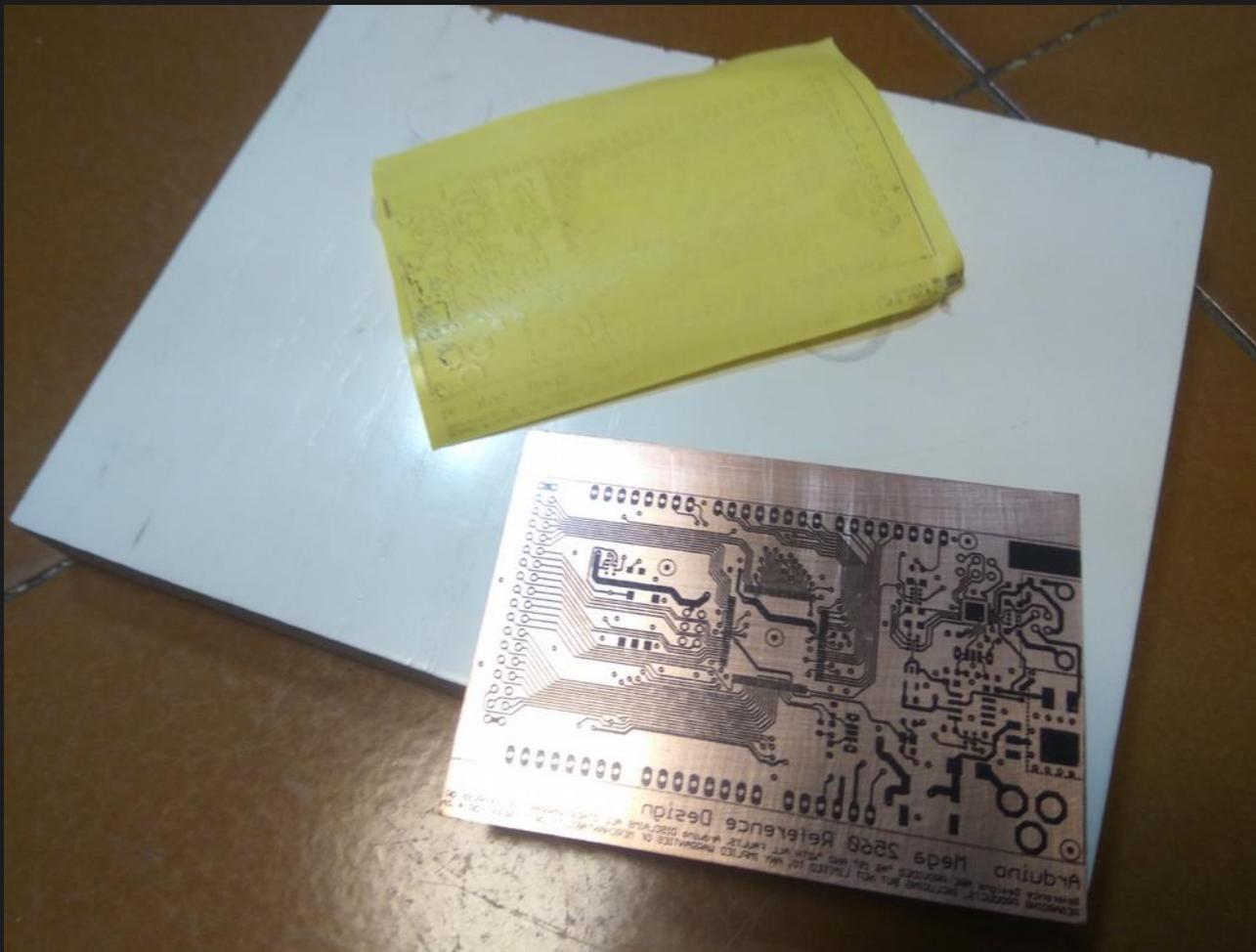
Testing Design

Print design into paper



Testing Design

Transfer the toner into the PCB



Testing Design

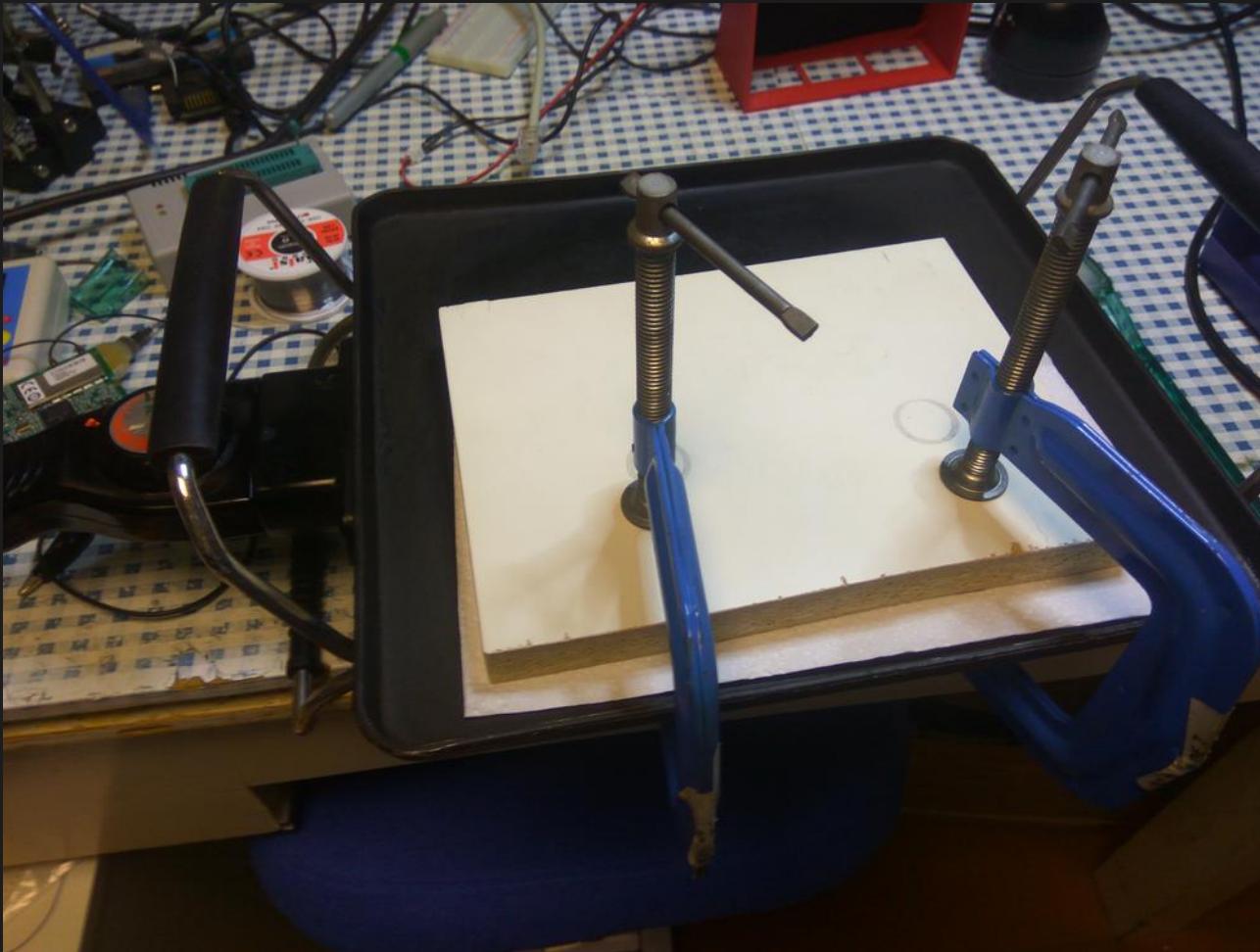
Toner transfer can be done using normal paper or coated/glossy paper (much better).

The toner is transferred from the paper into the PCB by applying heat and pressure. This can be done in multiple ways:

- Normal home iron
- Frying pan (electric ones should do)
- Laminator

Testing Design

Toner transfer using electric pan



Testing Design

Toner transfer using laminator (easy to mod)

A white AmazonBasics A4 laminator with a black base and a control panel with buttons and a small display screen.

AmazonBasics - Plastificadora A4
de [AmazonBasics](#)

 96 opiniones de clientes | 22 preguntas respondidas

Precio: **EUR 22,49 ✓prime** | GRATIS Envío 1 día
Precio final del producto

En stock.

¿Quieres recibirla el miércoles 6 sep.? Cómpralo antes de **12 hrs y 36 mins** y elige **Entrega hoy** al completar tu pedido. [Ver detalles](#)

Vendido y enviado por Amazon con paquete certificado **abrefácil**. Se puede envolver para regalo.

Nombre de estilo: **Plastificadora**

Plastificadora EUR 22,49 ✓prime	Plastificadora + Láminas EUR 48,47 ✓prime
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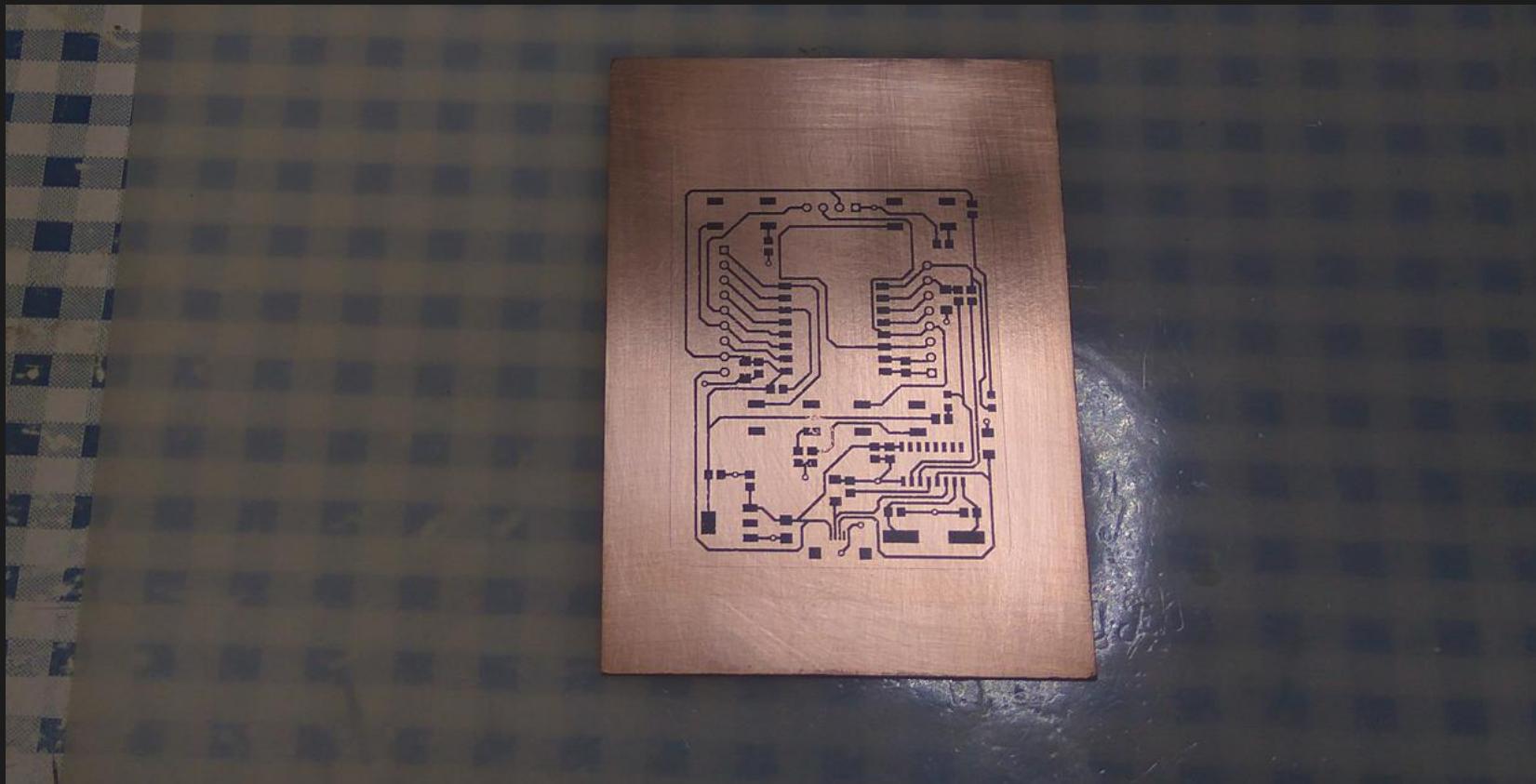
- Plastifica documentos de hasta 22,9 cm de ancho.
- Control de temperatura seleccionable de 2 posiciones: 80 µm y 125 µm
- Apropiada para fotografías.
- Para plastificar con fundas de hasta 5 mil de grosor.
- Dos fundas plastificadoras de 24 x 28 cm incluidas.

[Avisar de alguna información del producto errónea.](#)

Se envía en el embalaje original:
Este producto se envía en la caja del fabricante, por lo que en su exterior se muestra lo que contiene. Si

Testing Design

Toner transfer results



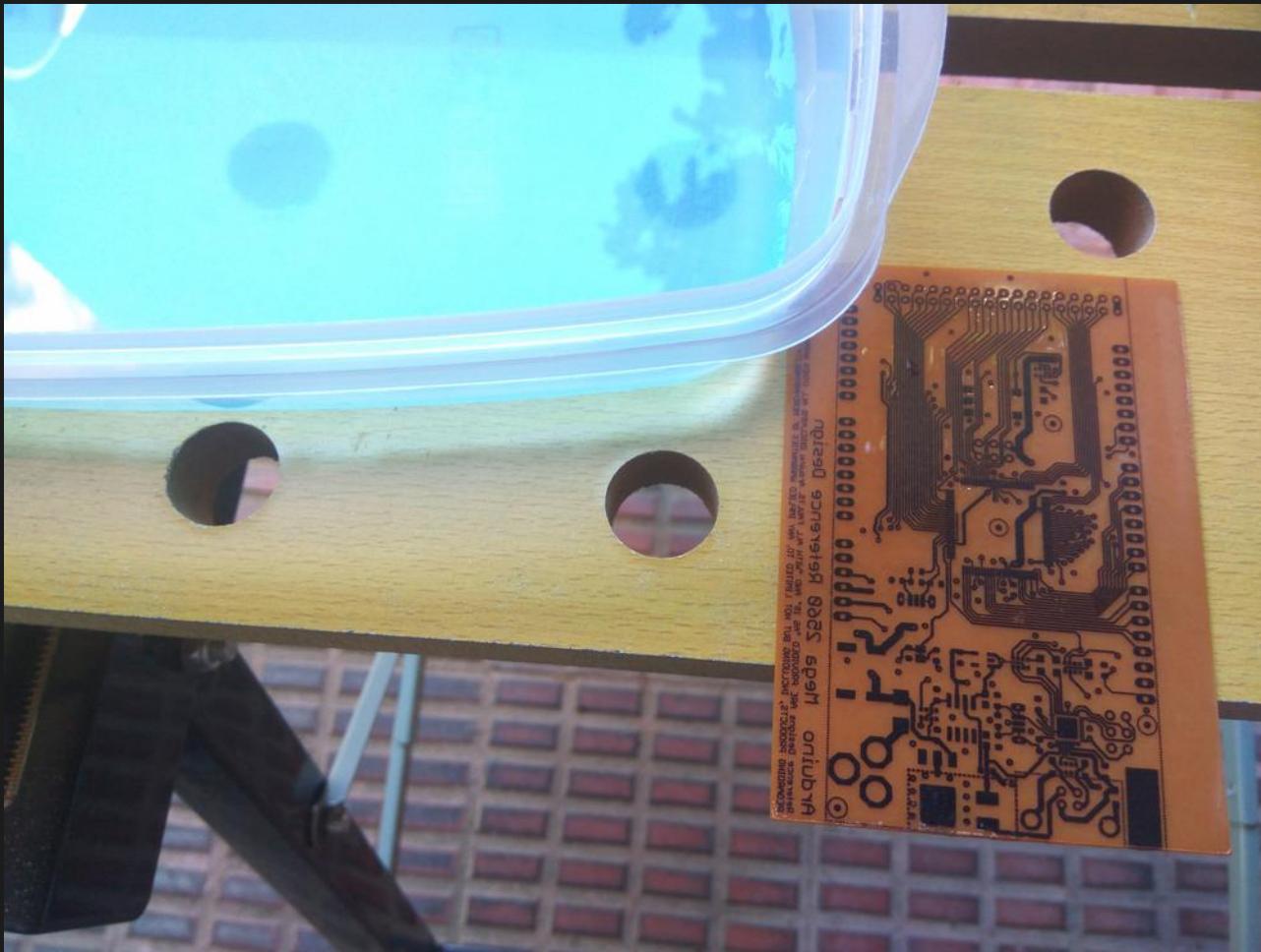
Testing Design

Etching (remove exposed copper)



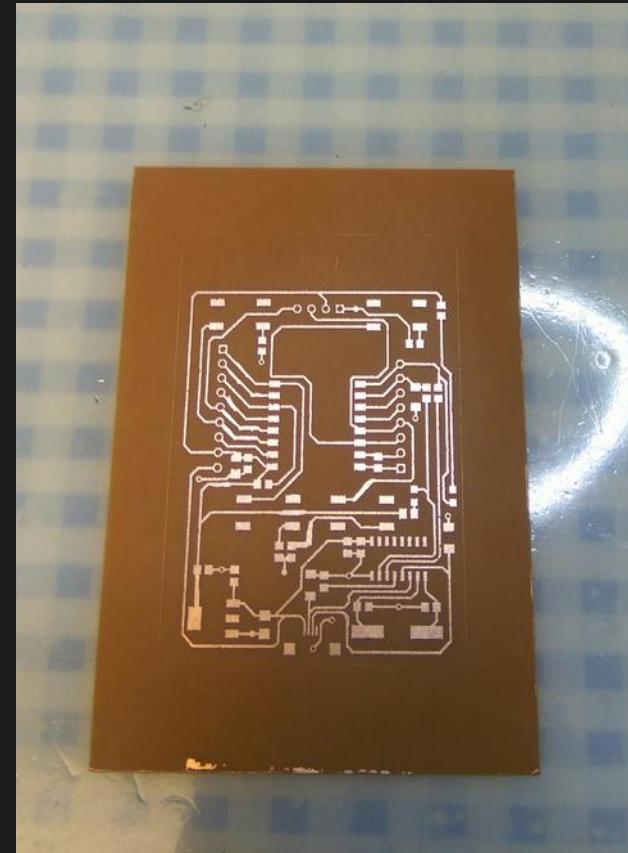
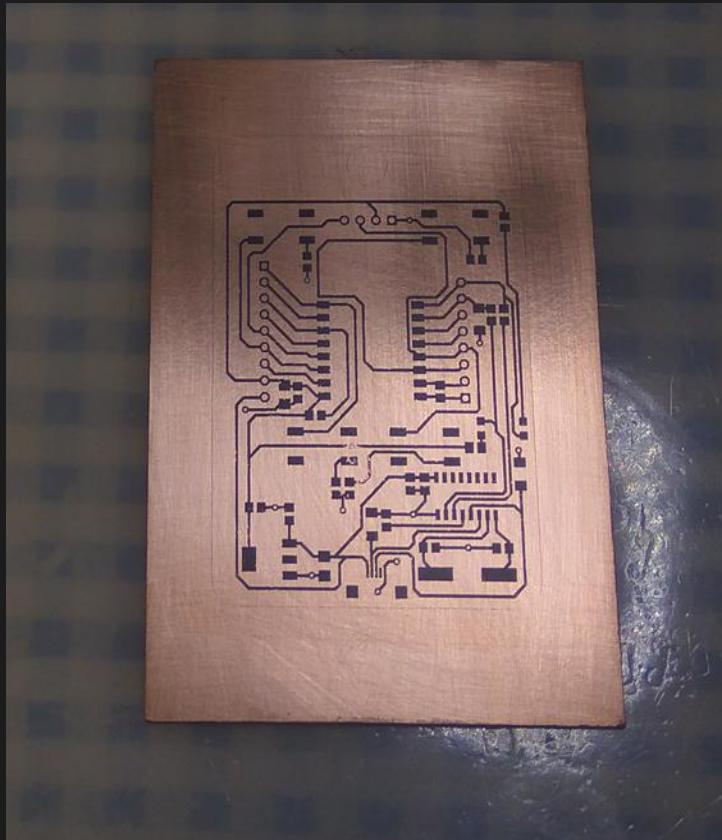
Testing Design

Board after removing the copper



Testing Design

Toner transfer technique after etching



Testing Design

Once the boards are etched, you can apply solder mask. Although usually is not worth the trouble when making home made PCBs.

You can find solder mask in multiple formats:

- Paste solder mask
- Dry film
- Coating sprays

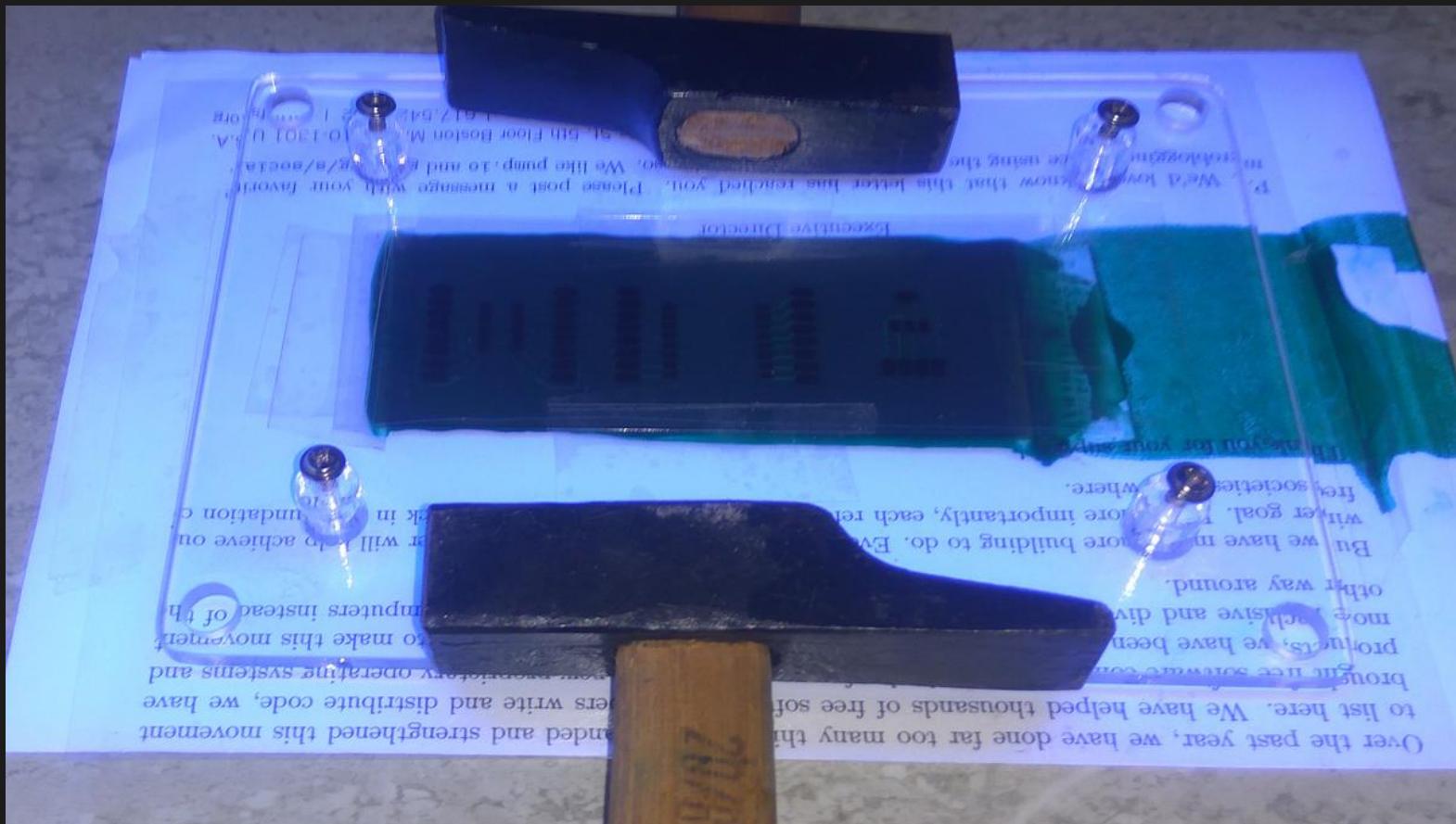
Testing Design

Paste solder mask



Testing Design

Applying solder mask



Testing Design

There are some other methods for creating PCBs, such as milling, etc... Or even lasers. Everybody loves lasers!



Testing Design

Testing Design



Testing Design

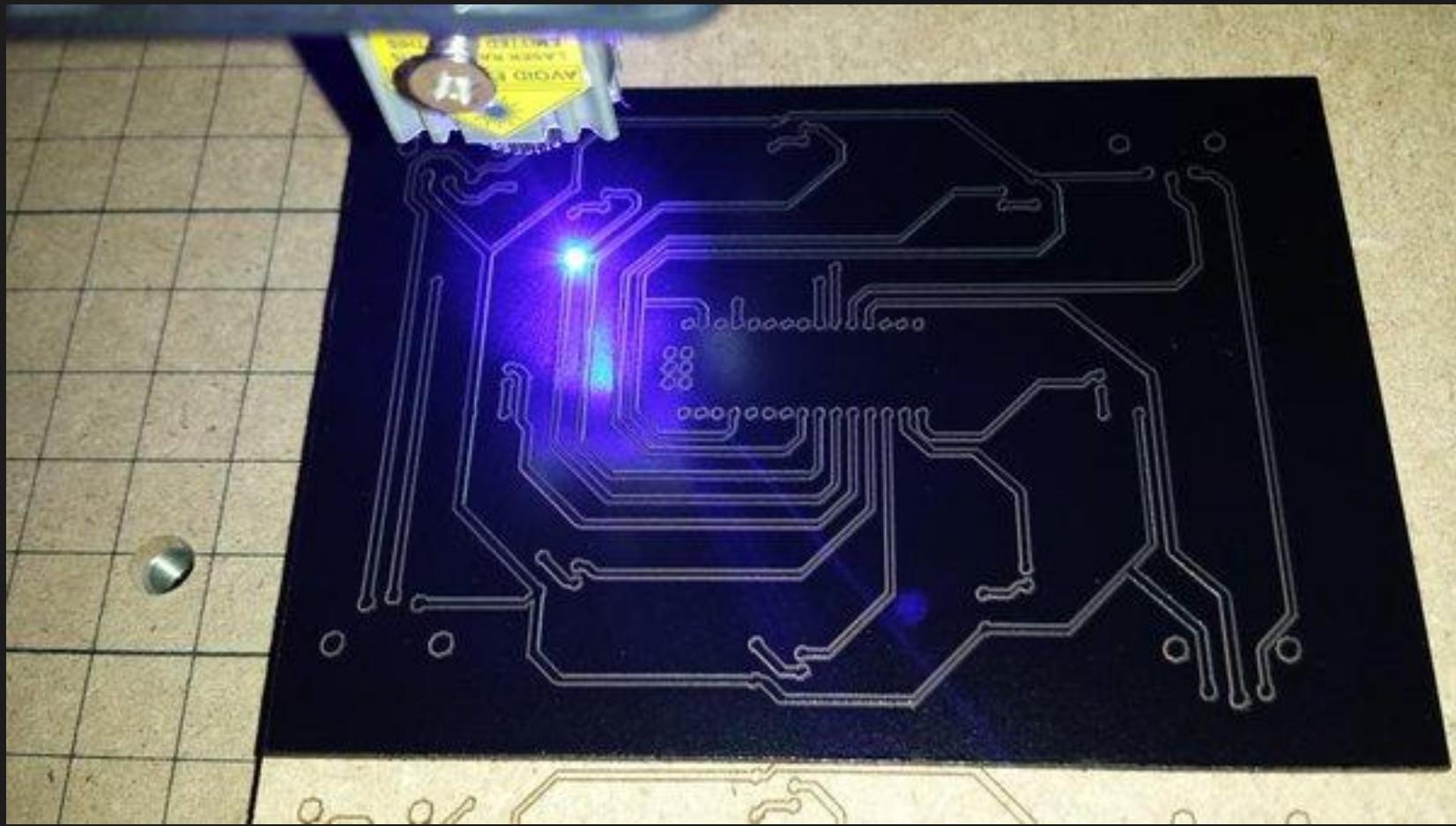
Using a laser mounted on a CNC machine or 3D printer you can do multiple things:

- Coat blank copper PCBs with paint, and then remove the paint using the laser to print the design instead of using toner transfer technique.
- Remove soldermask from pcb pads.

Sadly I didn't have the time to test it...

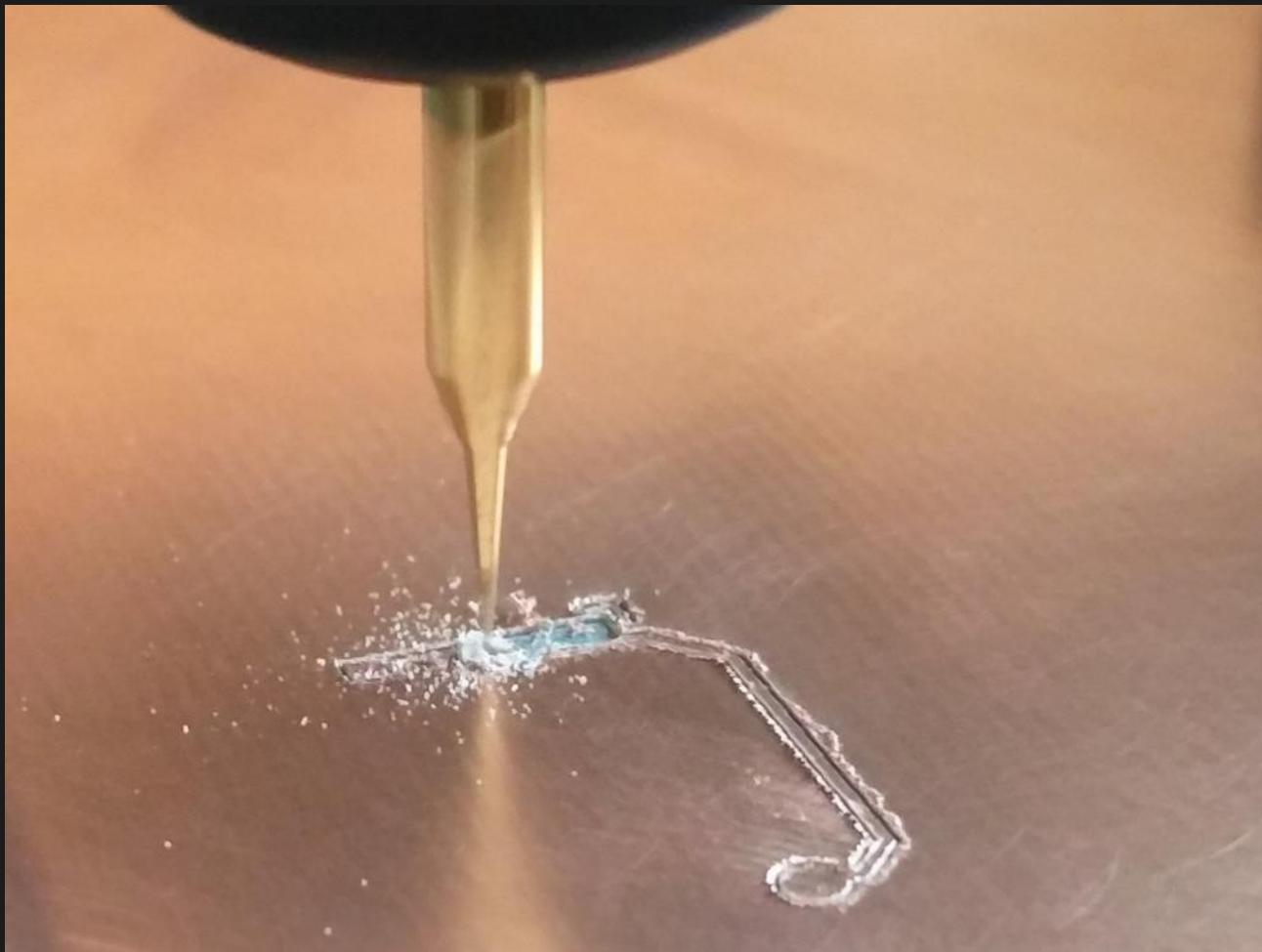
Testing Design

Laser



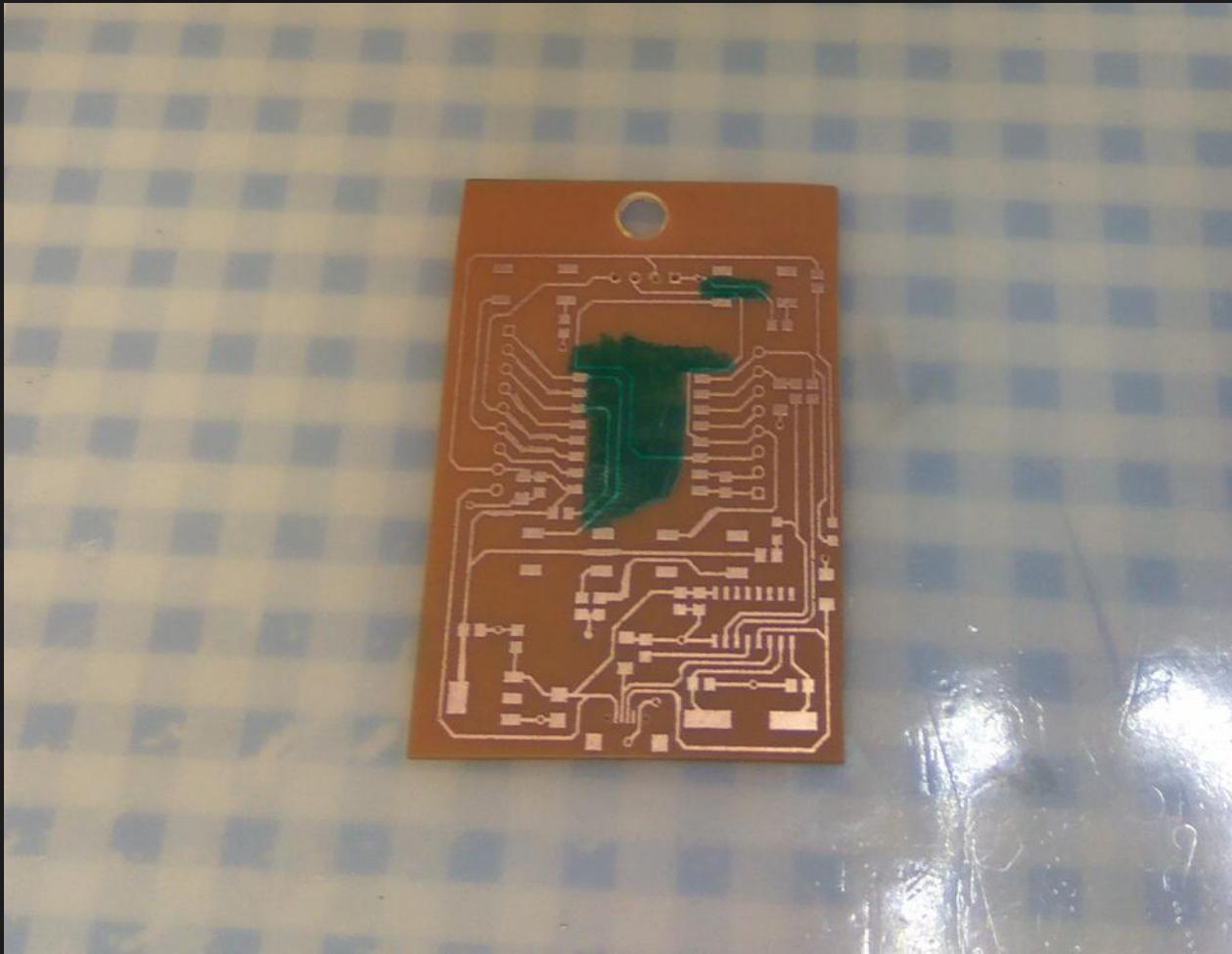
Testing Design

CNC Milling



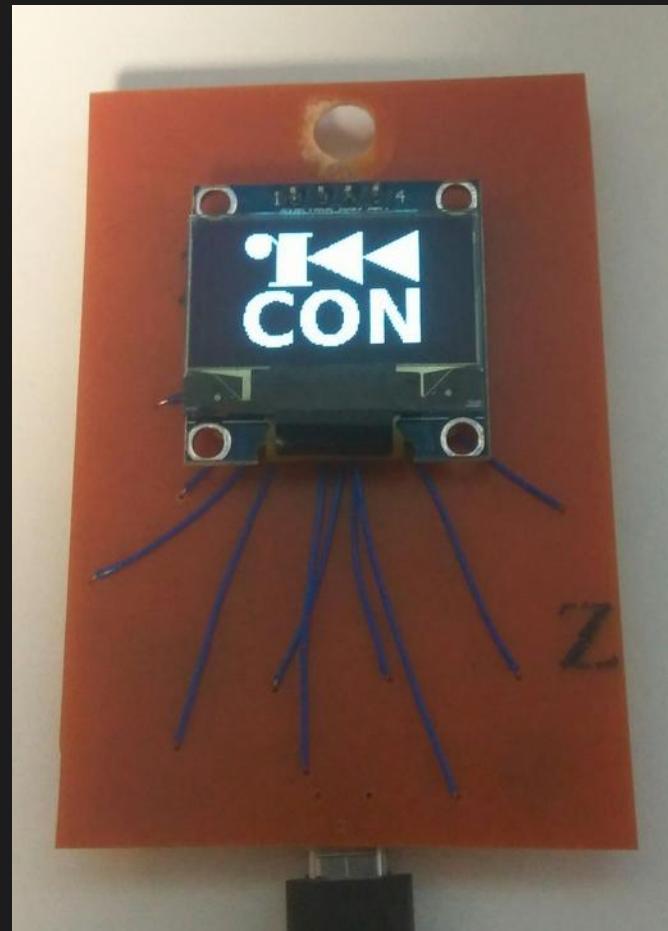
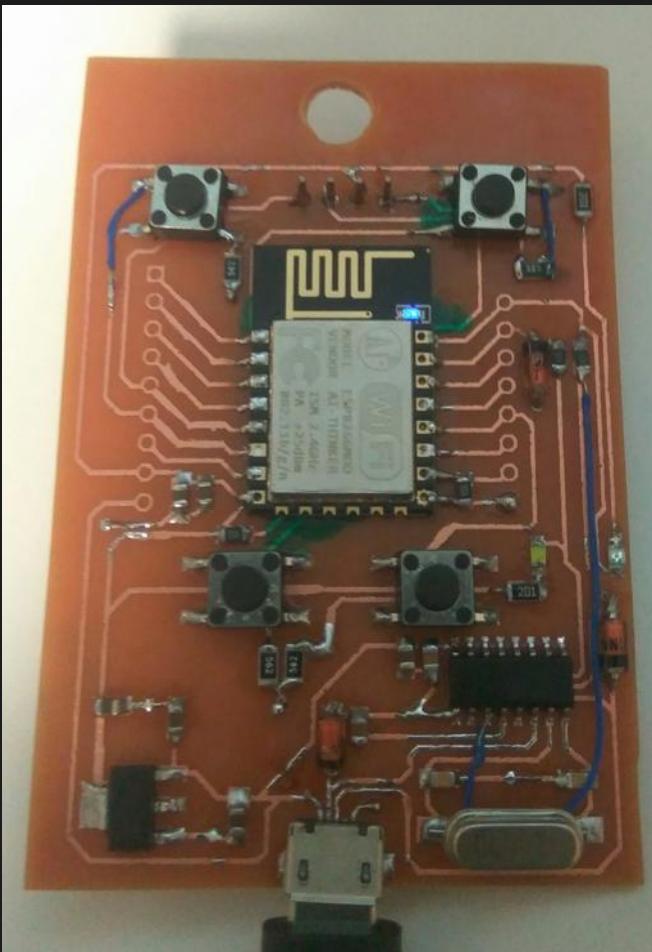
Testing Design

Cut, drill bias, holes, etc...



Testing Design

Finally solder the components



Manufacturing

Once we have checked everything is working and fixed any bugs we found during the process, we can start to manufacture the badges.

We just have to generate gerber files from our pcb layout and send them to our preferred manufacturer.

Manufacturing: PCBs

PCB manufacturing have become really cheap lately. You can get pretty good quality PCBs at prices as low as 5 USD per 5 PCBs.

Some known places are:

- PCBWay
- Seeed Studio
- OSH Park

Manufacturing: PCBs



Manufacturing: PCBs

I chose seedstudio and I think quality was pretty good, although these services are supposed to be for prototyping instead of manufacturing which they use to offer at higher prices with better quality.

Manufacturing: PCBs

Seeedstudio were kind enough to contact me offering discount coupon codes for people attending r2con.

https://www.seeedstudio.com/fusion_pcb.html

<https://www.seeedstudio.com/r2con-2017-badge-g-1026328>

Use coupon: **R2CON** at checkout for 10 boards at 4.9 USD price up to 1st of November.

Assembly: Stencils

If you are planning to make a lot of boards, you might also want to order a stencil. This will save you lots of time, and will make your life easier.

There are multiple places to order.

OSH Stencils (Polyimide): 5 USD (min)

OSH Stencils (SS): 10 USD (min)

Seeedstudio (SS): 9.90 USD

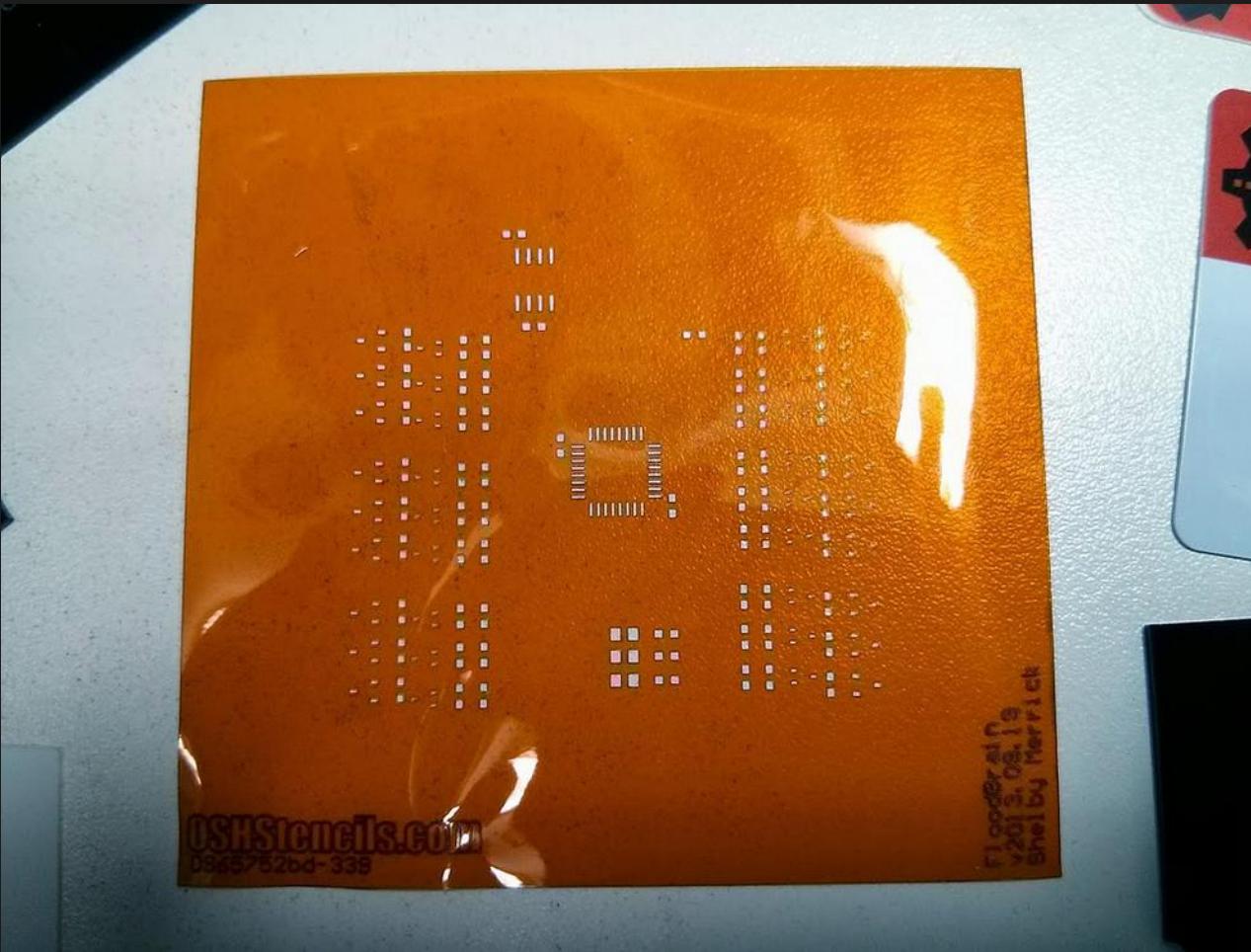
Assembly: Stencils

Again you can also use laser for making
your own stencils



Assembly: Stencils

Polyimide



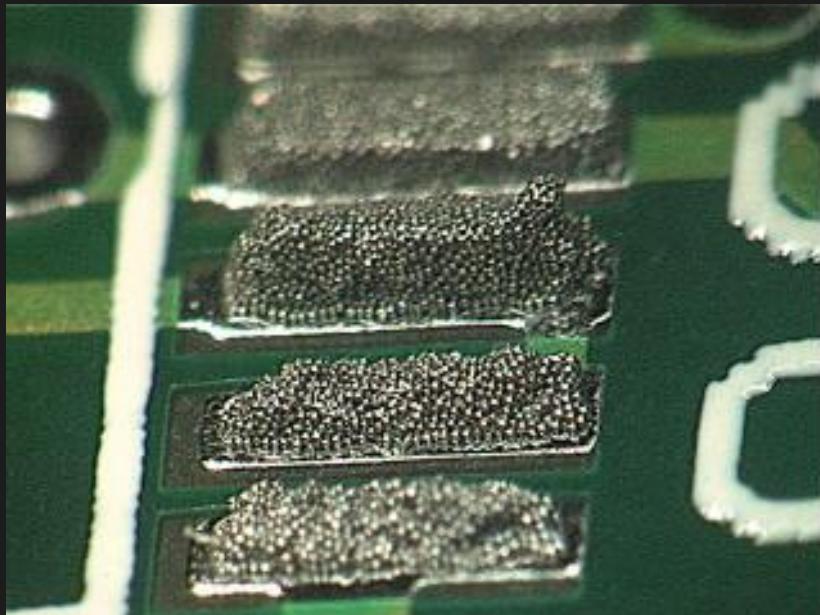
Assembly: Stencils

Stainless Steel

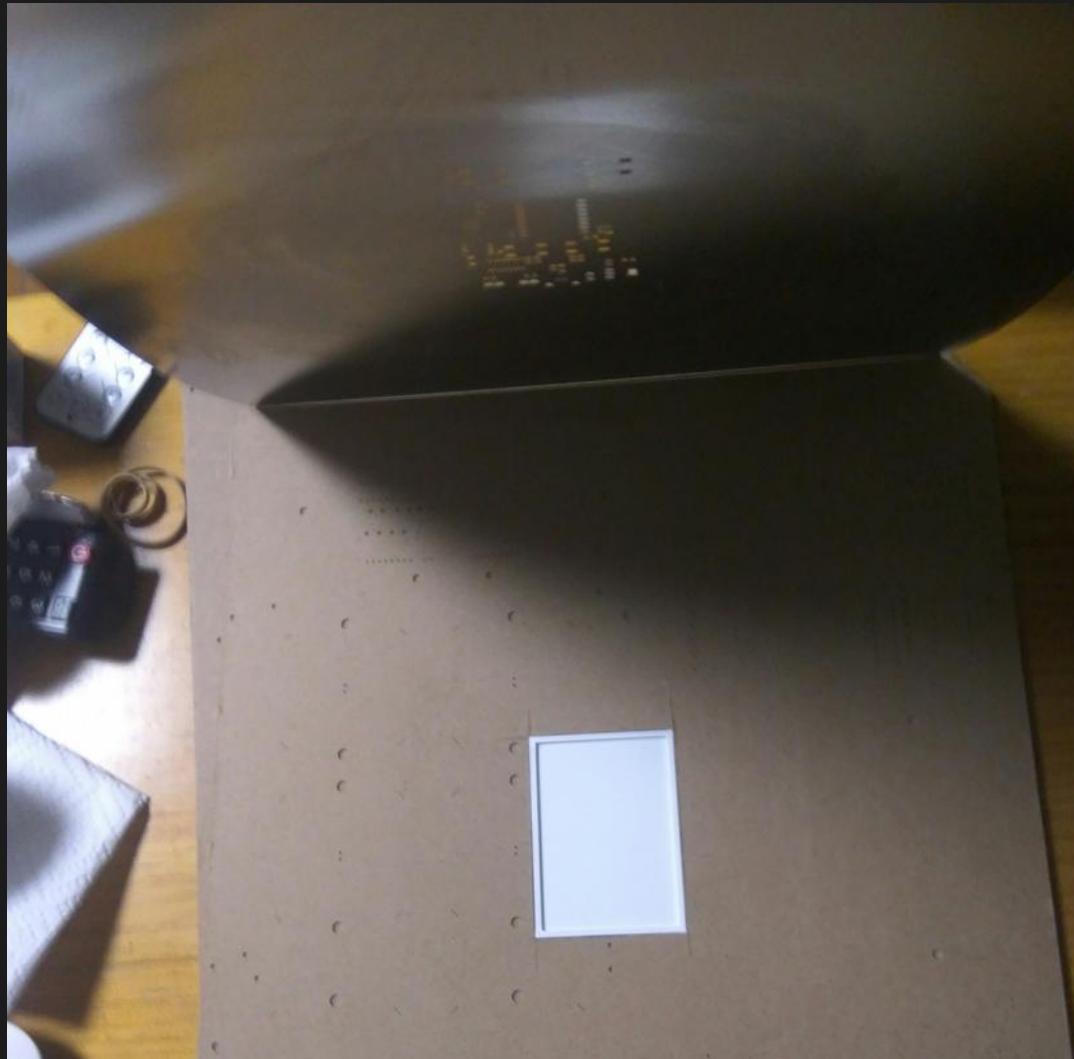


Assembly: Solder paste

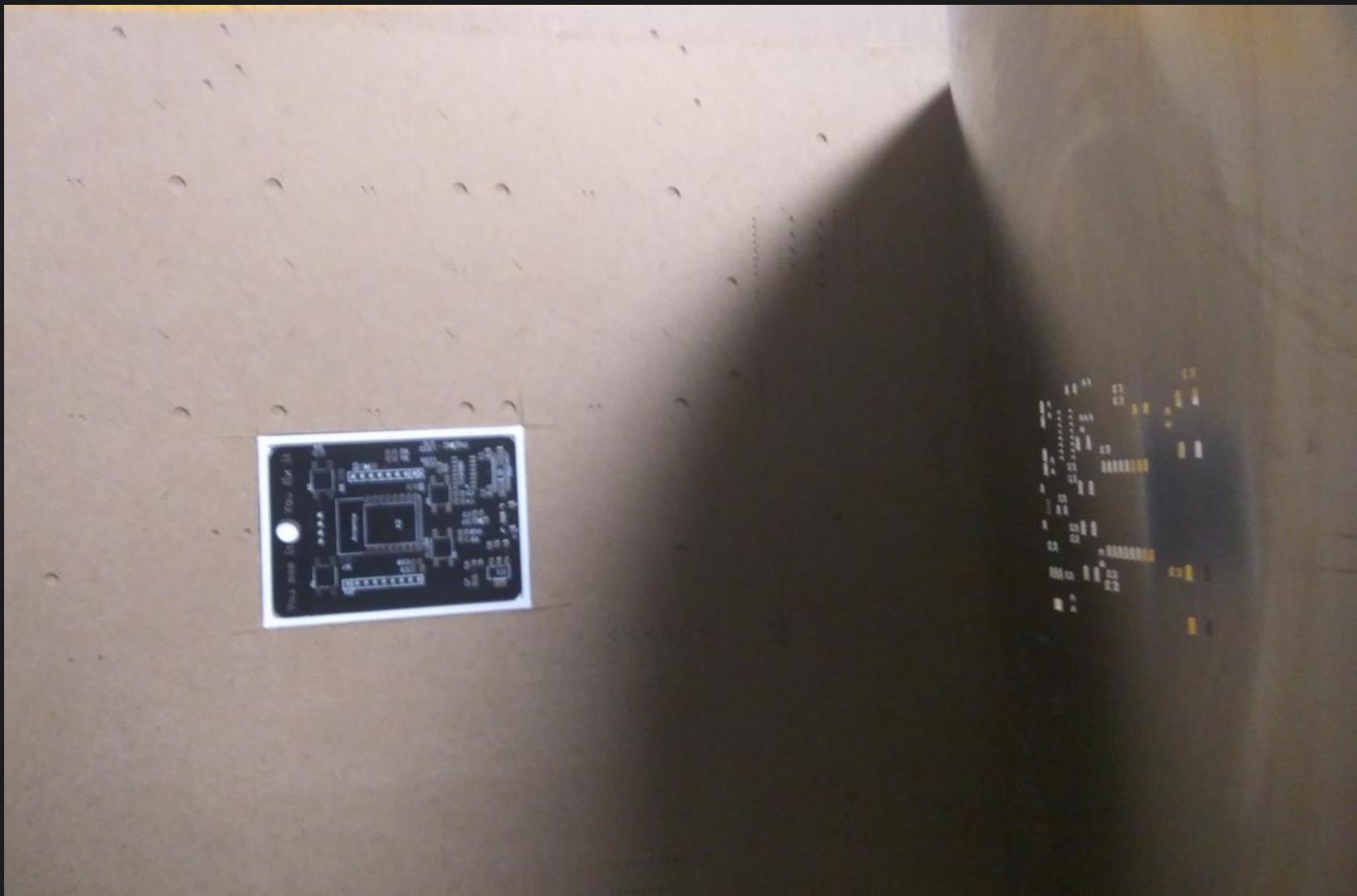
When working with stencils instead of the common solder, solder paste is used. Its basically solder powder + flux



Assembly: Applying paste



Assembly: Applying paste



Assembly: Applying paste



Assembly: Applying paste

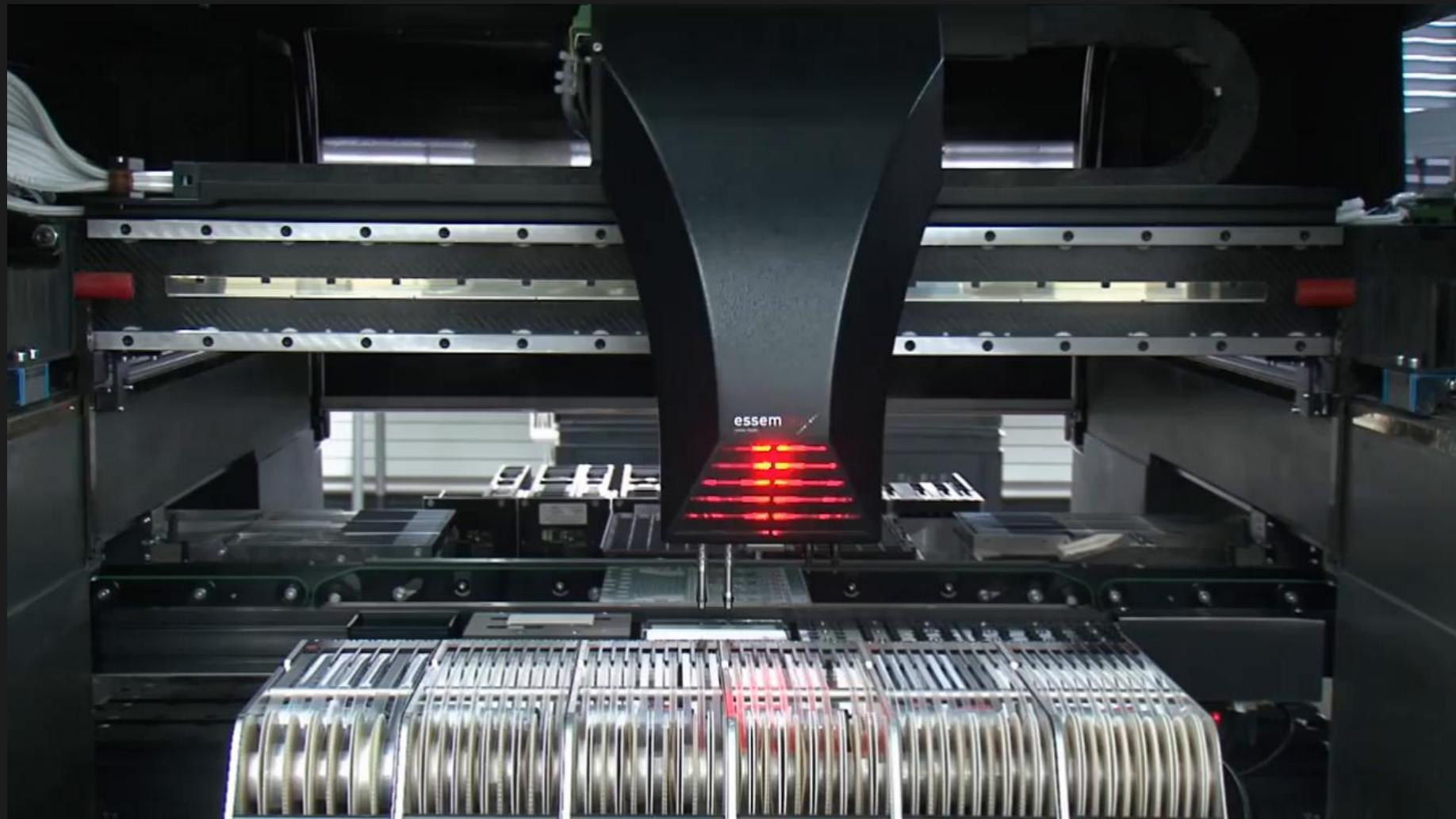


Assembly: Pick & Place

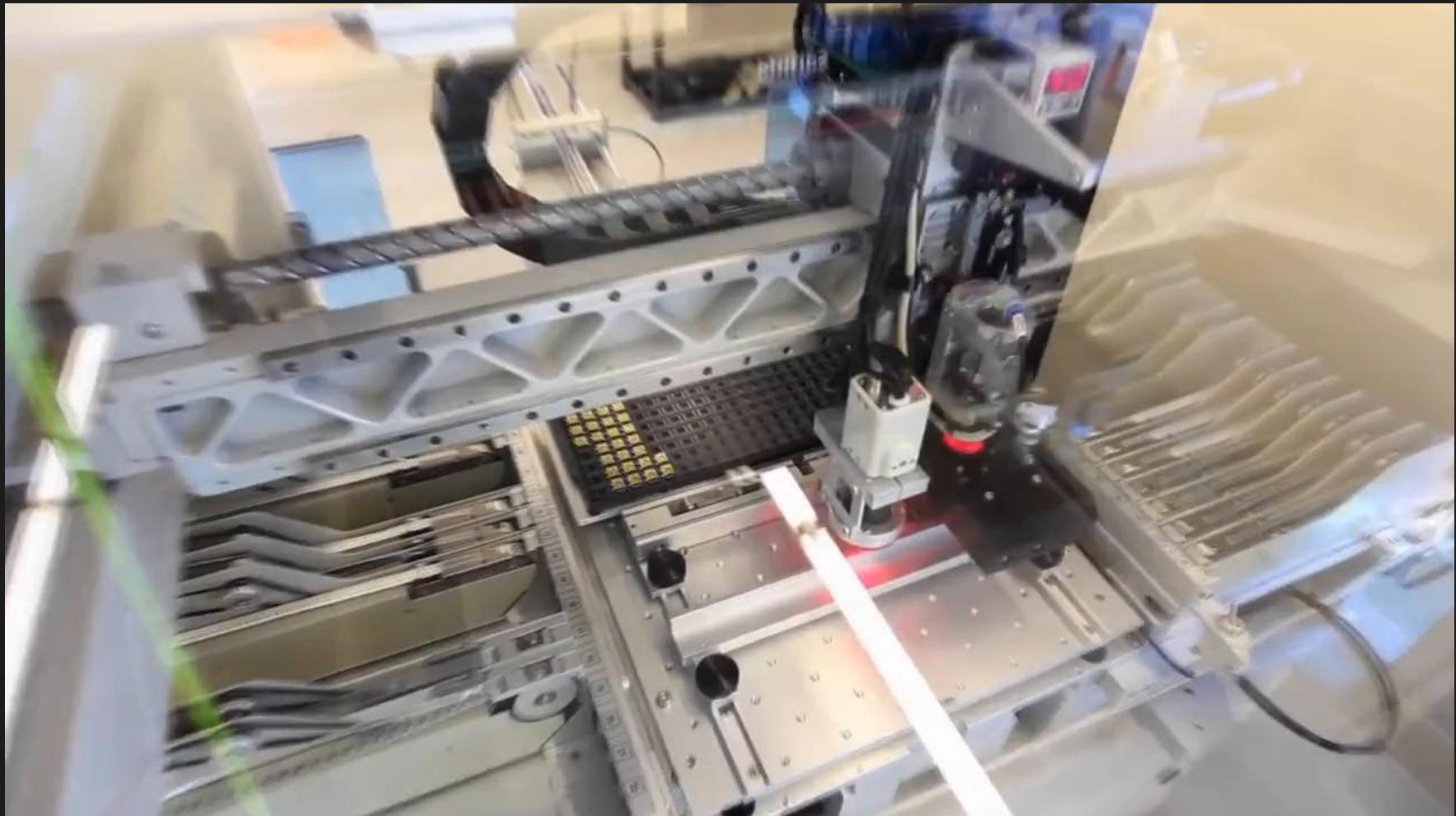
Once the solder paste is in place, you must place each component at its position.

This is done using a pick and place machine, but in our case was done by hand using a pair of tweezers and microscope.

Assembly: Pick & Place



Assembly: Pick & Place



Assembly: Pick & Place

Our human pick and place machine



+



+



Assembly: Pick & Place

Danito working hard....



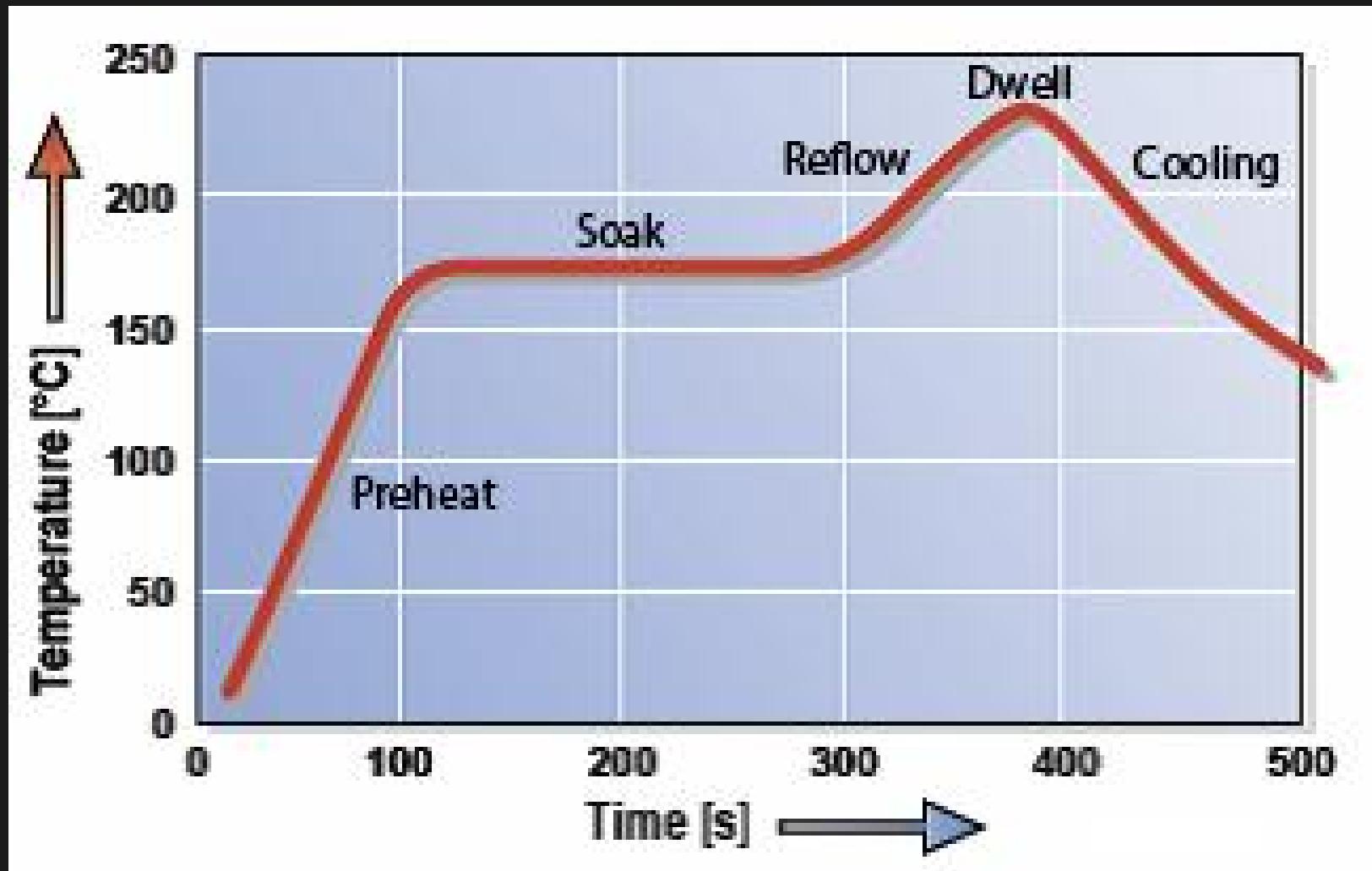
Assembly: Reflow

Once the solder paste and the components are in place, we have to apply heat in order to solder everything.

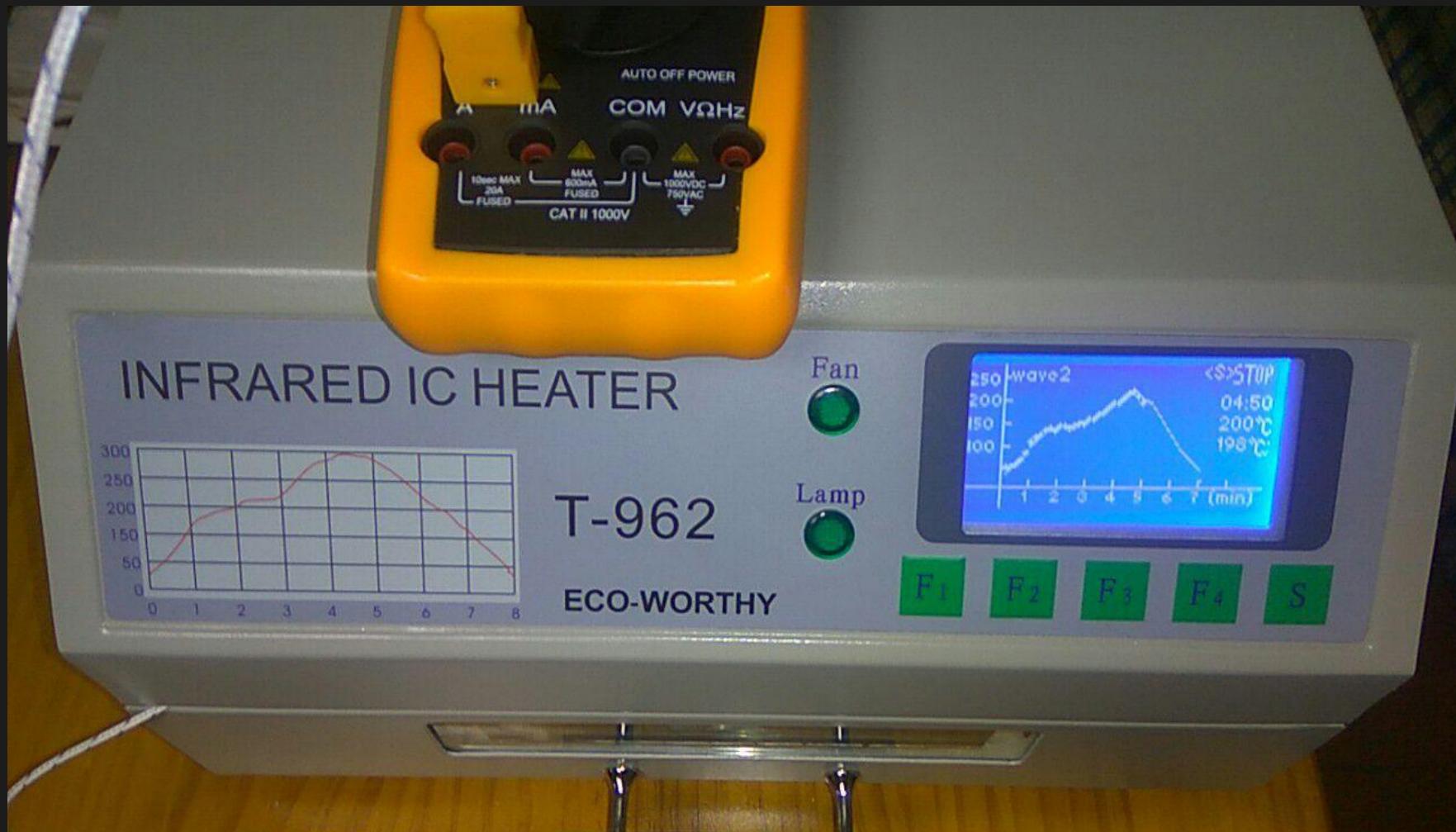
This process is called reflow.

It can be made using a heat gun, a reflow oven, by modifying a toaster or even using a frying pan.

Assembly: Reflow



Assembly: Reflow



Assembly: Reflow

The T-962 is a relatively cheap oven, have been a long time around, and there is a good open source and modding community around.

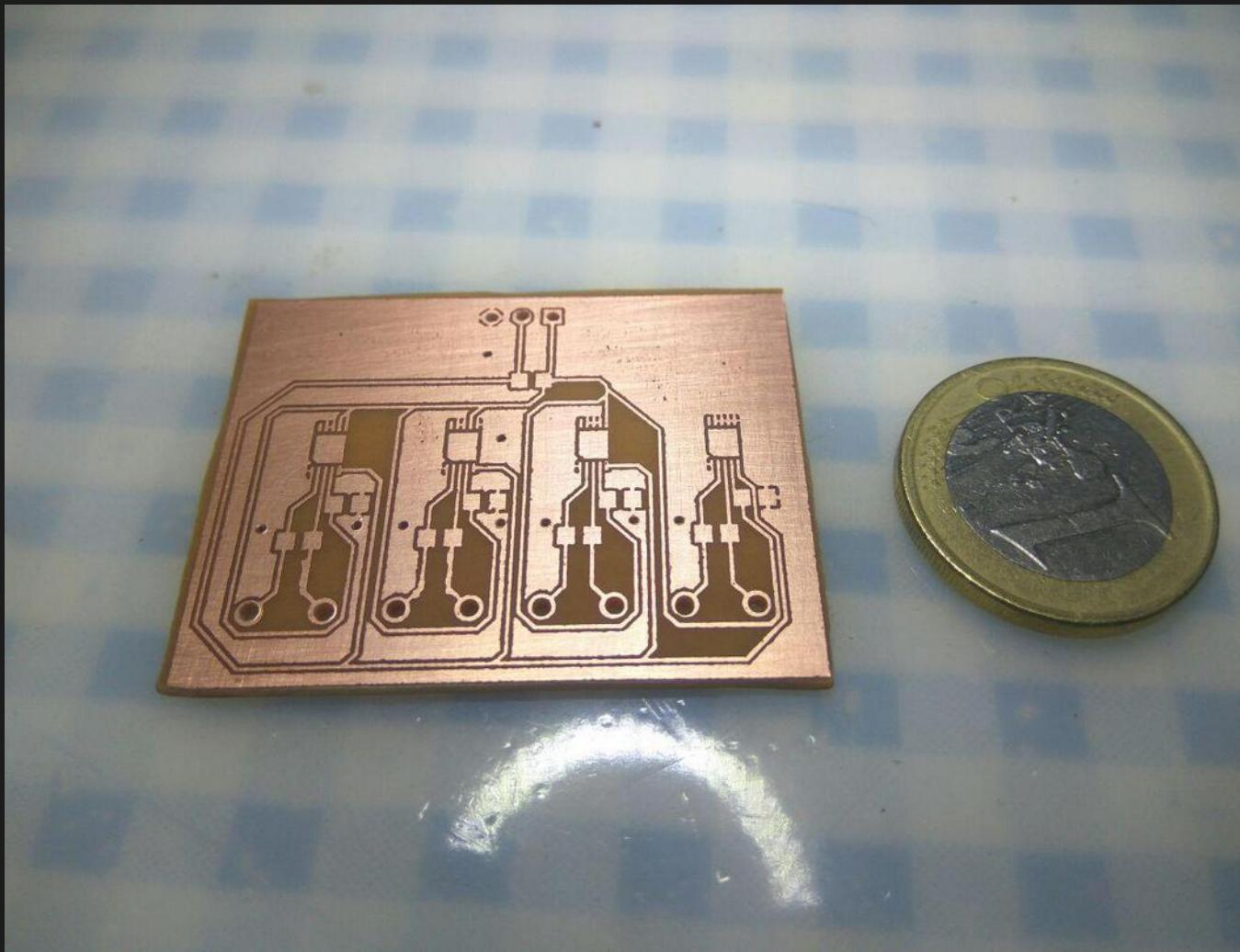
There is even an open source firmware with great improvements compared to the default one.

Assembly: Reflow

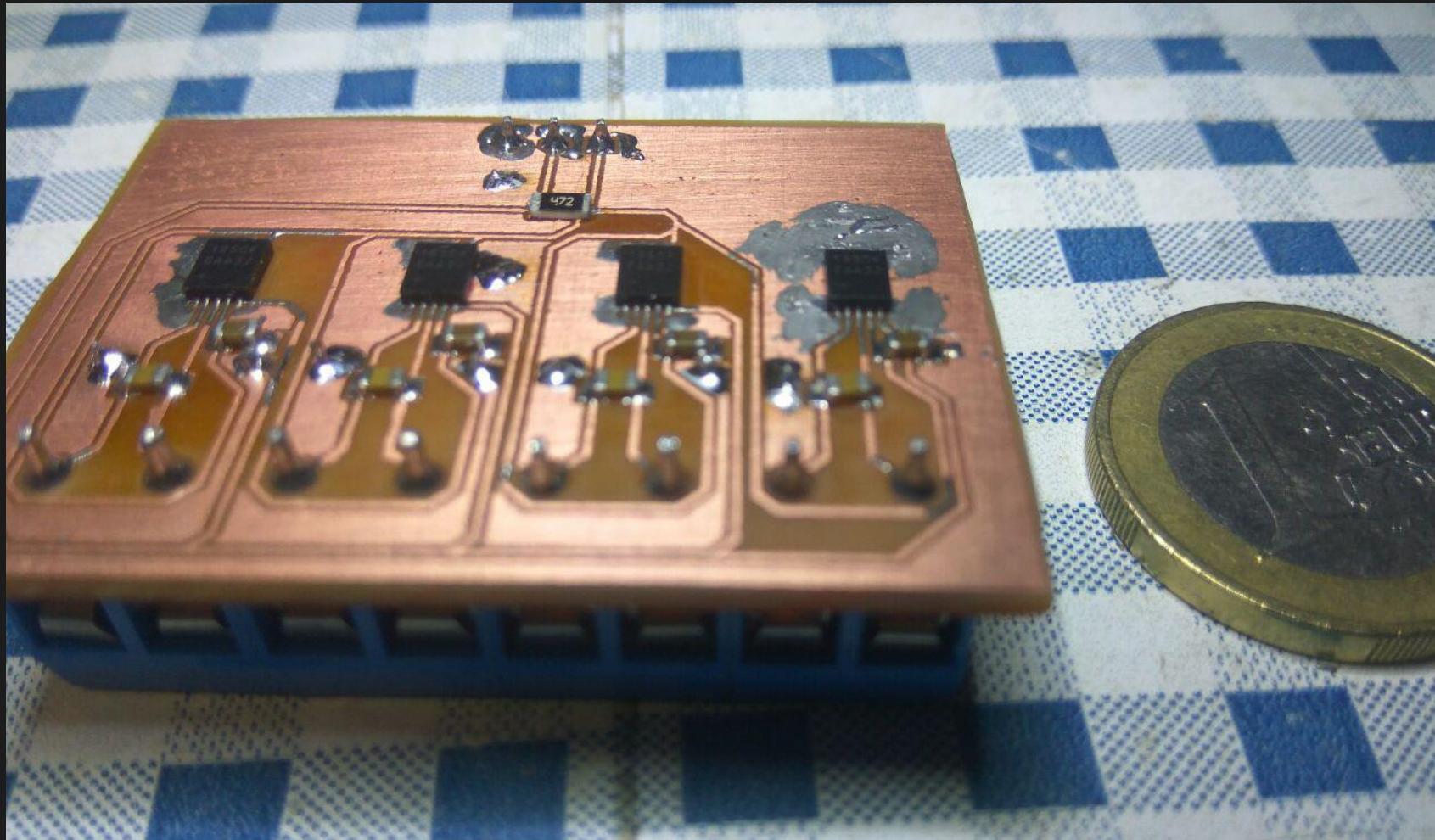
In order to use the oven I did some mods:

- Create my own PCB design for the extra I2C thermocouple interface using only one layer
- Modify the firmware to be able to choose between the different thermocouples

Assembly: Reflow



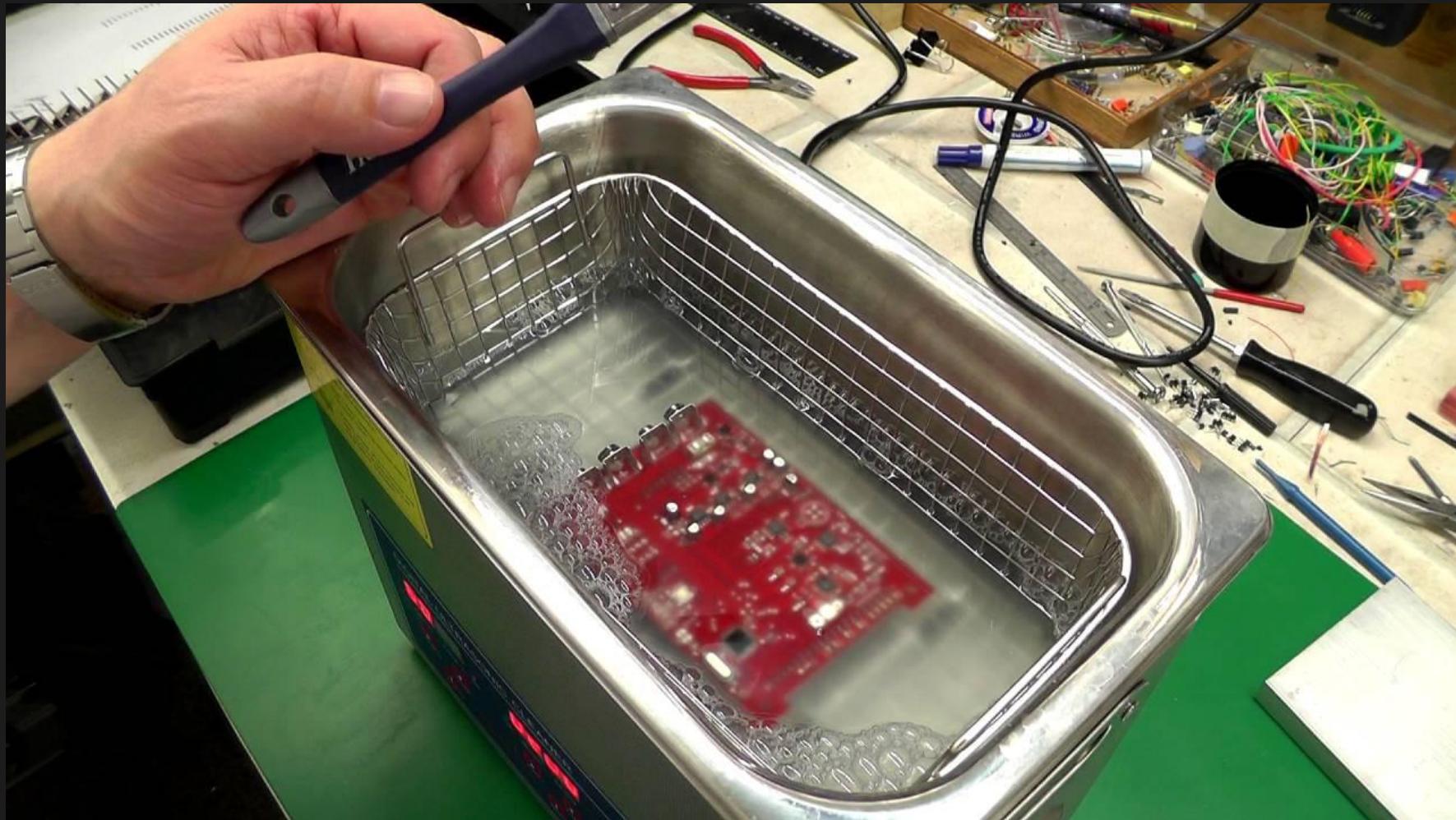
Assembly: Reflow



Assembly: Reflow



Assembly: Cleaning



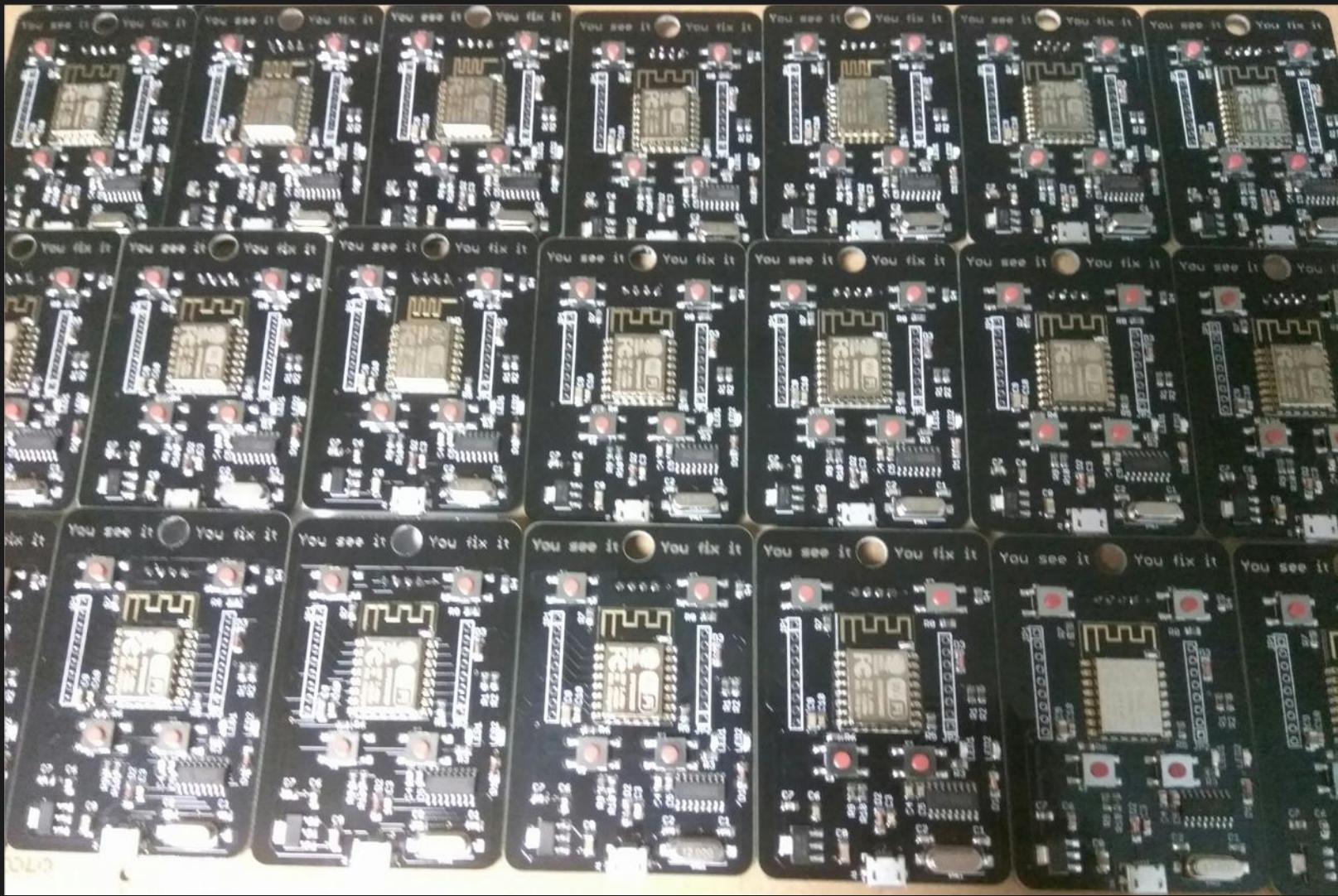
Assembly: Cleaning

Cleaning flux residues from the cheap solder paste I was using is really hard.

Boards do not look bad and the flux is supposed to be no clean, so I opted to leave them as they are.

Sorry for it 😞

Assembly: Results



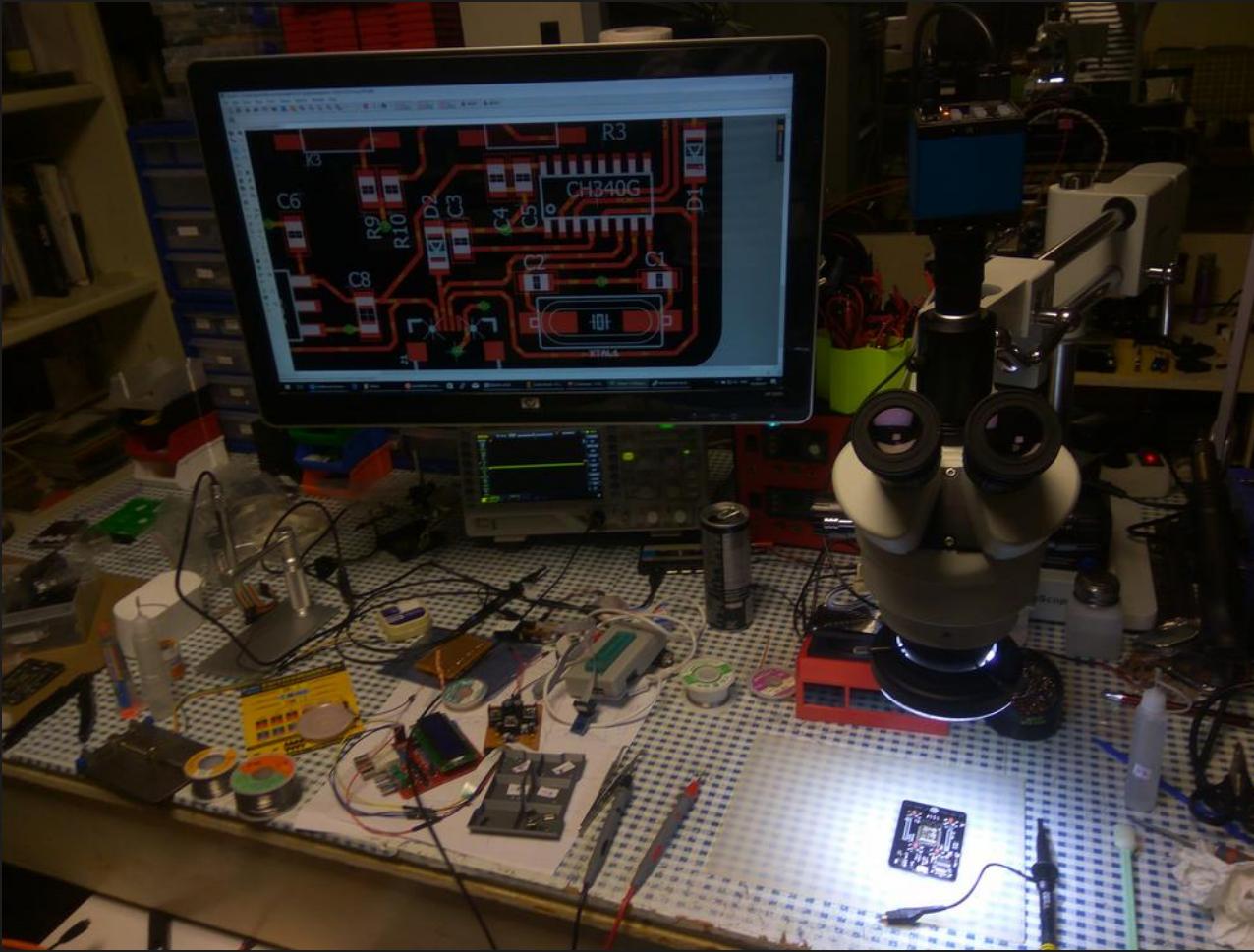
Assembly: Testing

Any manufacturing process has defects, and our home made process obviously also have defects.

Sadly In order to trace them you have to debug them:

- Visual inspection
- Testing with multimeter
- Testing with oscilloscope

Debugging



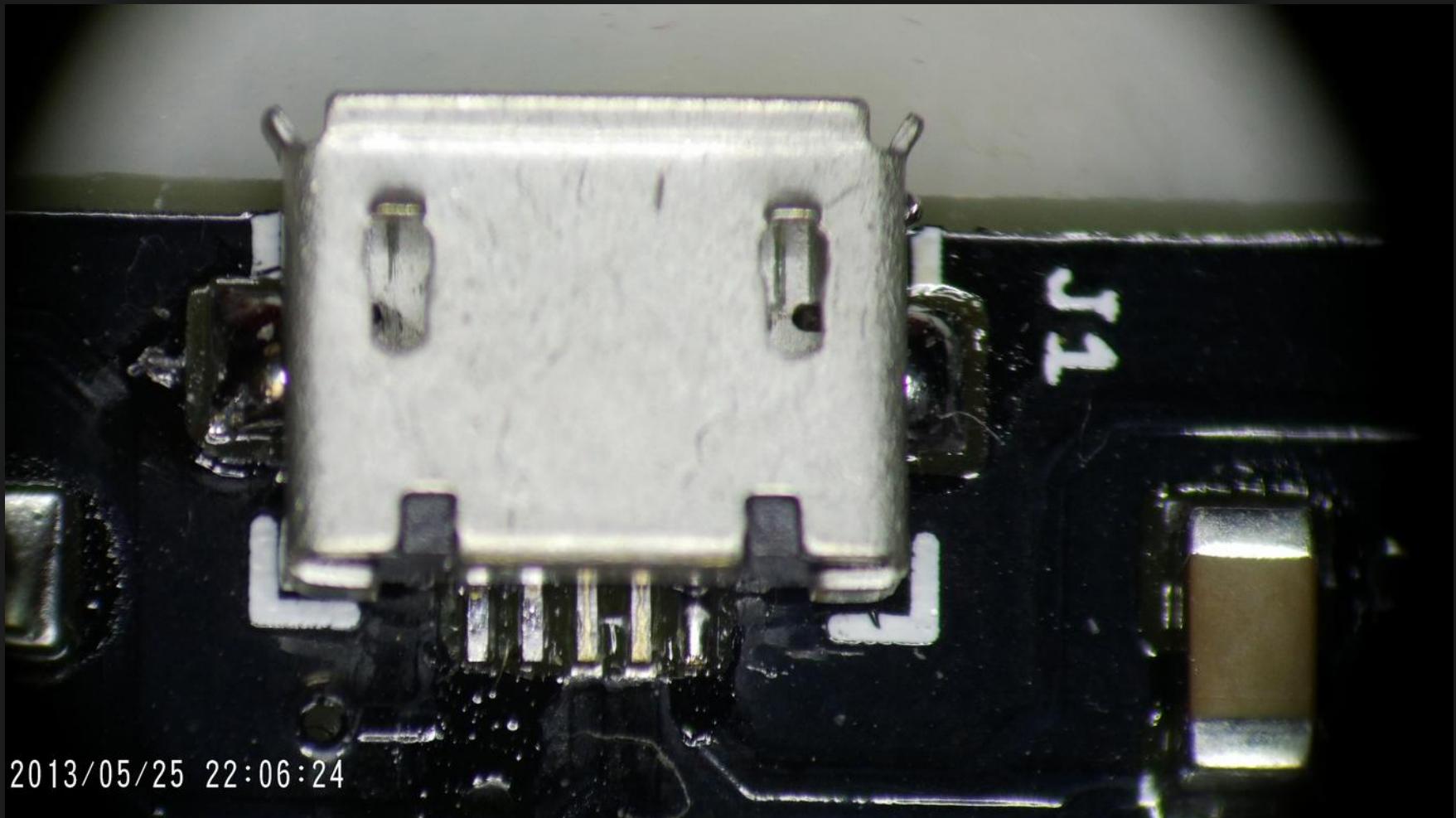
Common Issues

- ~ 5 shorted micro usb
- 4 bad 12 Mhz crystals
- 2 bad caps ESP power (short)
- 2 bad caps 3v ref usb (short)
- 1 bad resistor (reflow problem)

Some of the boards had multiple of these issues in one board.

Design Flaws

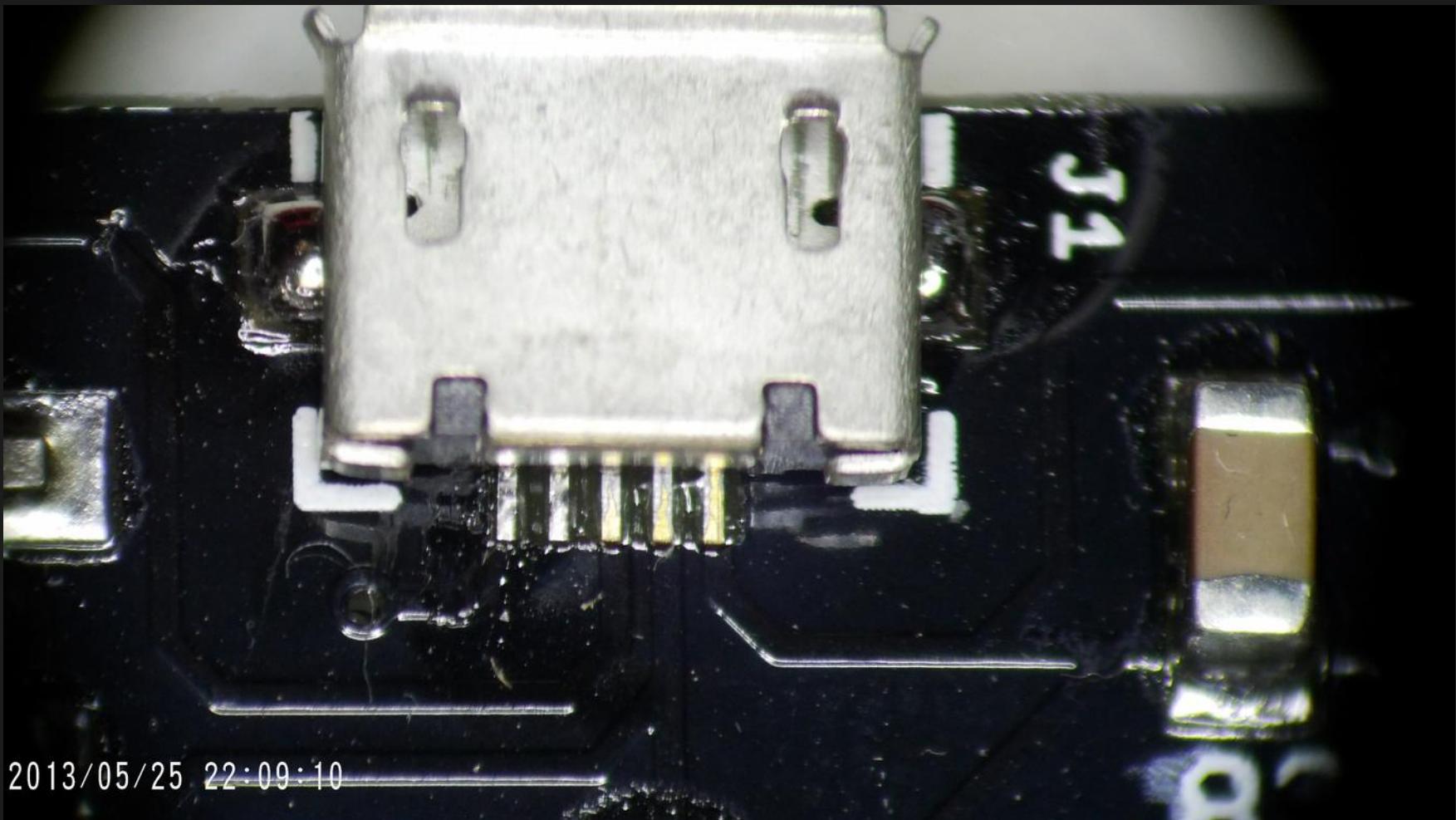
Shorted USB 1



2013/05/25 22:06:24

Design Flaws

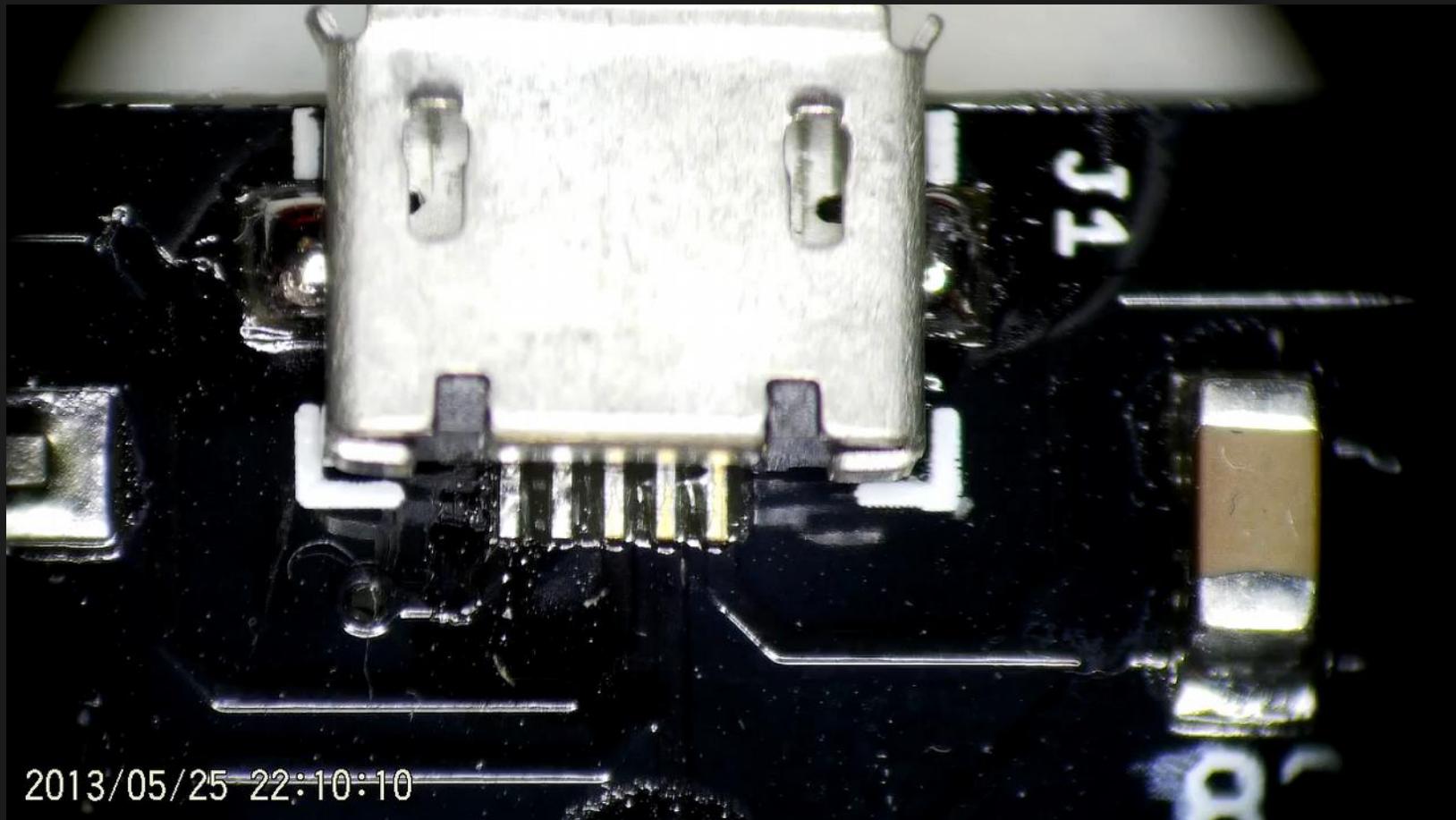
Shorted USB 2



2013/05/25 22:09:10

Design Flaws

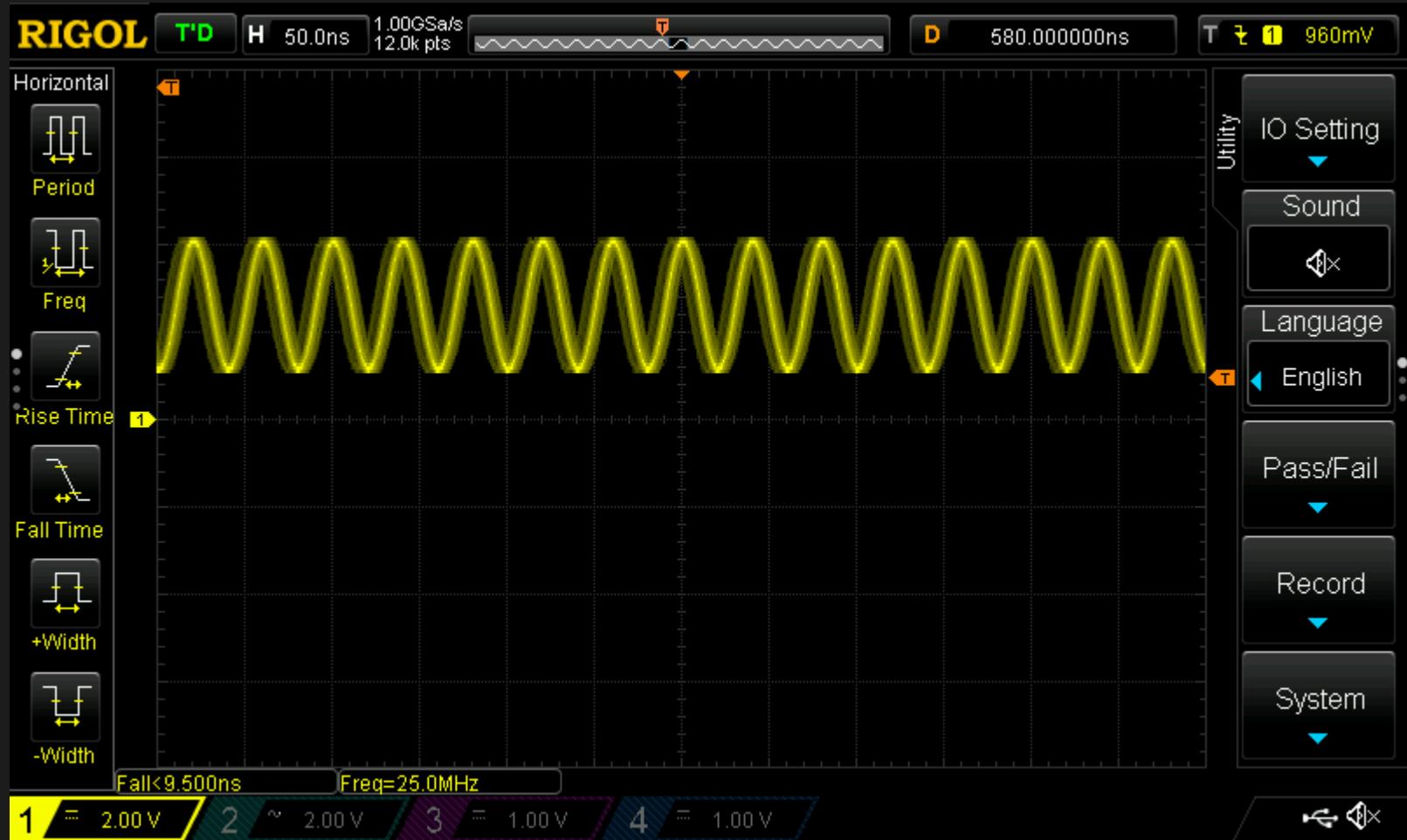
Fix for shorted USB



2013/05/25 22:10:10

Design Flaws

Bad 12MHz Crystal



Design Flaws

Bad 12MHz Crystal



Design Flaws

Bad 12MHz Crystal



Design Flaws

Bad 12MHz Crystal



2013/05/25 22:39:59

Design Flaws

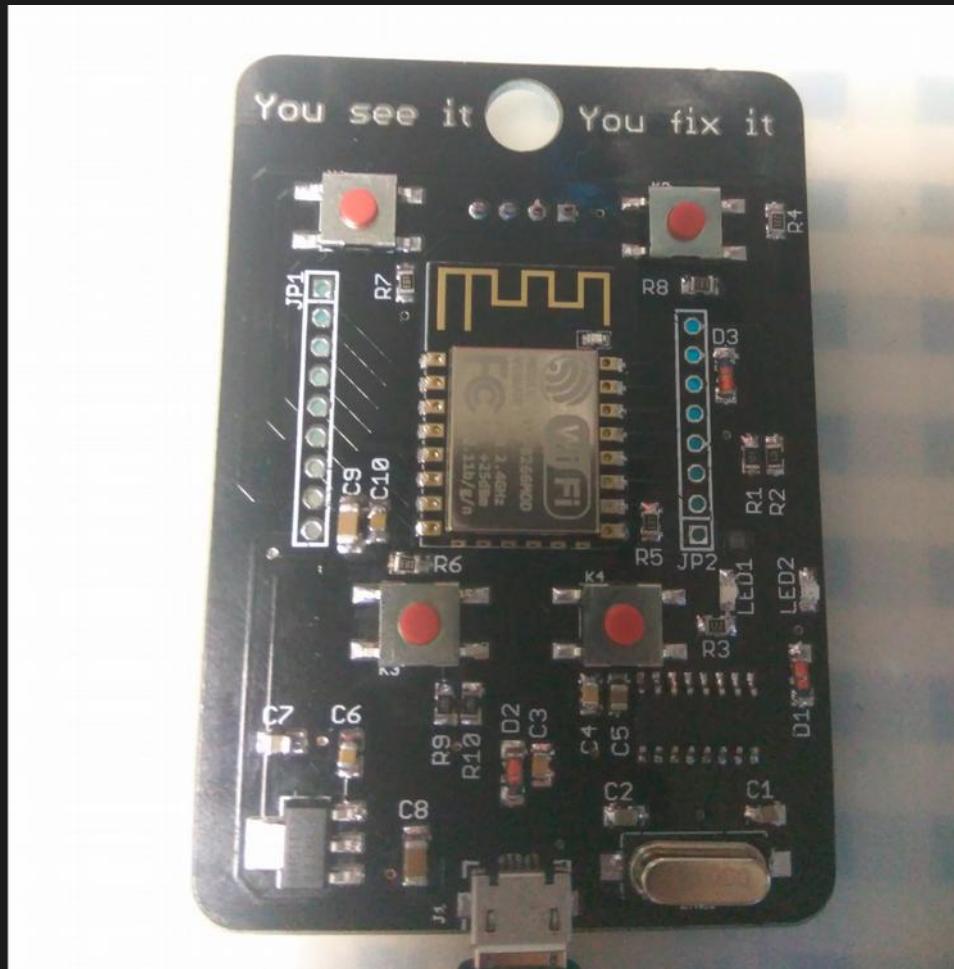
Bad 12MHz Crystal

2013/05/25 22:39:59



Design Flaws

Short under caps



BOOM

Item	Value	Qty.
Capacitor	22pF	2
Capacitor	10nF	2
Capacitor	100nf	2
Capacitor	10uF	2
Capacitor	100uF	2
Zener diode	3.3v	3
LM1117	3.3v	1
Micro USB		1
Cristal	12MHz	1
ESP8266 (12F)		1
OLED (I2C)	128x64	1
CH340G		1
LEDS		2
Resistor	470R	2
Resistor	220R	2
Resistor	10K	4
Resistor	5K6	2

Pricing PCBs

Item	SKU	Name	Description	COO	HS Code	Quantity	Unit Price	Ext. Price
1	S01010001	FUSION PCB Service	PCB	CHINA	8534009000	30	0.91	27.30
2	S03000001	Fusion Stencil Service	SMT Stencil	CHINA	7314500000	1	19.90	19.90
3	A05	FREIGHT COST	FREIGHT COST			1	42.38	42.38
TOTAL						32	USD	89.58

Item	Qty.	Unit Price	Price
PCBs	30	0.91 USD	27.30 USD
Stencil	1	19.90 USD	19.90 USD
Shipping	1	42.38 USD	42.38 USD
TOTAL			89.58 USD

Pricing Components

Item	Qty.	Unit Price	Price
OLED Screen	20	2.23 EUR	44.69 EUR
ESP-12F (8266)	20	1.59 EUR	31.88 EUR
CH340G	20	0.41 EUR	8.25 EUR
Buttons	200	0.027 EUR	5.57 EUR
Caps/Resis/Crystals/etc...			21.48 EUR
Micro USB	50	0.062 EUR	3.13 EUR
LD1117 3.3V	20	0.28 EUR	5.65 EUR
TOTAL:			120.56 EUR

Total Pricing

Item	Qty.	Unit Price	Price
Components			120.56 EUR
PCBs			74.66 EUR
TOTAL			195.22 EUR

Total per badge: 9.76 EUR

This is aprox price and could be cut by 1/2

Problems buying from china

There are some problems when dealing with Aliexpress and such dealers:

- Bad or wrong value components on the same lot
- Delays / Long delivery time
- Components do not come with datasheet or are not always exactly as shown in images

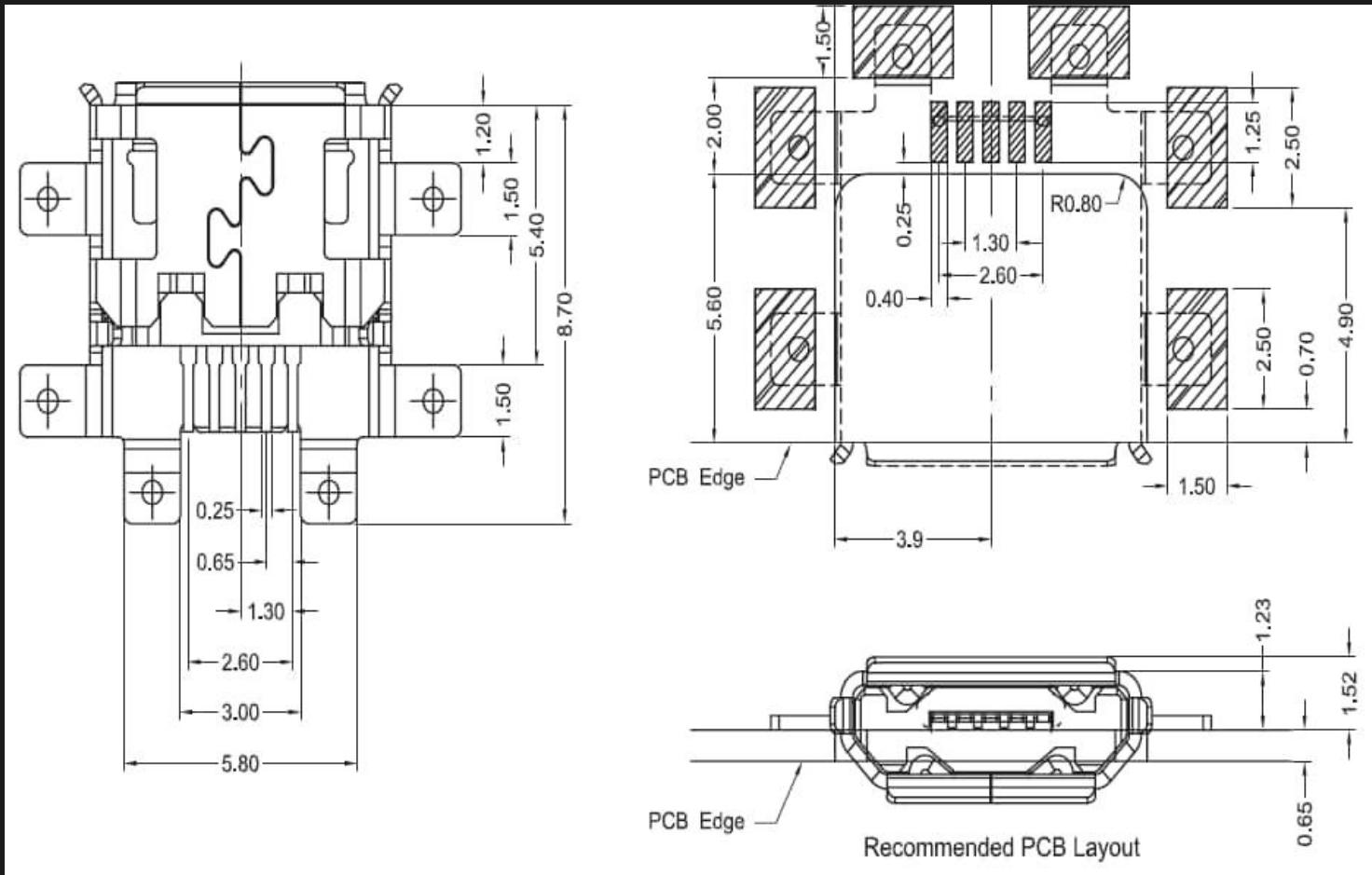
So basically you have to guess and pray.

Problems buying from china

Usually when you buy from reputable sources you get part numbers, datasheets containing specs and product dimensions, etc...

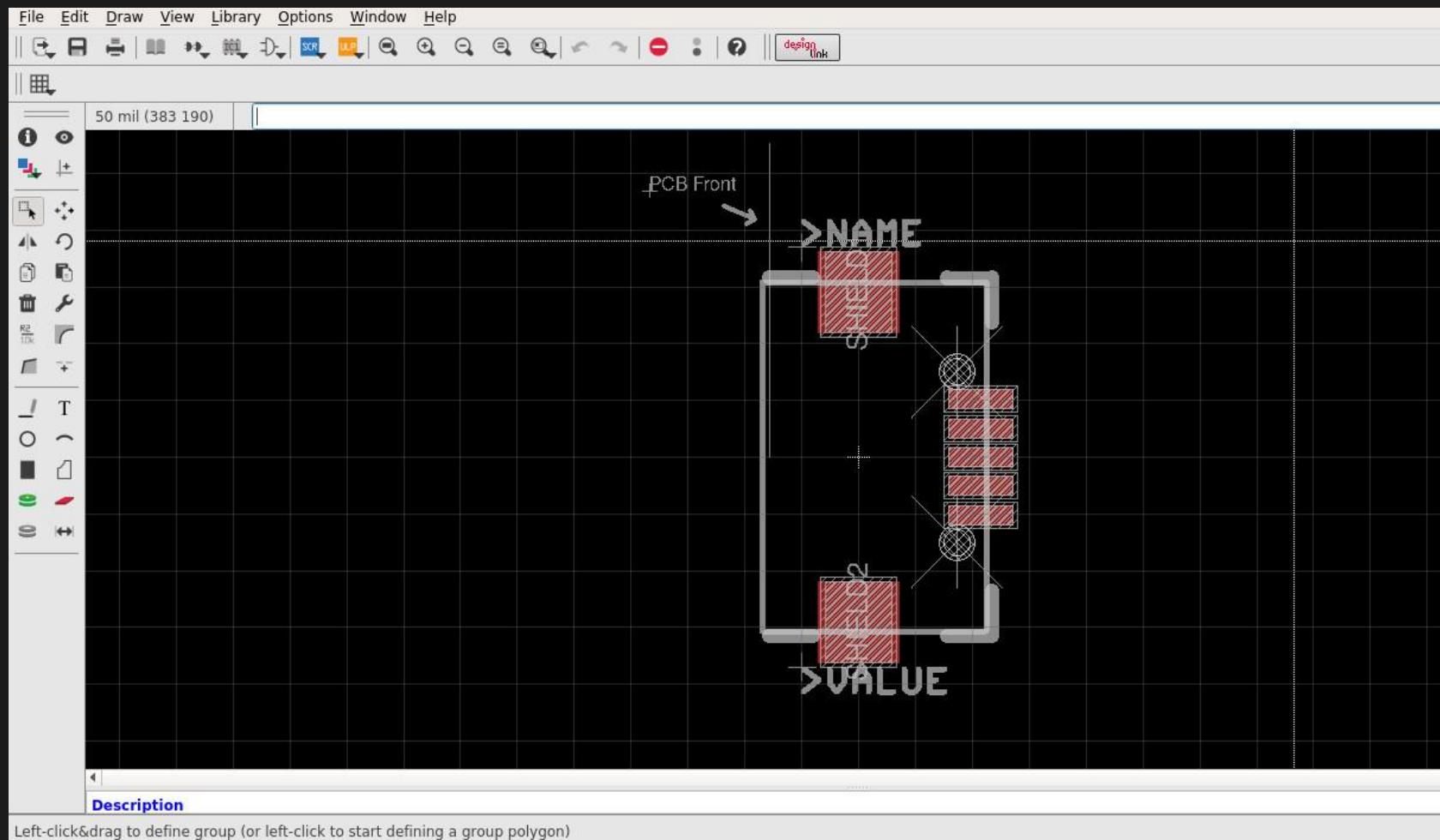
Problems buying from china

Part dimensions on the datasheet

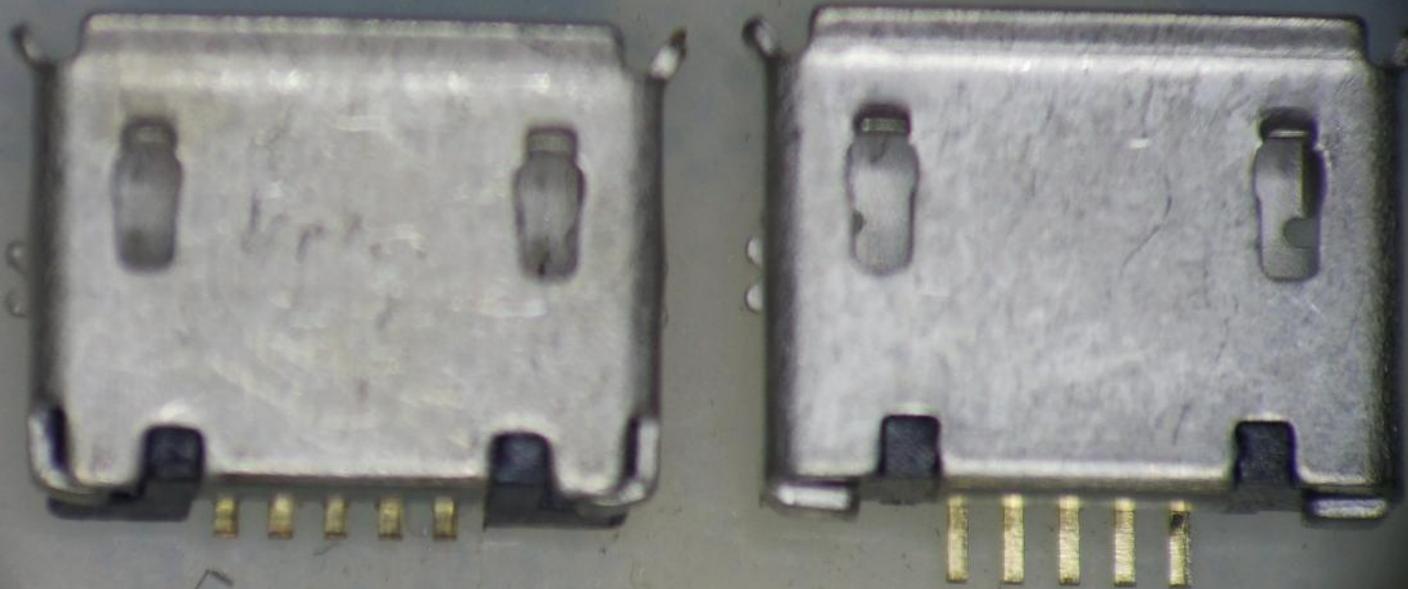


Problems buying from china

With the datasheet you design the part

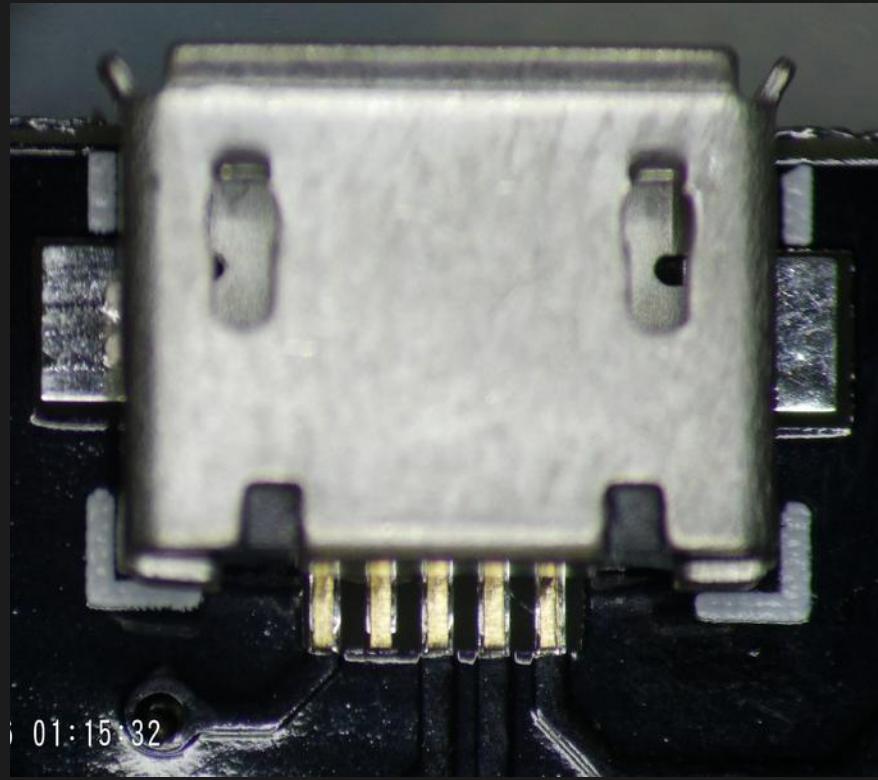
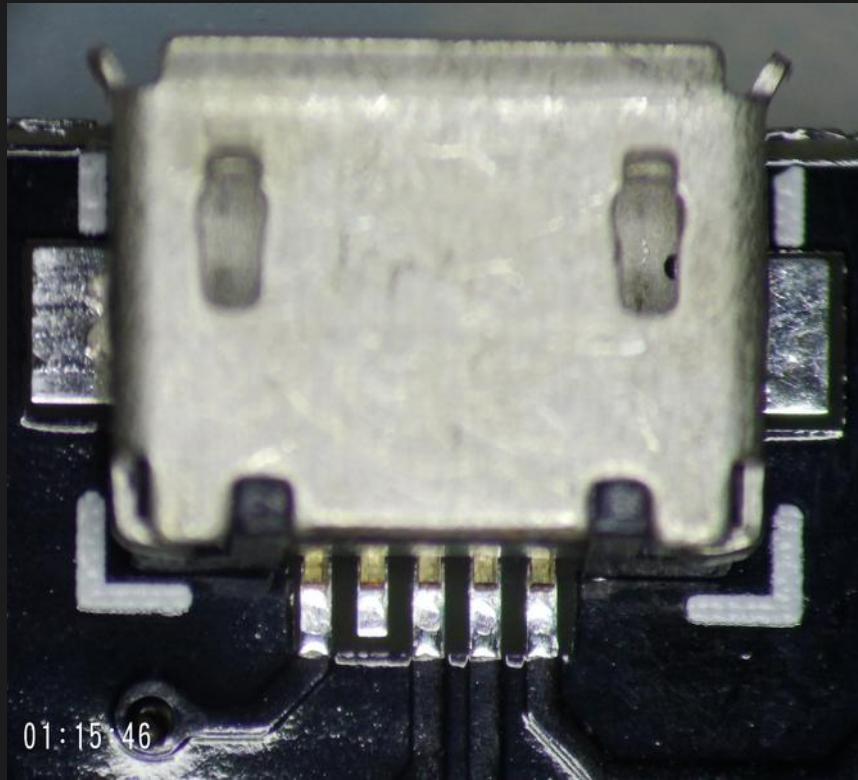


Problems buying from china



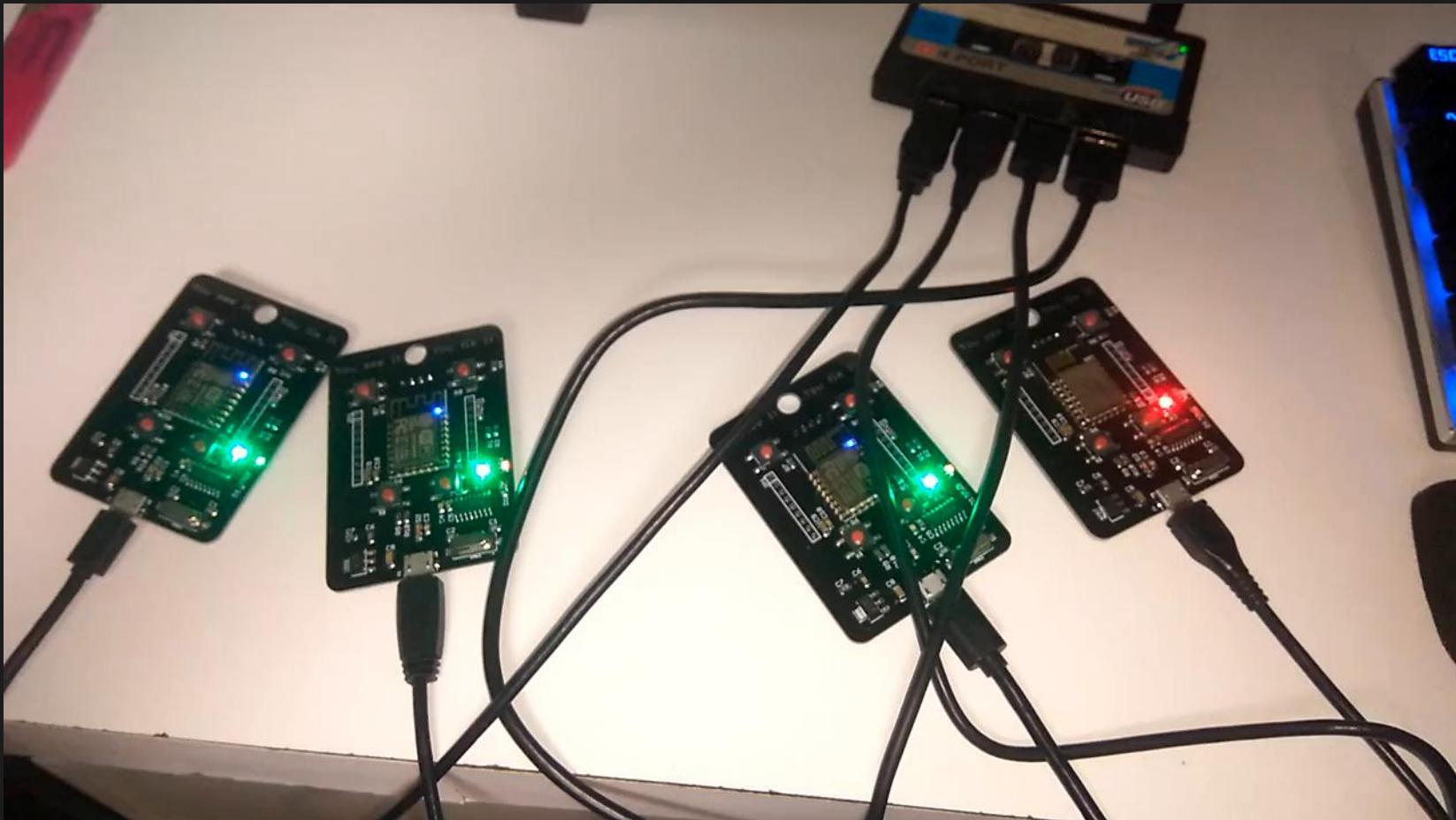
2013/05/26 01:16:14

Problems buying from china



Software

Flashing firmwares



Software

The software is composed of two components:

- Backend which downloads statistics from github REST API and packs them into buffers using C like structures. (node.js)
- Native firmware which connects to backend, gets the data and casts it to a structure.

Software

Backend

```
5  /* TOP CONTRIBUTORS */
6  const topContrib = Struct()
7      .array('list', 10, Struct()
8          .chars('name', 12)
9          .word32Ule('commits')
10     );
11
12
13 /* MASTER STATUS */
14 const masterStatus = Struct()
15     .chars('global', 16)
16     .chars('travis', 16)
17     .chars('appveyor', 16)
18
19
20 /* PULL REQUESTS */
21 const pullRequests = Struct()
22     .array('list', 10, Struct()
23         .chars('title', 64)
24         .word32Ule('id')
25     );
26
```

Firmware

```
37 struct _top_contribs {
38     struct {
39         char name[12];
40         uint32_t commits;
41     } list[10];
42 } __attribute__((packed));
43
44
45 struct _status {
46     char global[16];
47     char travis[16];
48     char appveyor[16];
49 } __attribute__((packed));
50
51 struct _prs {
52     struct {
53         char title[64];
54         uint32_t id;
55     } list[10];
56 } __attribute__((packed));
```

Software

Wireless Setup

```
Welcome to minicom 2.7.1
```

```
OPTIONS: I18n  
Compiled on Aug 13 2017, 15:25:34.  
Port /dev/ttyUSB0, 04:25:47
```

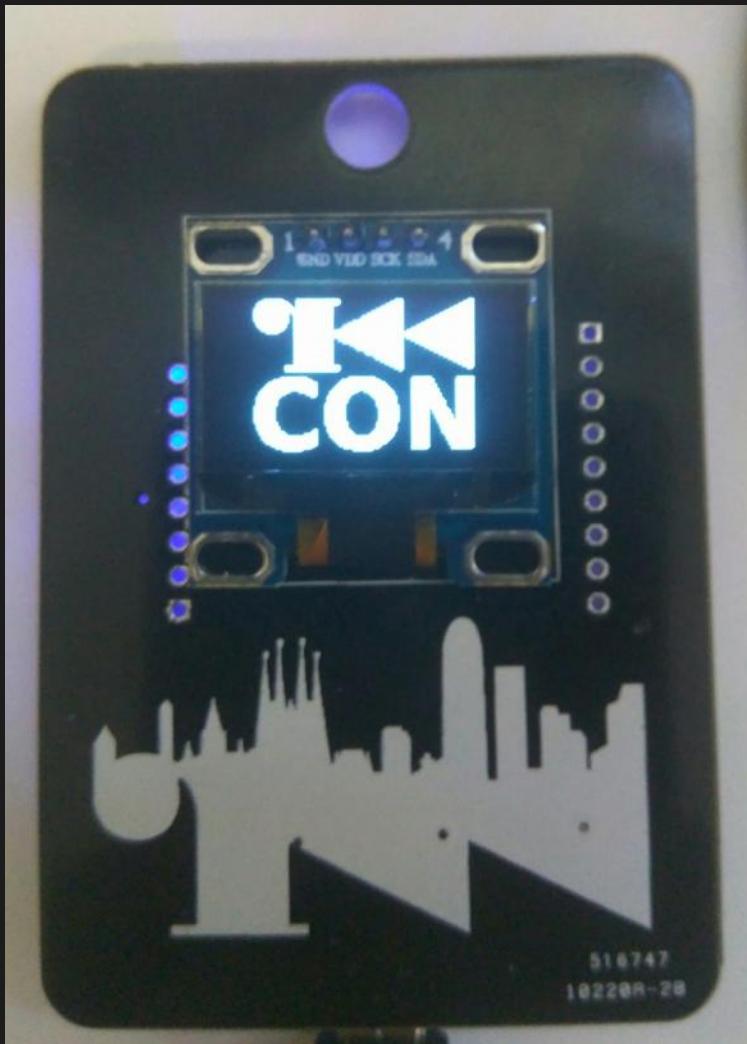
```
Press CTRL-A Z for help on special keys
```

```
Wireless configuration menu  
Only Open and WPA networks are supported  
For Open network leave password blank  
To exit this menu press any button on the badge.
```

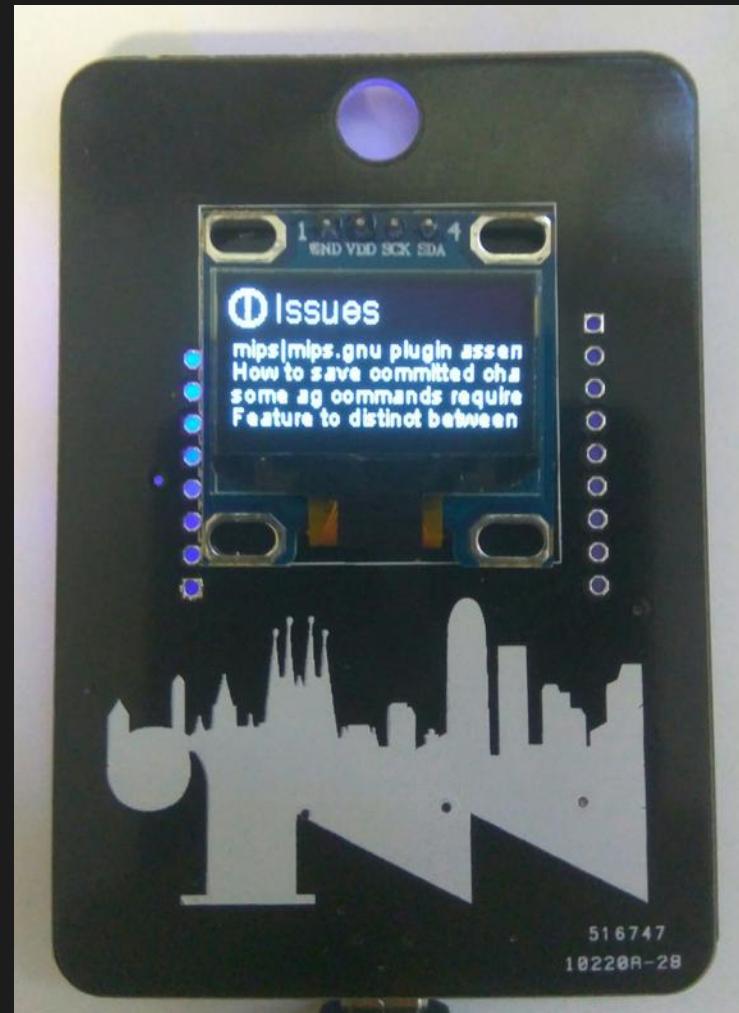
```
Enter ESSID: AIRBNB  
Got ESSID: AIRBNB  
Enter Password: [REDACTED]  
Got WPA password: [REDACTED]  
Configuration saved to EEPROM.  
Connecting to network AIRBNB with password.....Connected with IP: 192.168.1.49
```

```
CTRL-A Z for help | 115200 8N1 | NOR | Minicom 2.7.1 | VT102 | Offline | ttyUSB0
```

Software



Software



Software



Software

Wireless Setup

```
Welcome to minicom 2.7.1
```

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OPTIONS: I18n  
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Enter ESSID: AIRBNB  
Got ESSID: AIRBNB  
Enter Password: [REDACTED]  
Got WPA password: [REDACTED]  
Configuration saved to EEPROM.  
Connecting to network AIRBNB with password.....Connected with IP: 192.168.1.49
```

Questions?

<https://github.com/jpenalbae/r2con2k17-badge/>