

simple spectro

<https://github.com/hackuarium/simple-spectro>

<https://hackuarium.github.io/simple-spectro>

<http://www.hackuarium.ch>

oceane@patiny.com

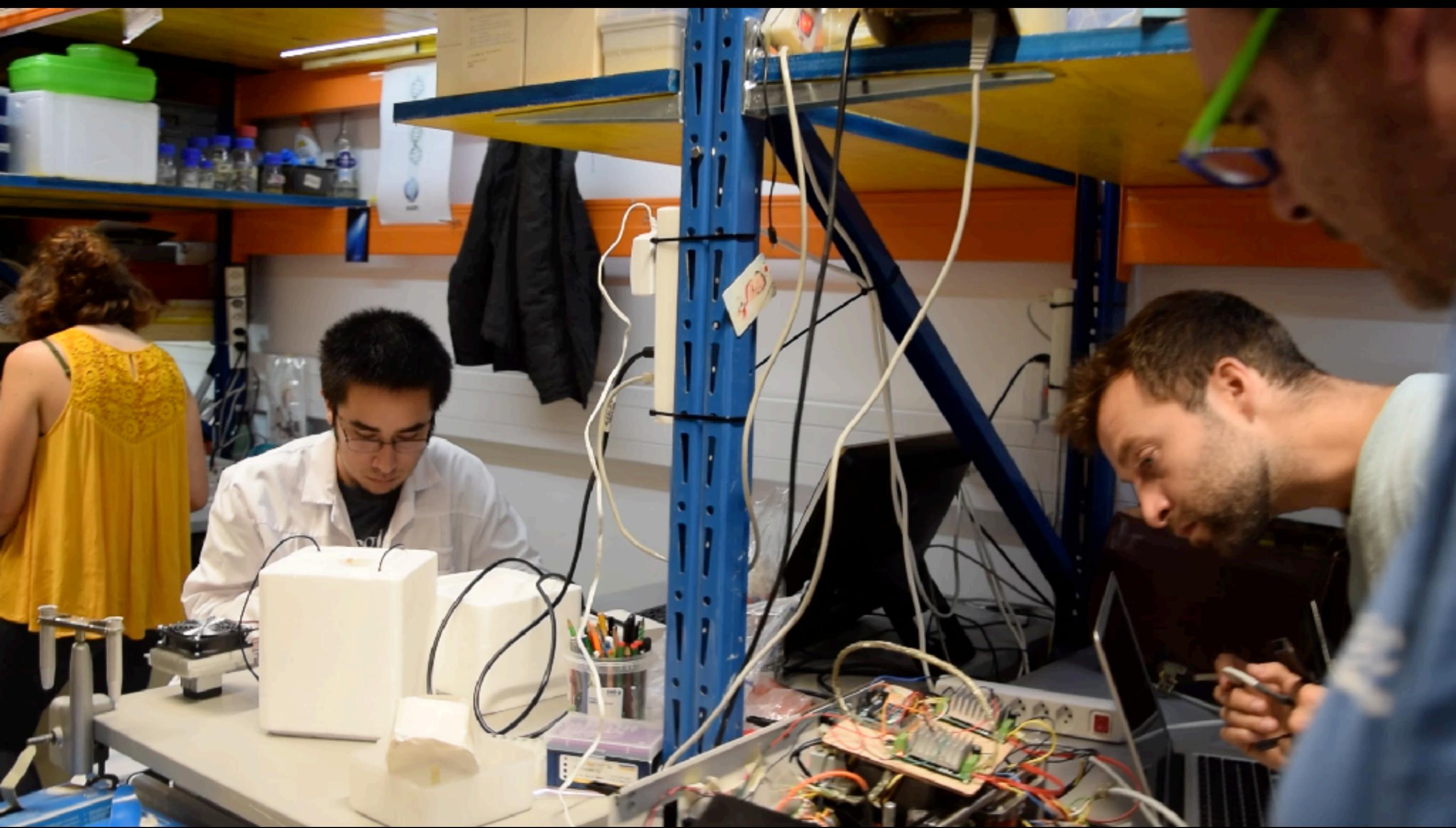
florian@patiny.com

luc@patiny.com

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UNIVERCITÉ
POWERED BY **INARTIS** FOUNDATION





DIX biology

Do It Together biology
and more ...

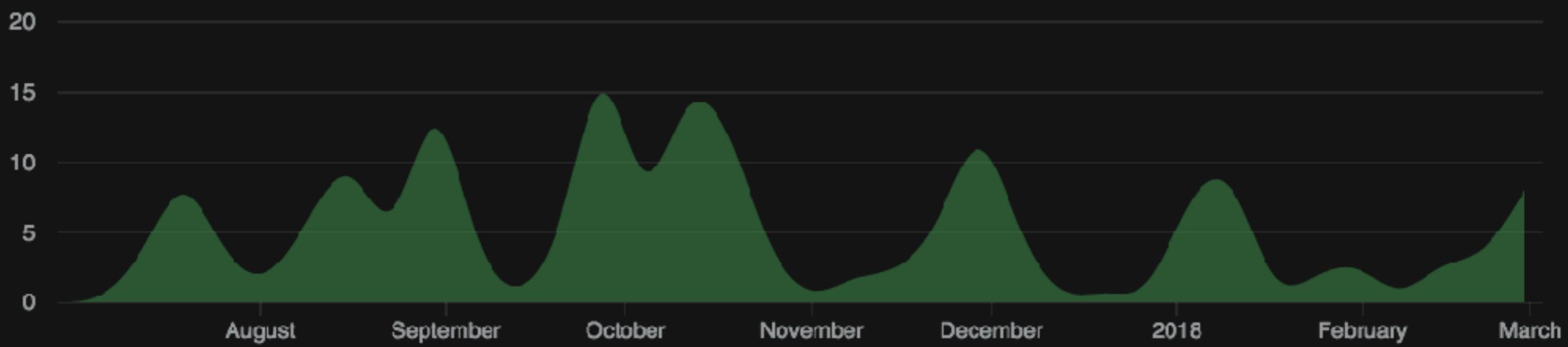
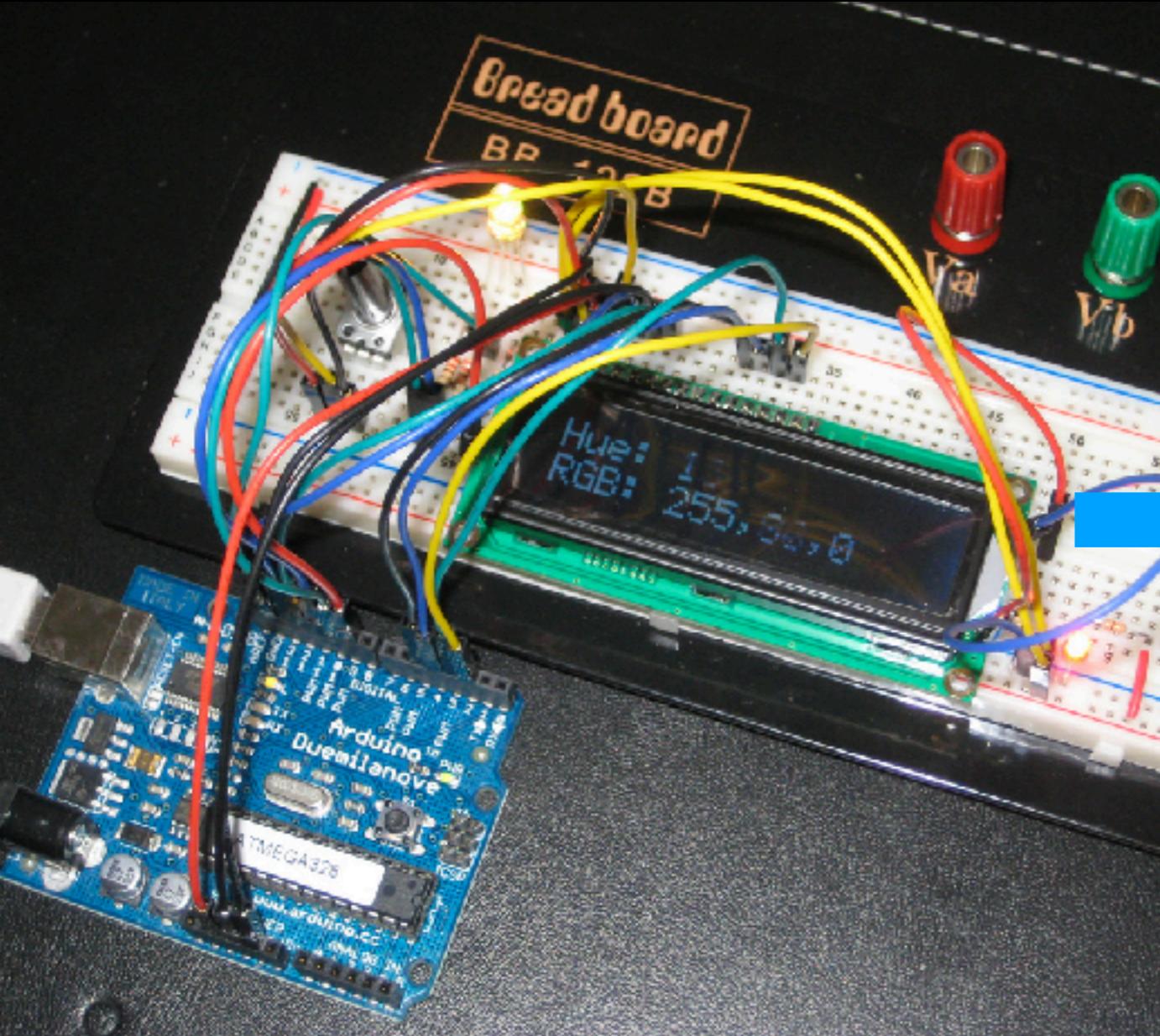
Meet us every Wednesday evening, 7.30pm-10.30pm

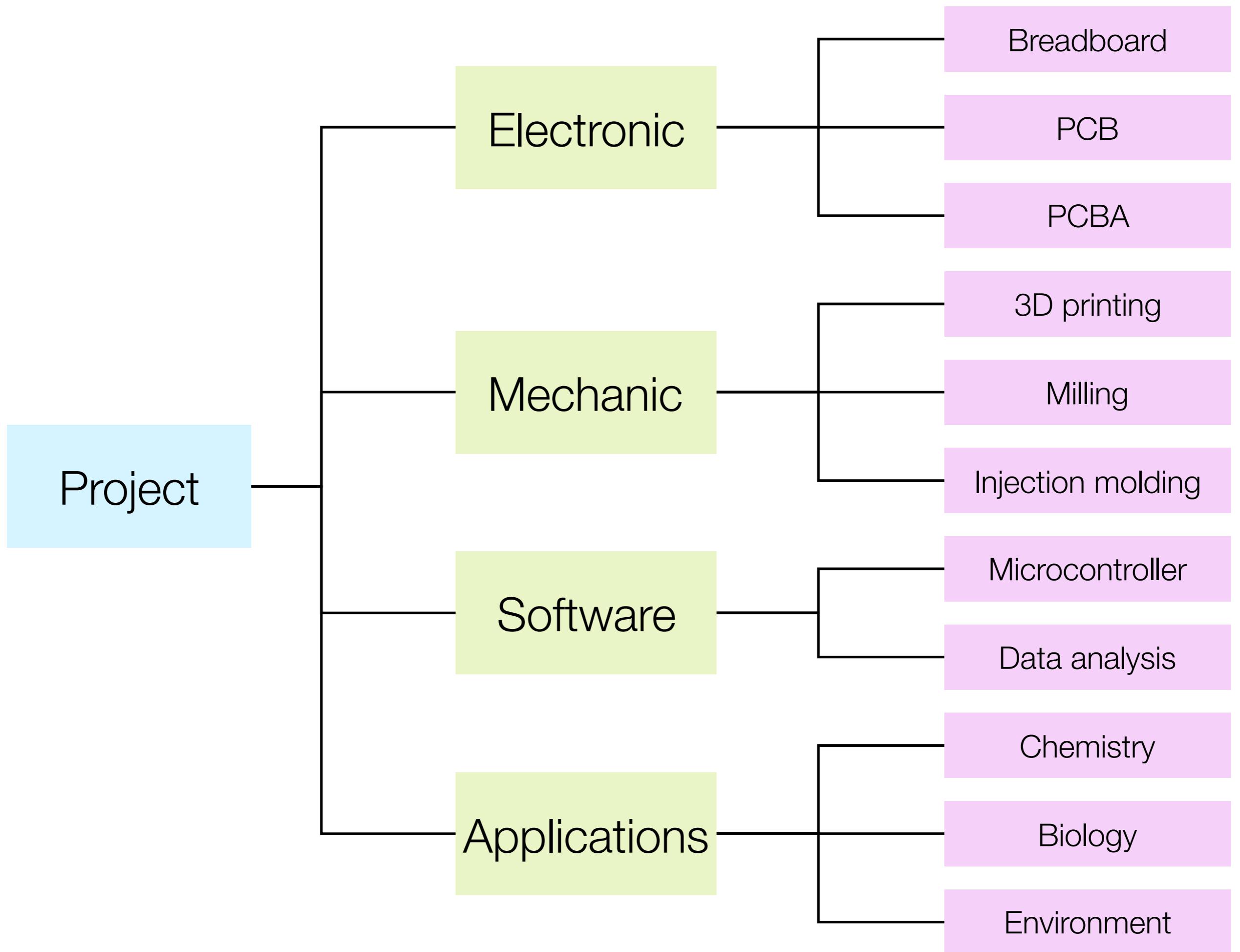
www.hackuarium.ch

UNIVERCITÉ



@Hackuarium



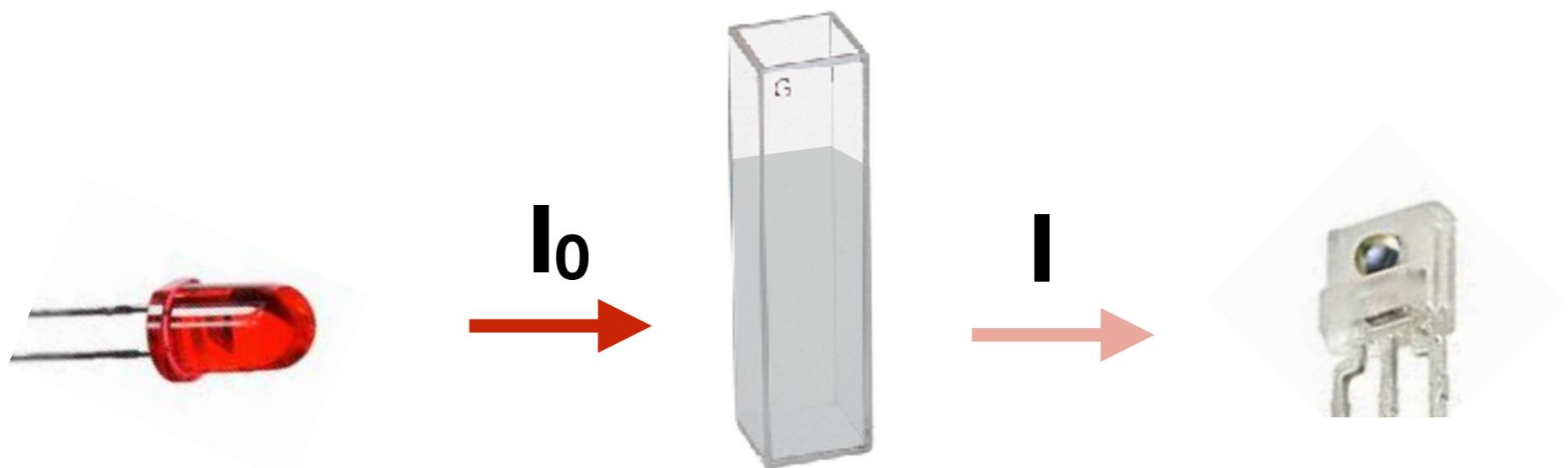


Agenda

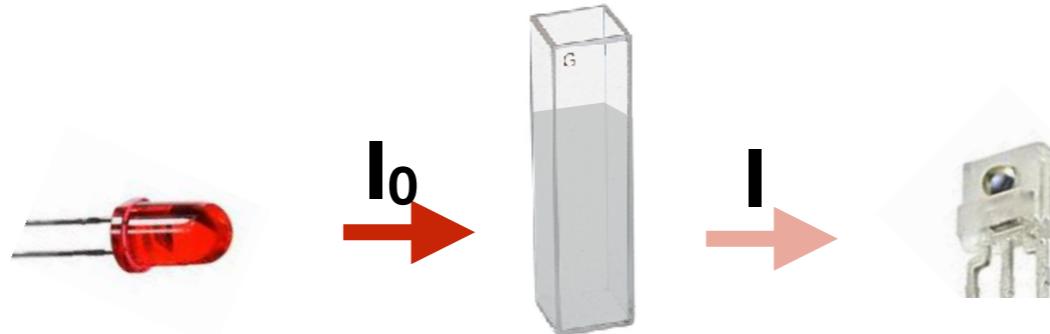
- 1. General overview**
- 2. Electronics**
- 3. Mechanics**
- 4. Programming**
- 5. Experiments**

General overview

Spectrophotometer ?



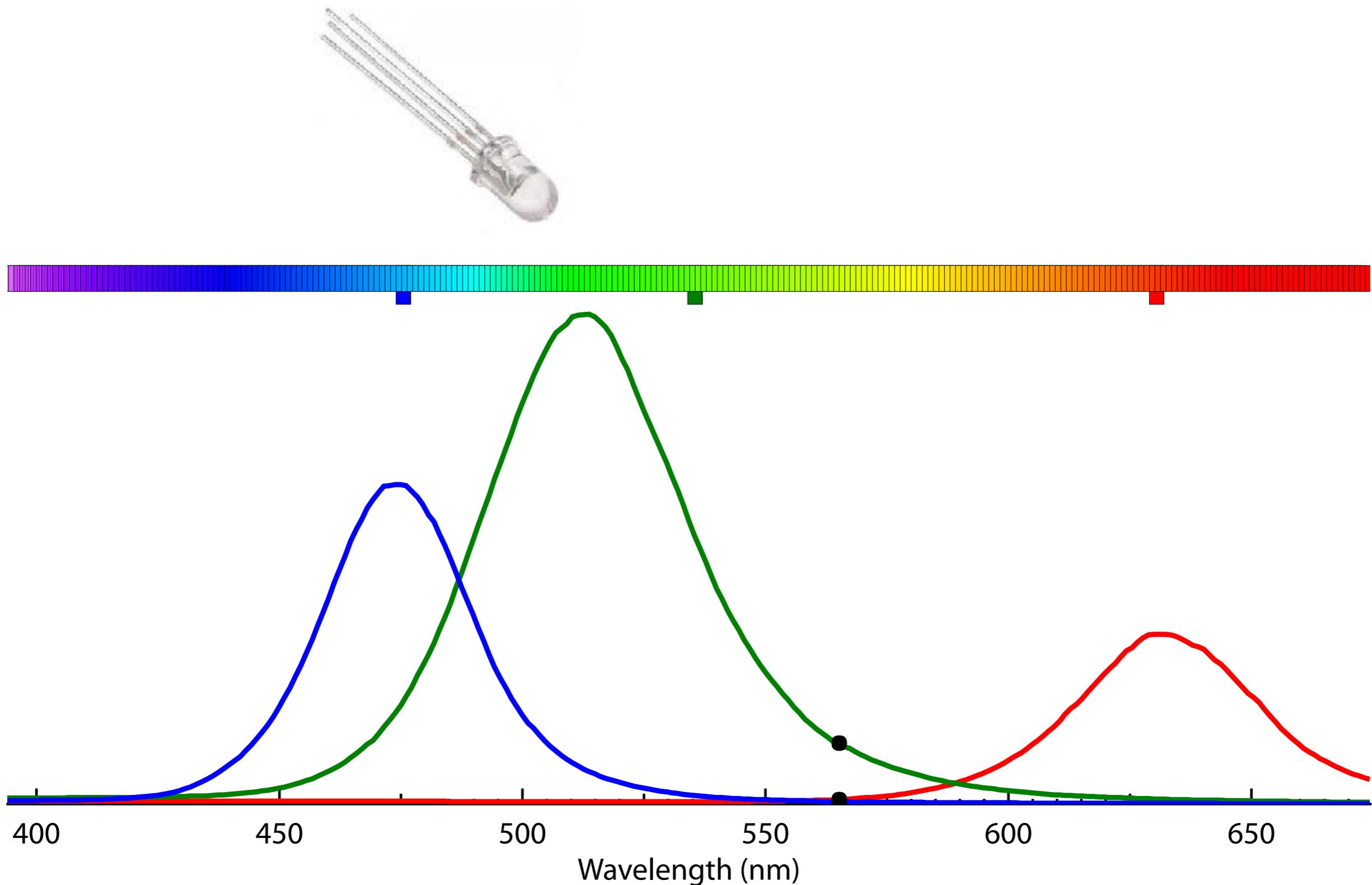
Beer-Lambert law

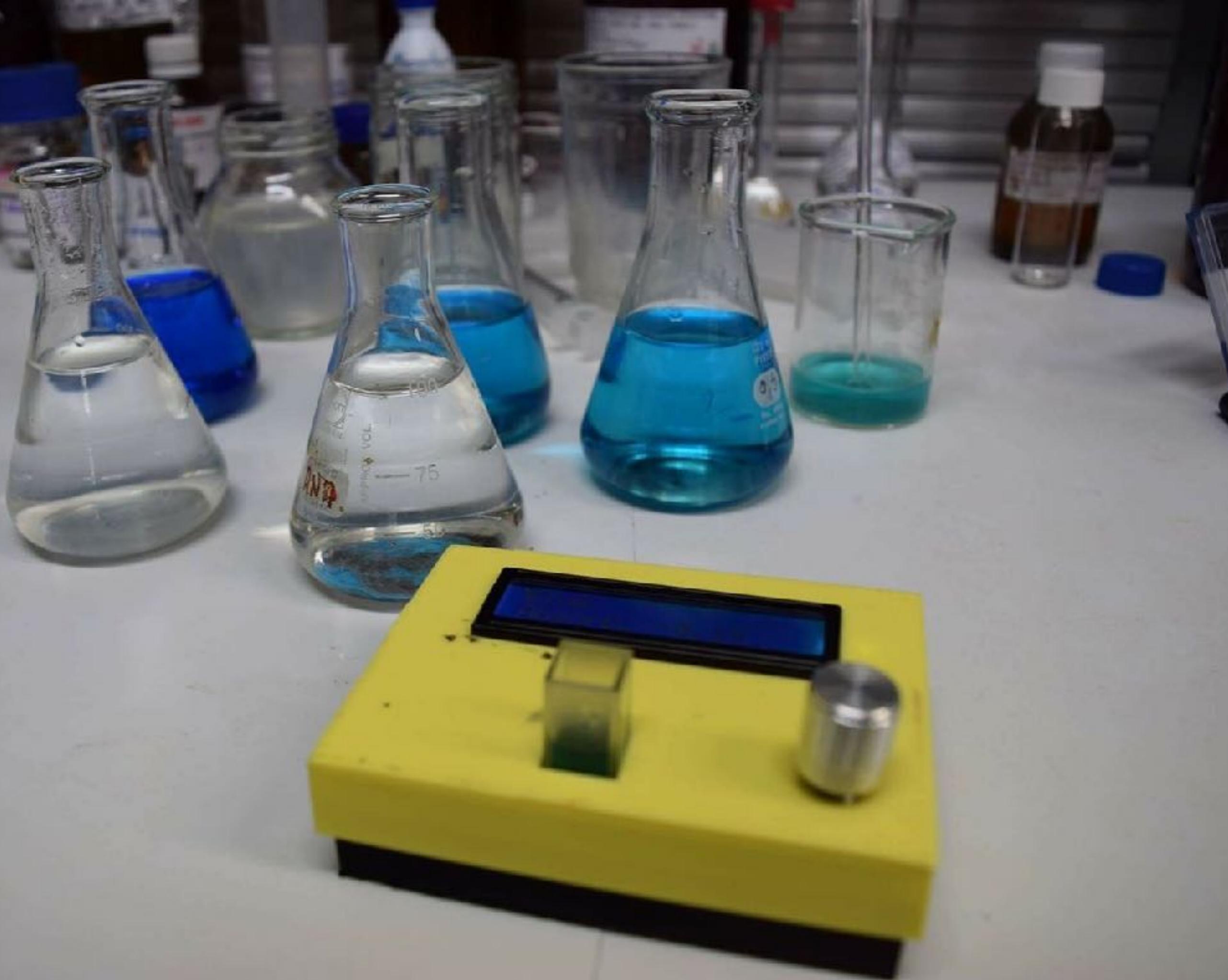


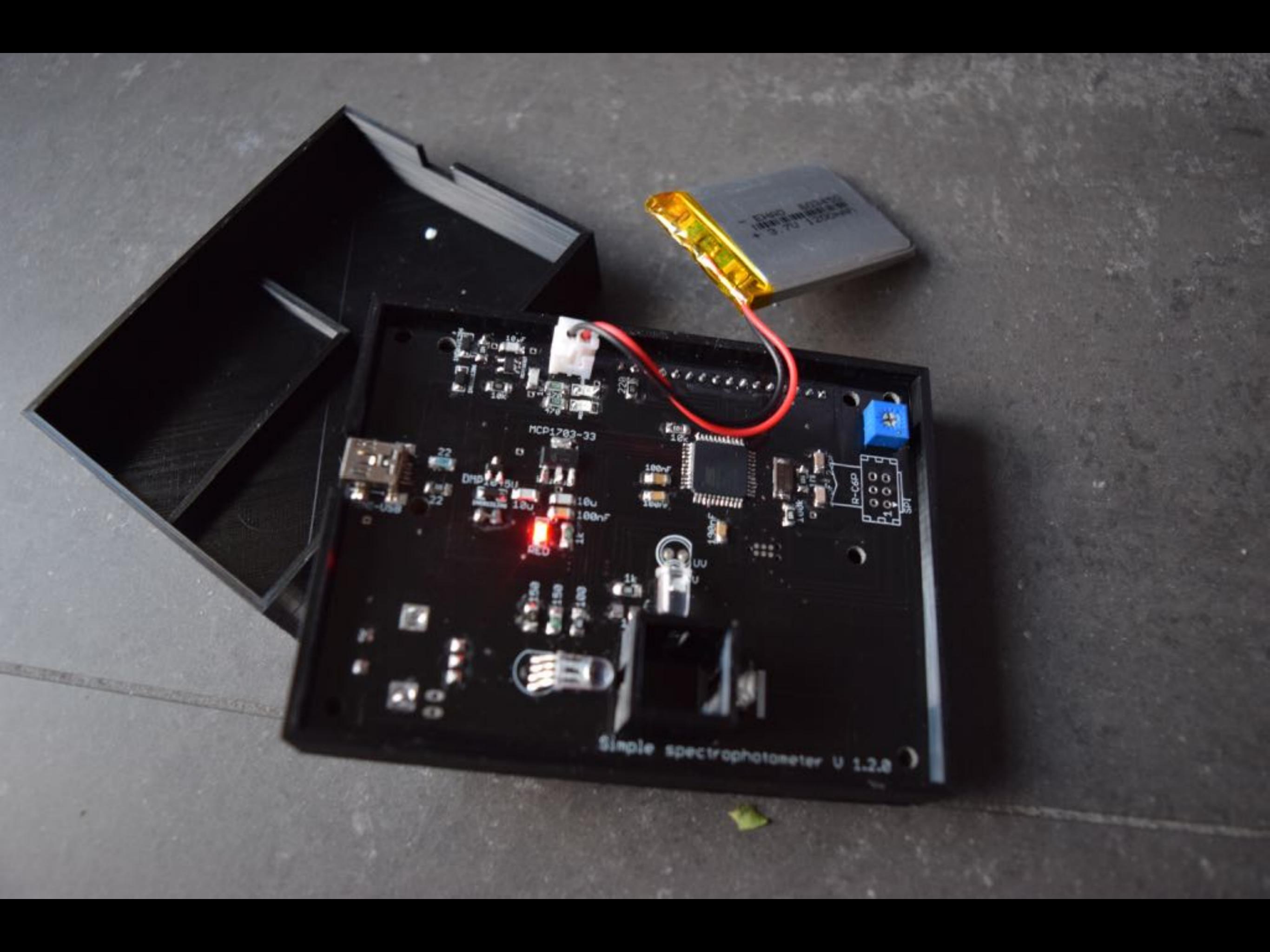
$$A = - \log (T) = - \log (I / I_0) = \epsilon L c$$

- A: absorbance
- T: transmittance
- I_0 : intensity of the light
- I: intensity of the light after the cell
- L: length of the cell
- c: concentration (M)
- ϵ : molar attenuation coefficient

RGB led ?







Single spectrophotometer V 1.2.0

1.*Acquire
2. Kinetic

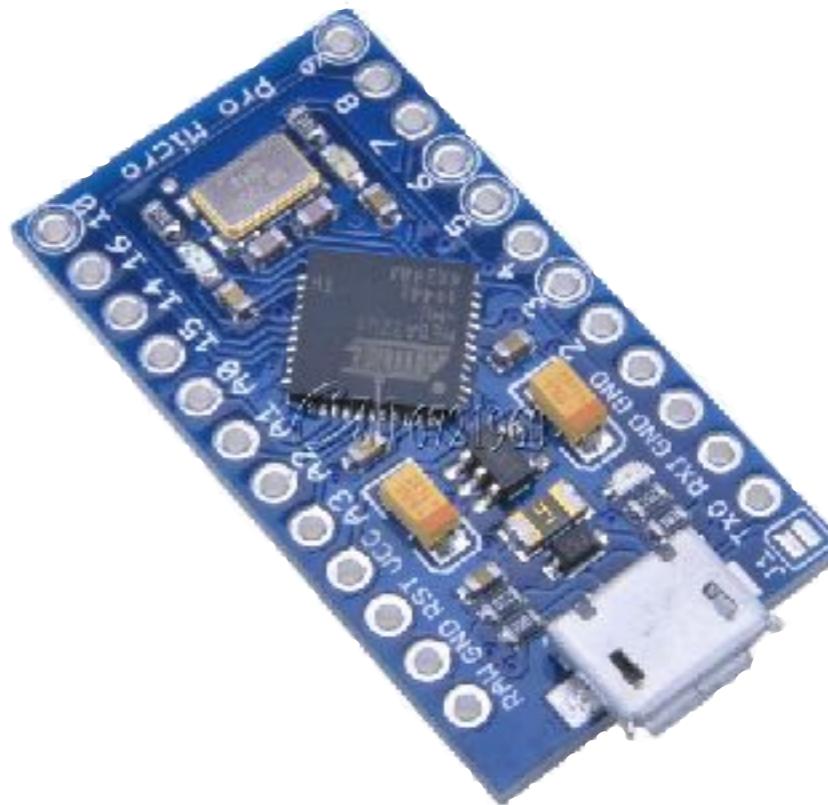
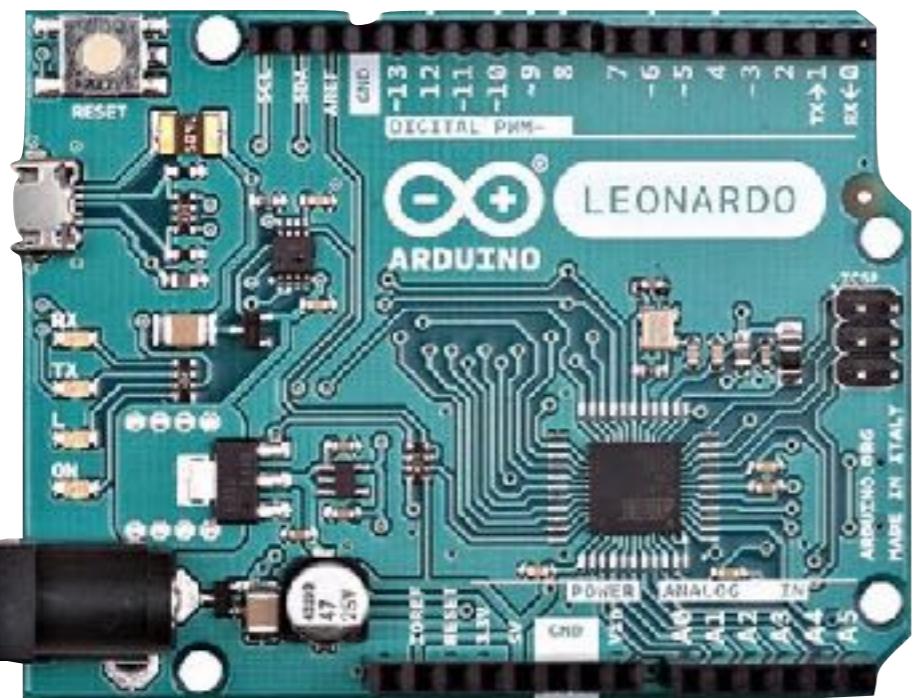


Electronics

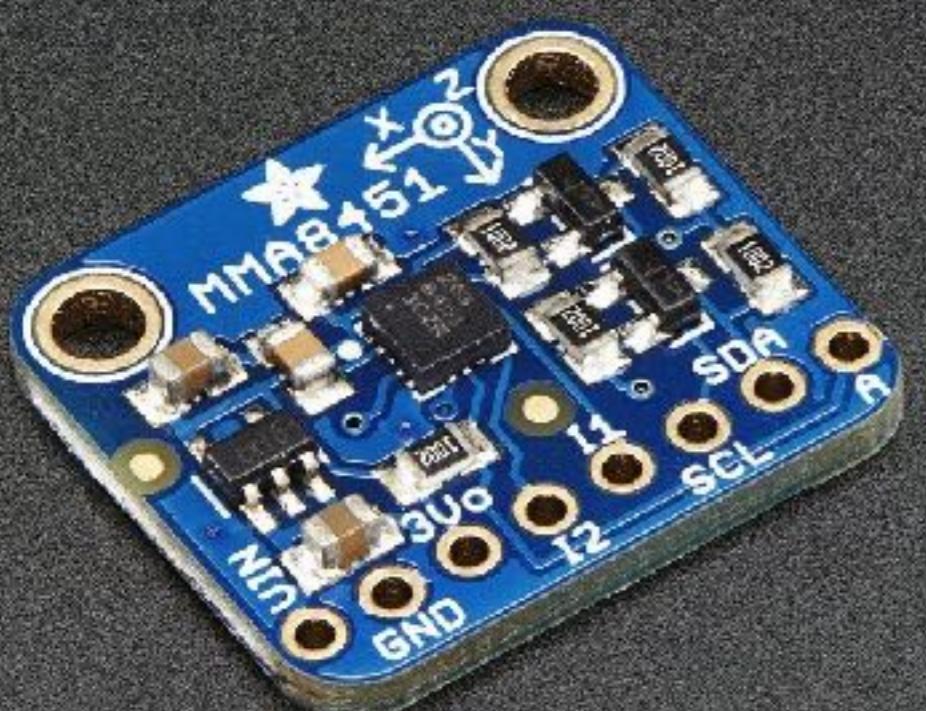
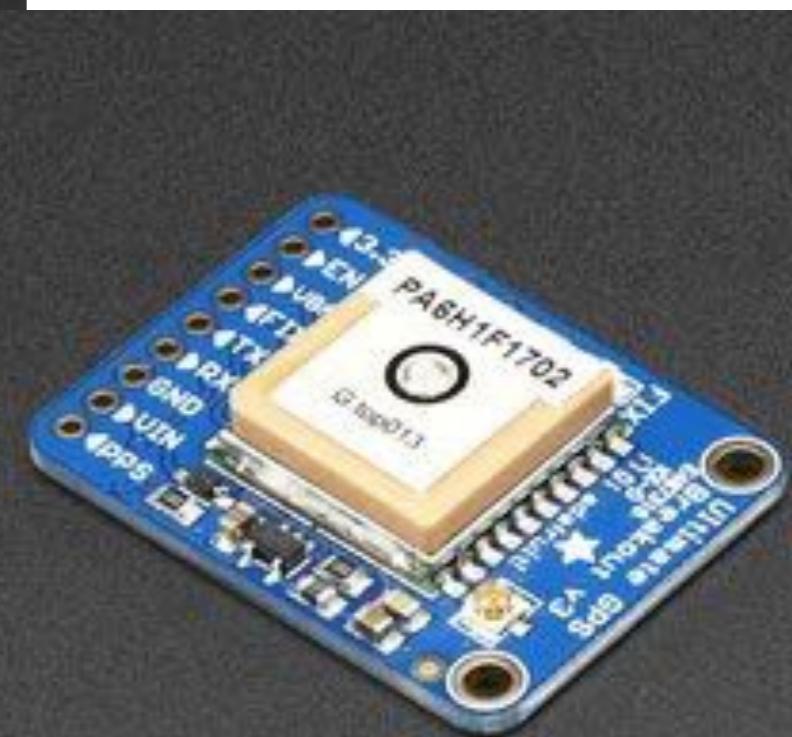
Arduino ...

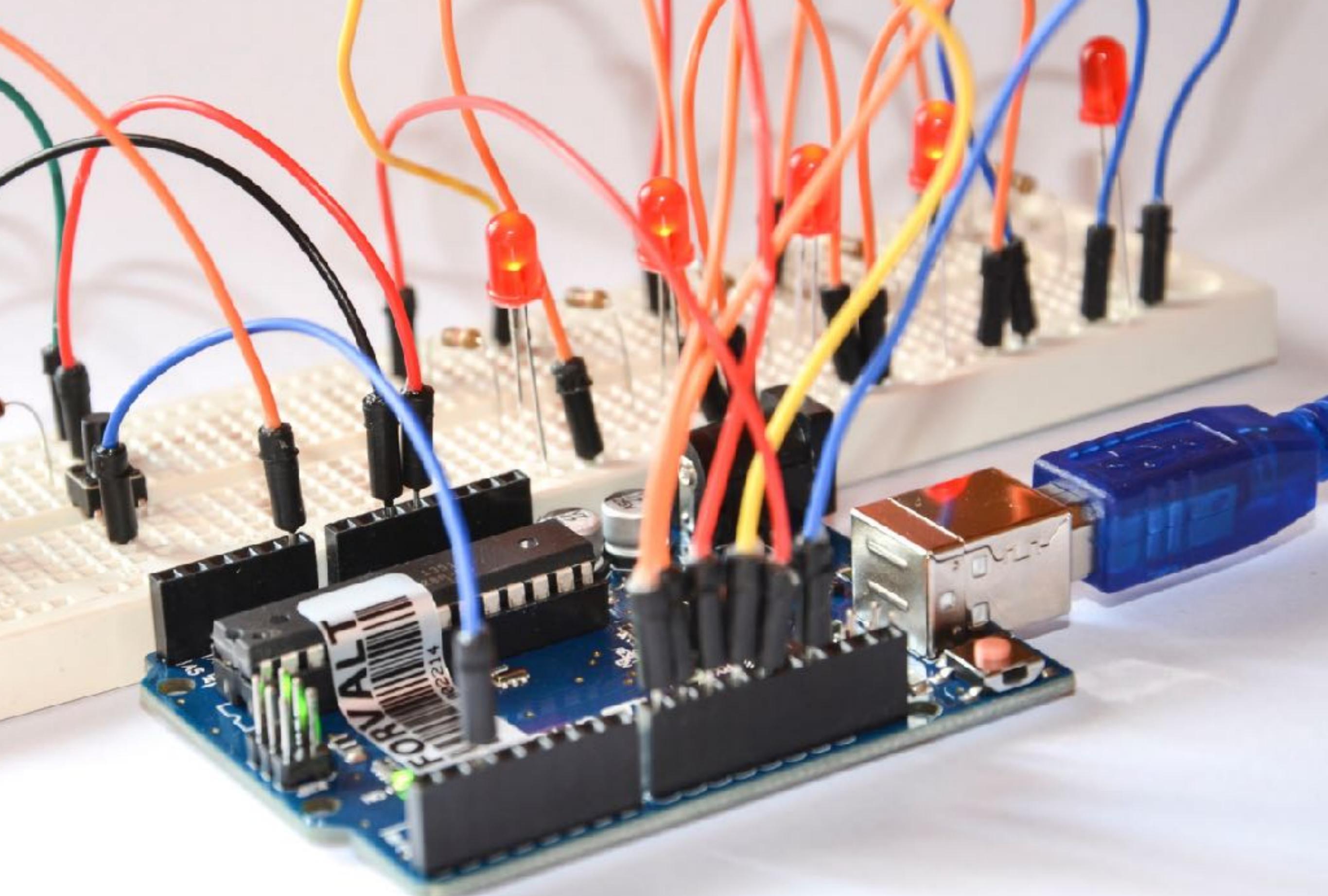
Classical approach

Arduino platform

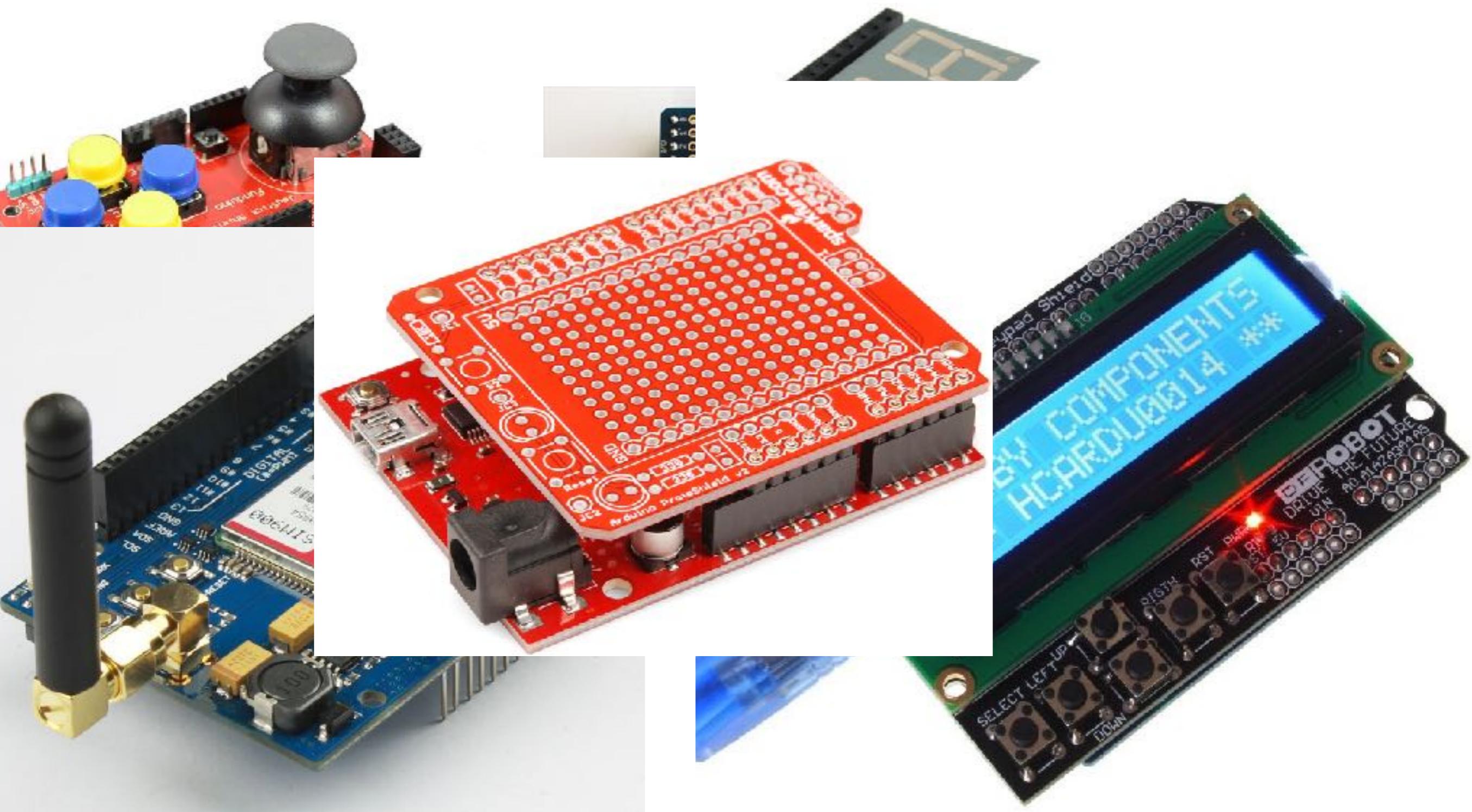


<https://www.adafruit.com/?q=breakout>

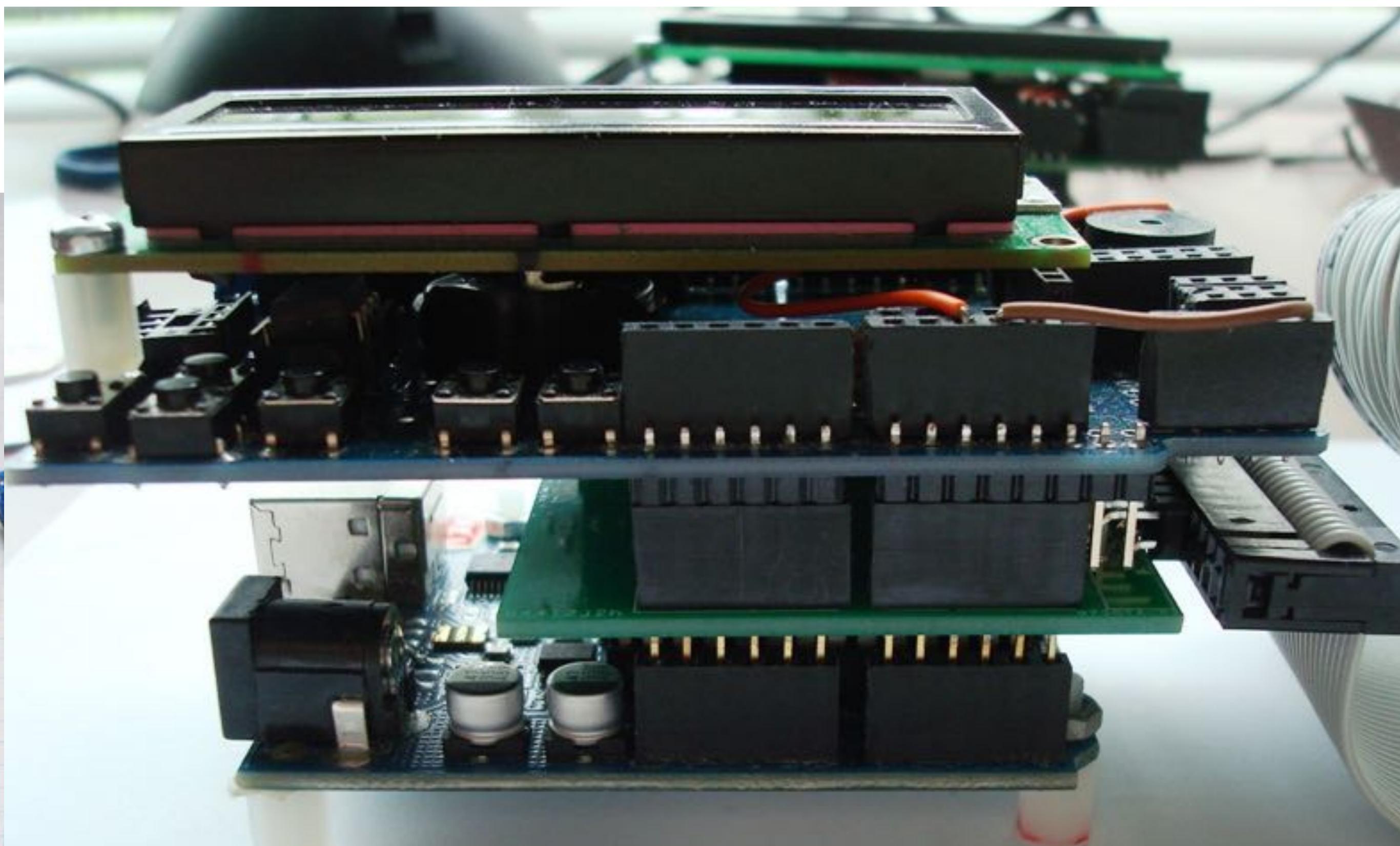




A solution : use of shields



May become a little bit complex ...

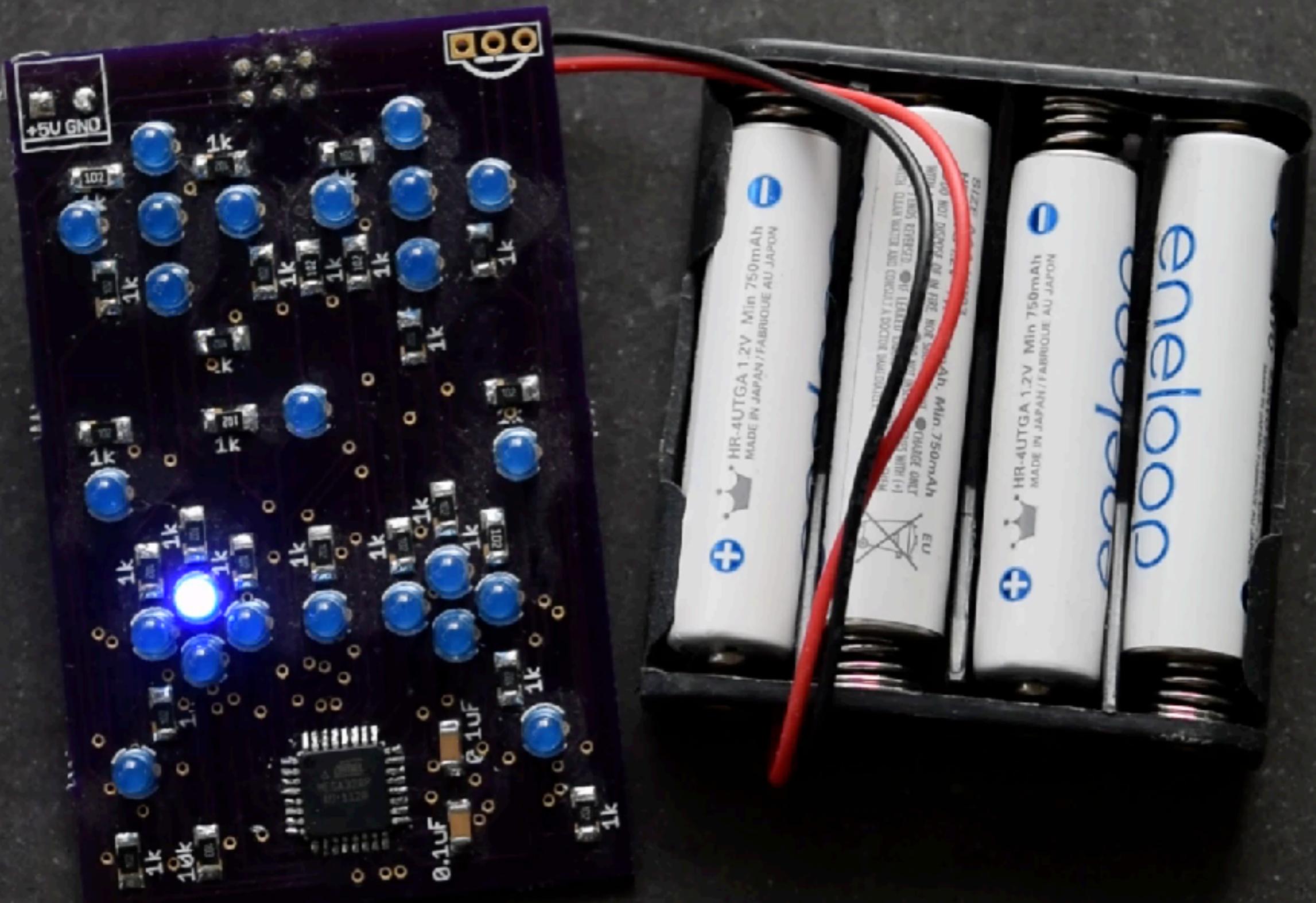


We tried this approach

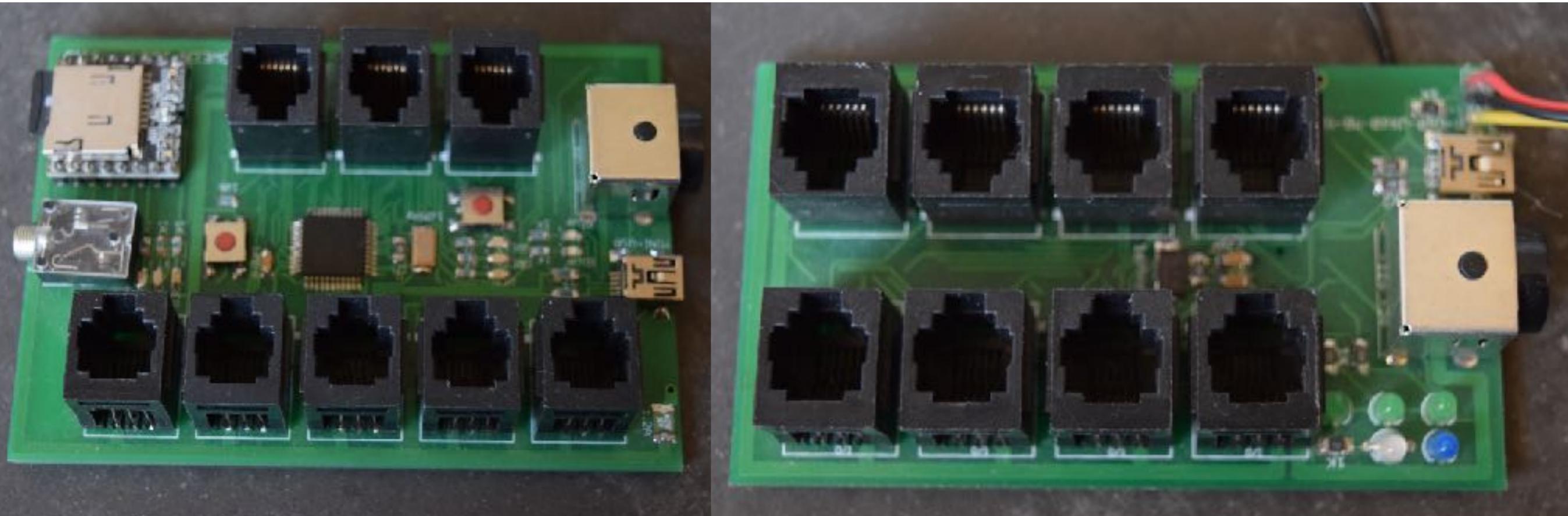
- **Arduino MEGA**
- **Extensions board for halloween decoration**
- **"This is what is need for my bioreactor"**



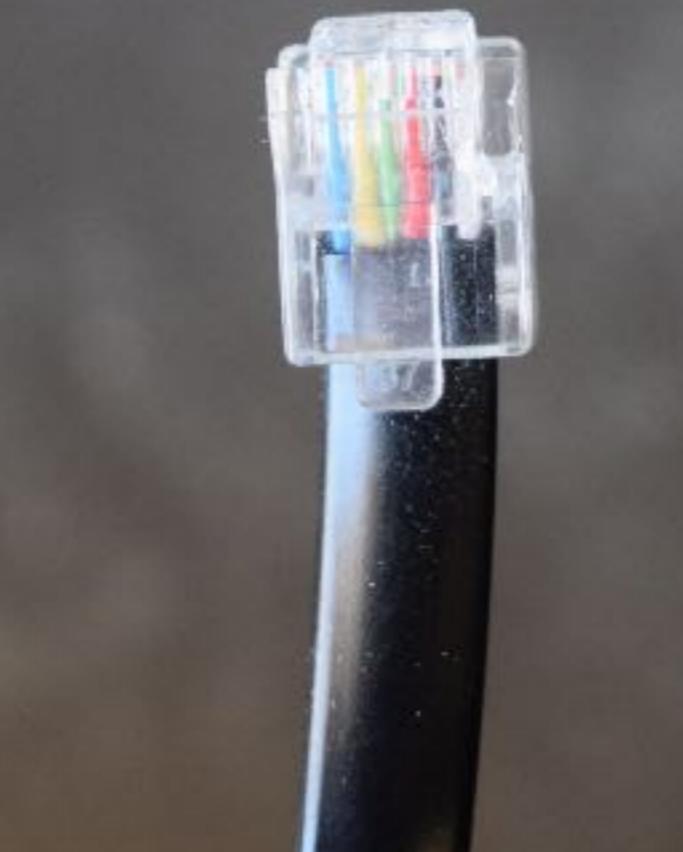
Can we make our own Arduino ?



Legoino : master board



Legoino : extensions





Arduino Leonardo

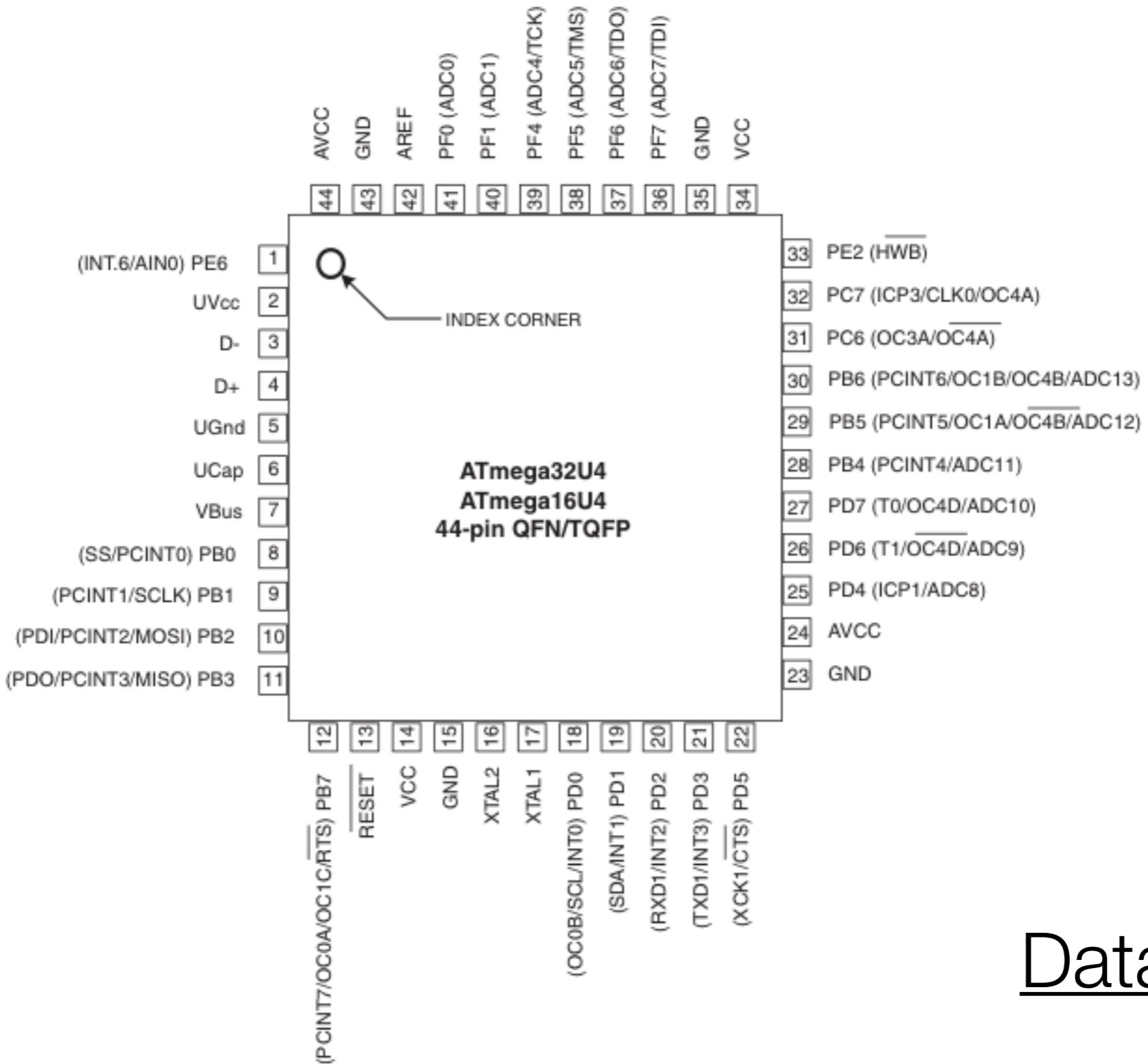
Arduino platform



Microcontroller : ATMEGA32U4

- **32 kb of programmable flash memory**
- **2.5 kb SRAM (Static random-access memory)**
- **1 kb EEPROM (Electrically Erasable Programmable Read-Only Memory)**
- **Operating voltage: 2.7v to 5.5V**
- **8 (min 2.7V) / 16 (min 4.5V) MHz**
- **26 I/O, 12 x 10bits ADC**
- **USART, I2C, USB, SPI**
- **2 x 16bits Timer / Counter**
- **4 x PWM 16 bits, 6 x PWM 11 bits**

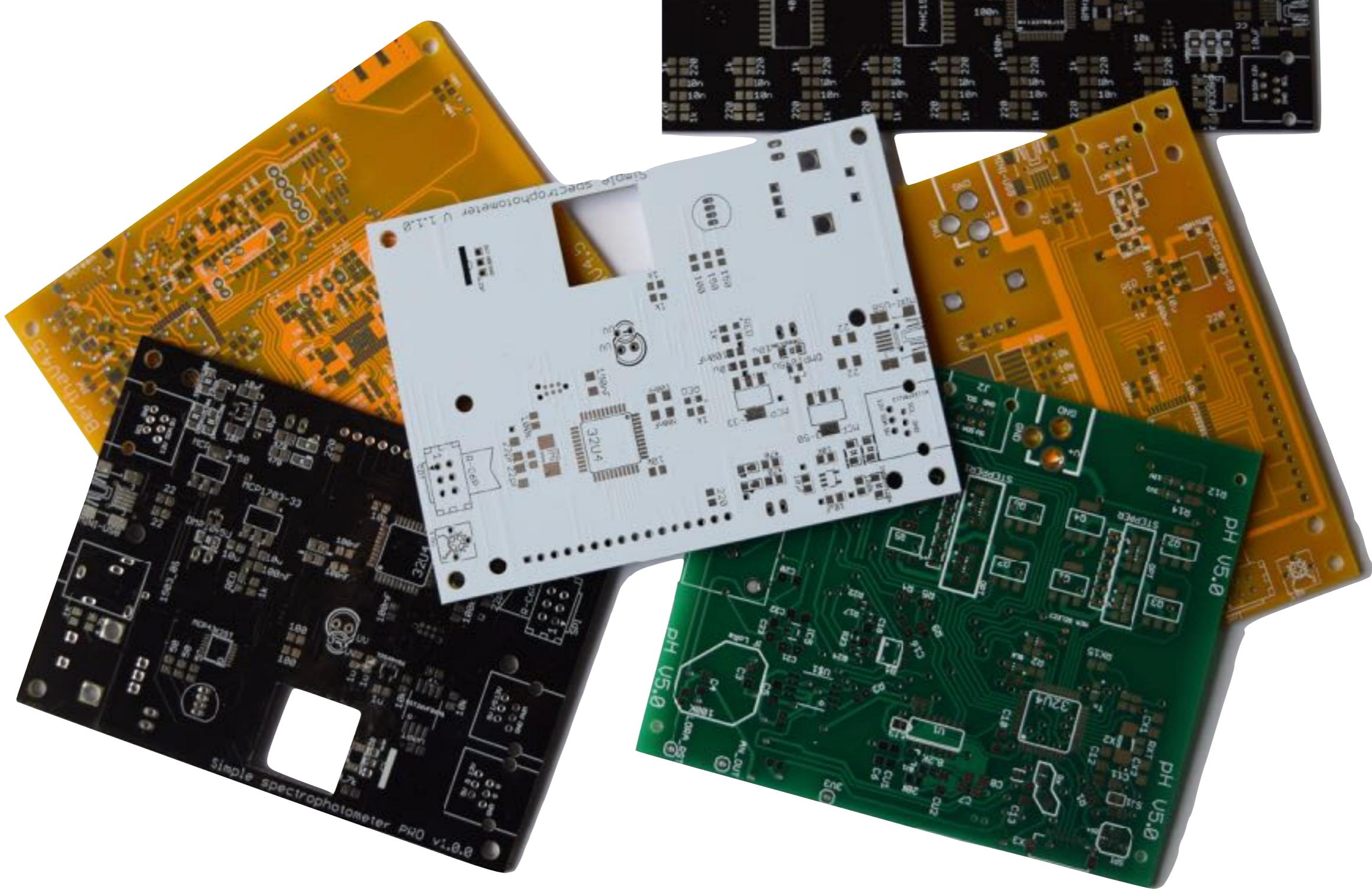
Microcontroller : ATMEGA32U4



Datasheet

Making your own PCB

www.pcbway.com - www.seedstudio.com



PCB production

- \$5 for 5 to 10 PCBs 10x10cm
- + shipping ... \$10 to \$25
- Numerous suppliers
 - <http://www.pcbway.com> (currently my preferred one)
 - <http://www.seedstudio.com>
 - <http://www.elecrow.com>
 - <https://oshpark.com> - \$5 for 3 per square inch
- You need Gerber Files

www.pcbway.com

To:Luc Patiny
From: PCBWay.com

NO:G118393
Date:11/27/2017

Recipient Buyer	Luc Patiny
Contact	Luc Patiny
Shipping address	ruelle des Châtaigniers 5, DENGES, 1026, SWITZERLAND
Tel	+41 78 909 84 68
Email	luc@patiny.com
Payment method	PayPal
Shipping method	DHL

Order Information

Part No. and description	Size (mm)	Qty	Unit price (USD)	Amount (USD)	Freight cost (USD)	Bank fee (USD)	Discount (USD)	Total (USD)
Electronic PCB: FR-4 1.6mm 1 oz 2layers Black mask White legend HASL with lead No. : W11337ASJ24 ledDisplay	92.7*68.6	10	0.500	5.00	25.00	2.00	-1.00	31.00



combine shipping

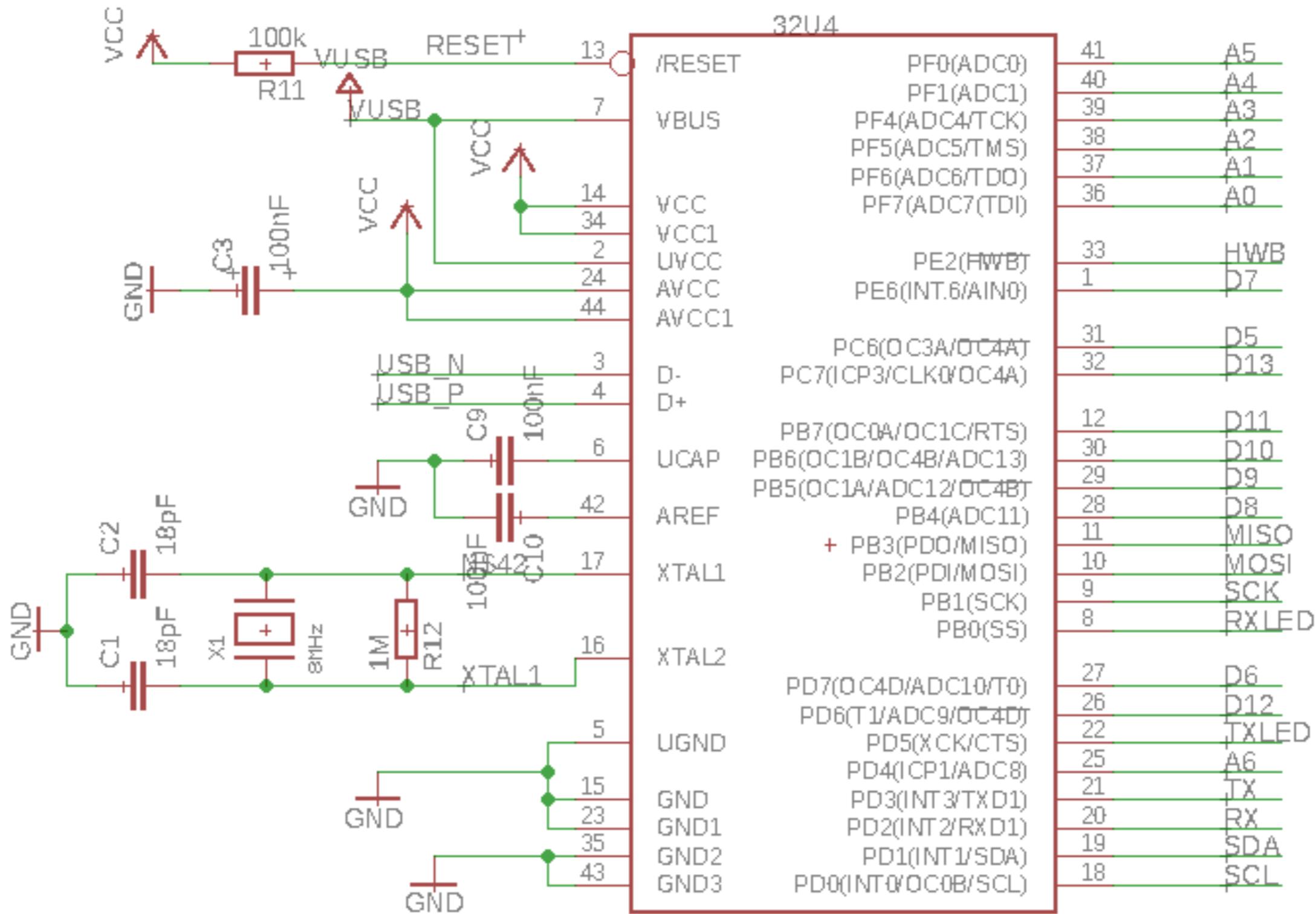
eagle

<https://www.autodesk.com/products/eagle/>

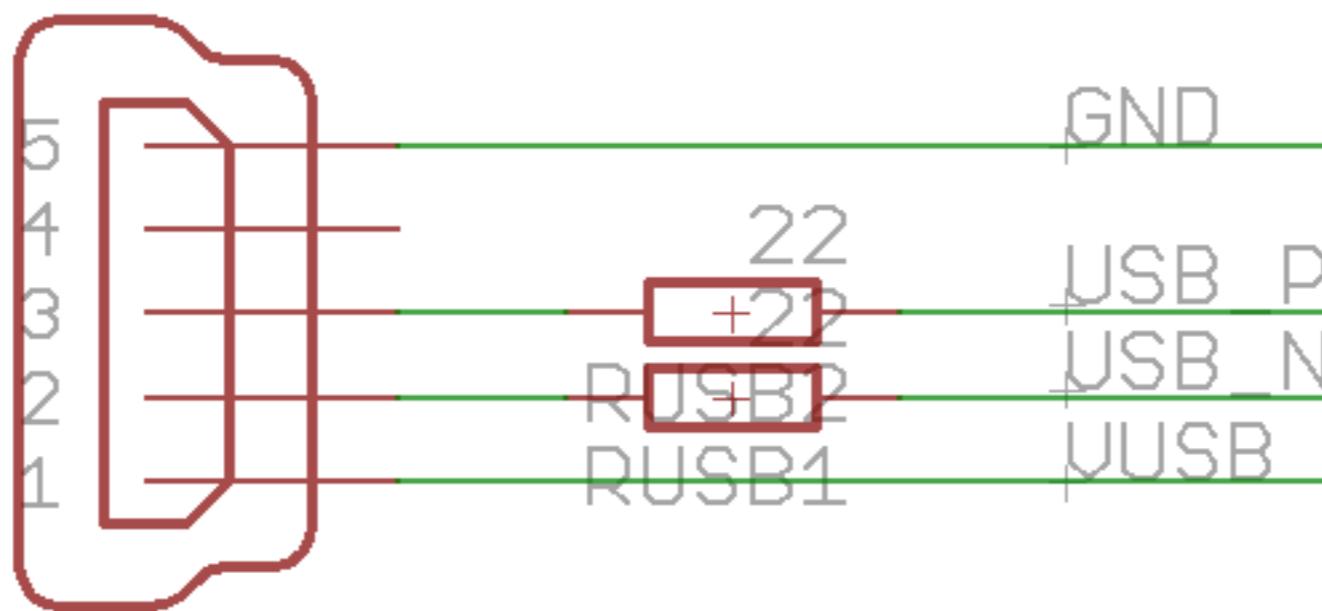
Opensource alternative: KiCad

<http://kicad-pcb.org/>

Schematic

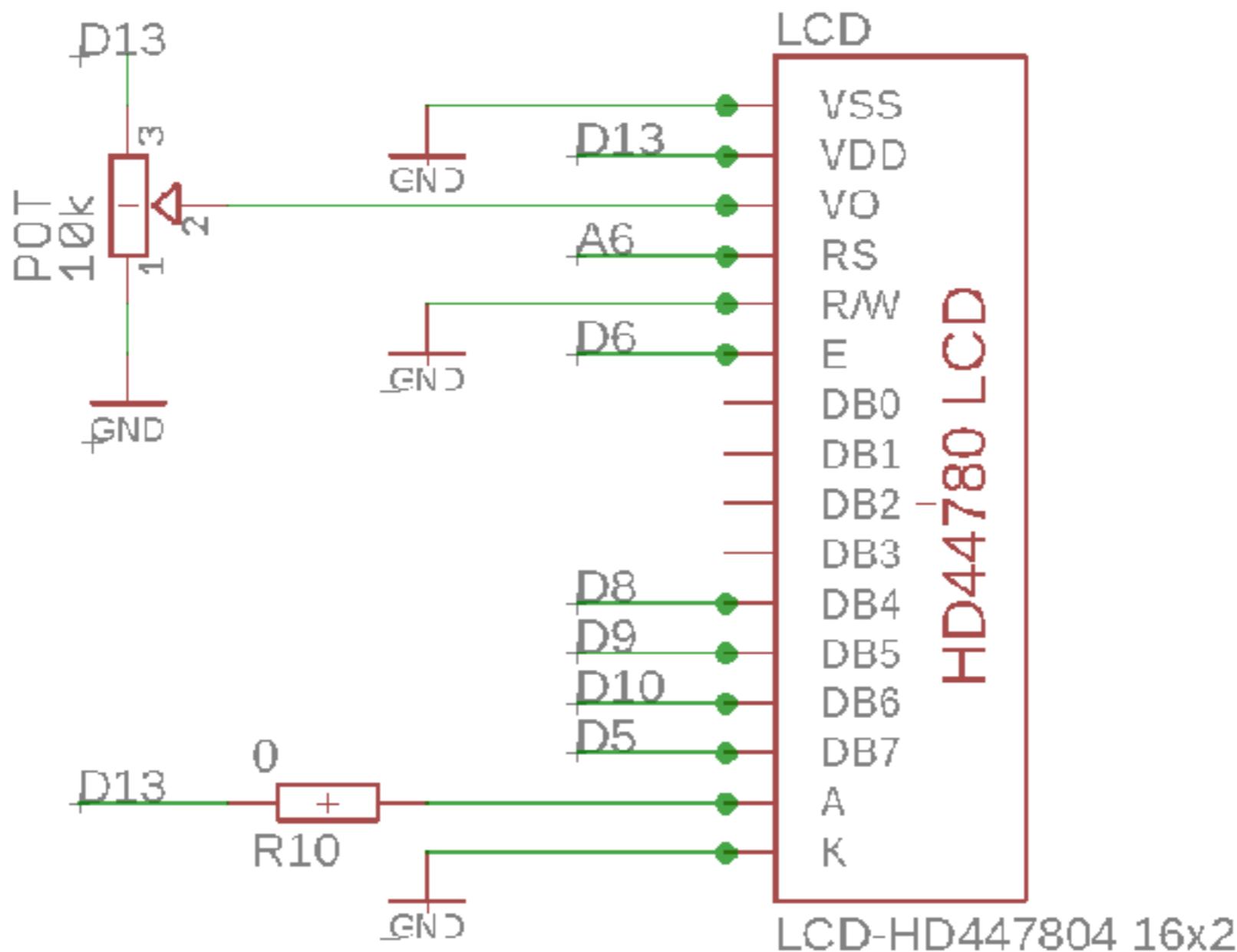


USB

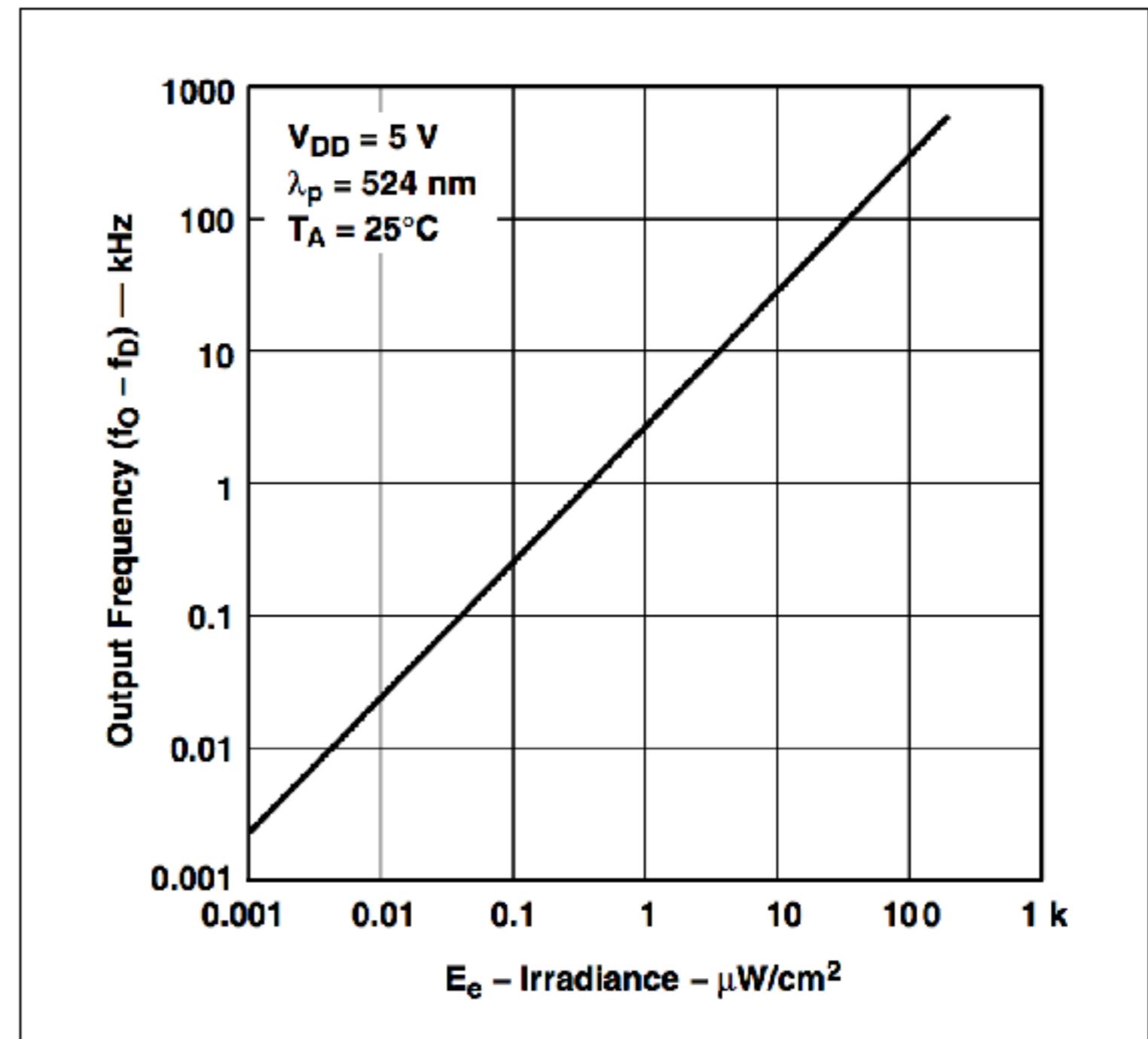
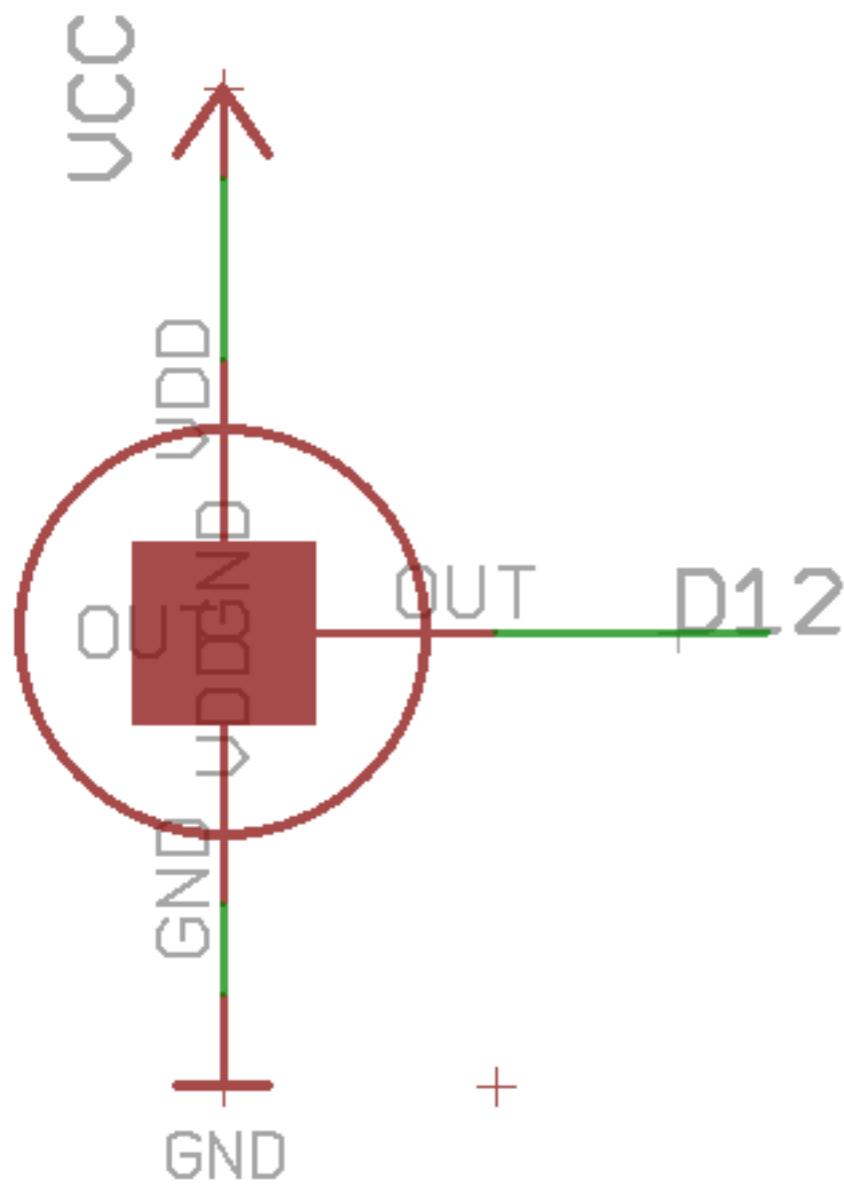


LCD

LCD 16x2



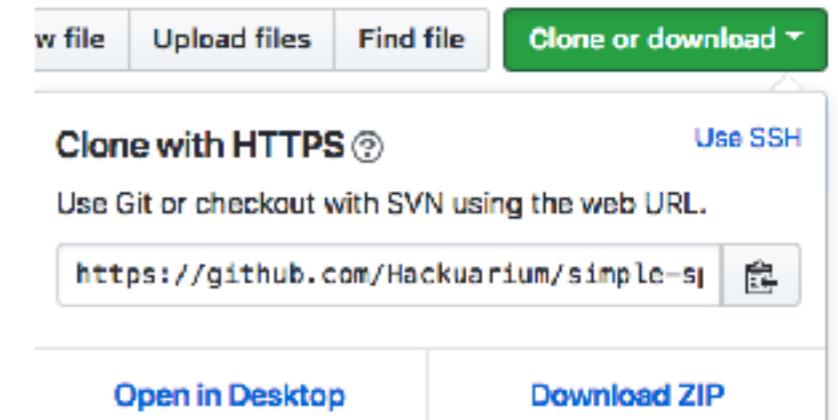
Light to frequency - TSL 237



Exercise

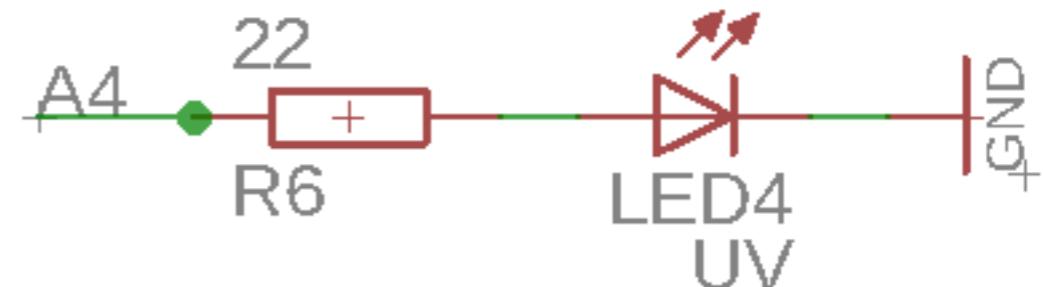
- **Download the project**

- <https://github.com/hackuarium/simple-spectro>

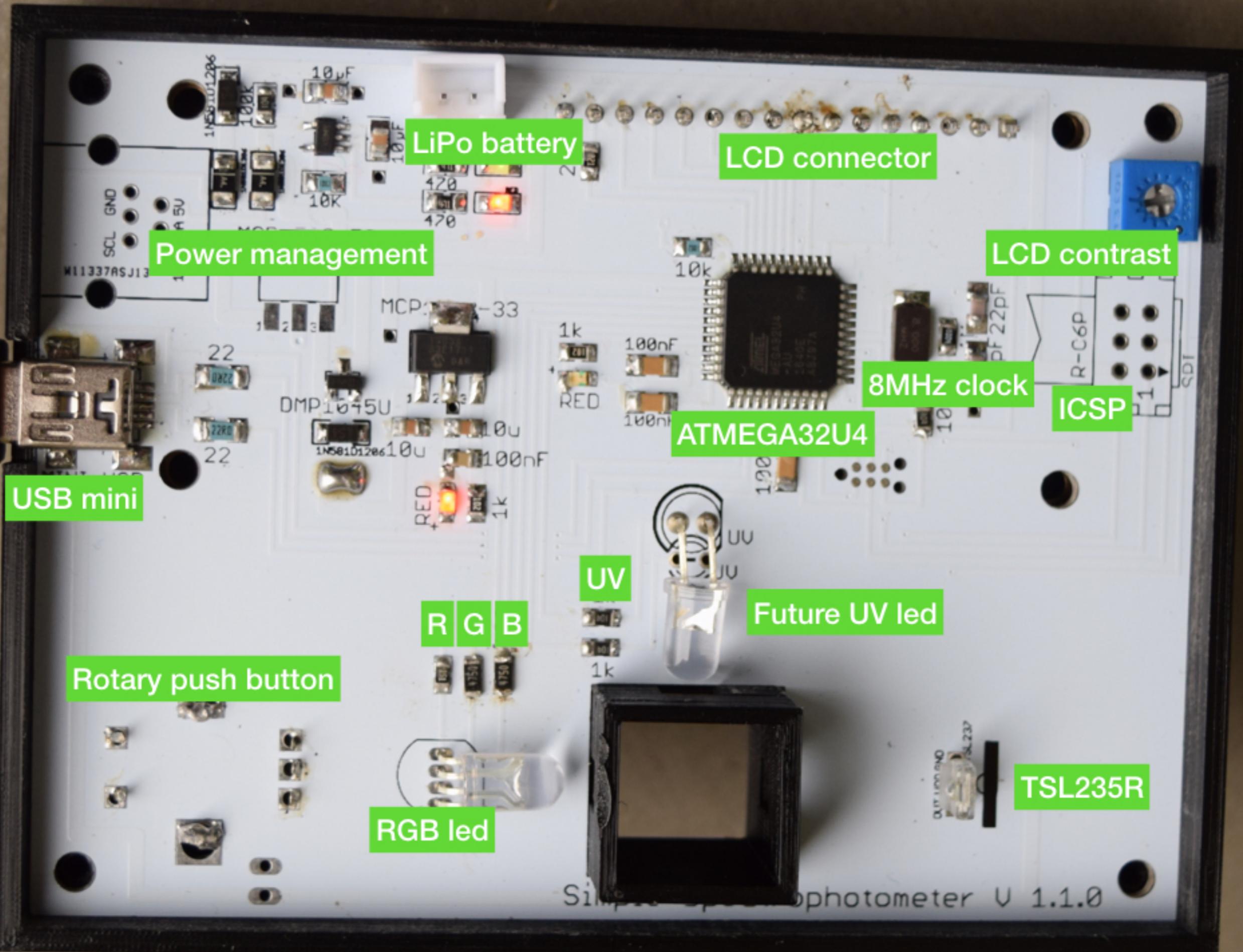


- **In eagle**

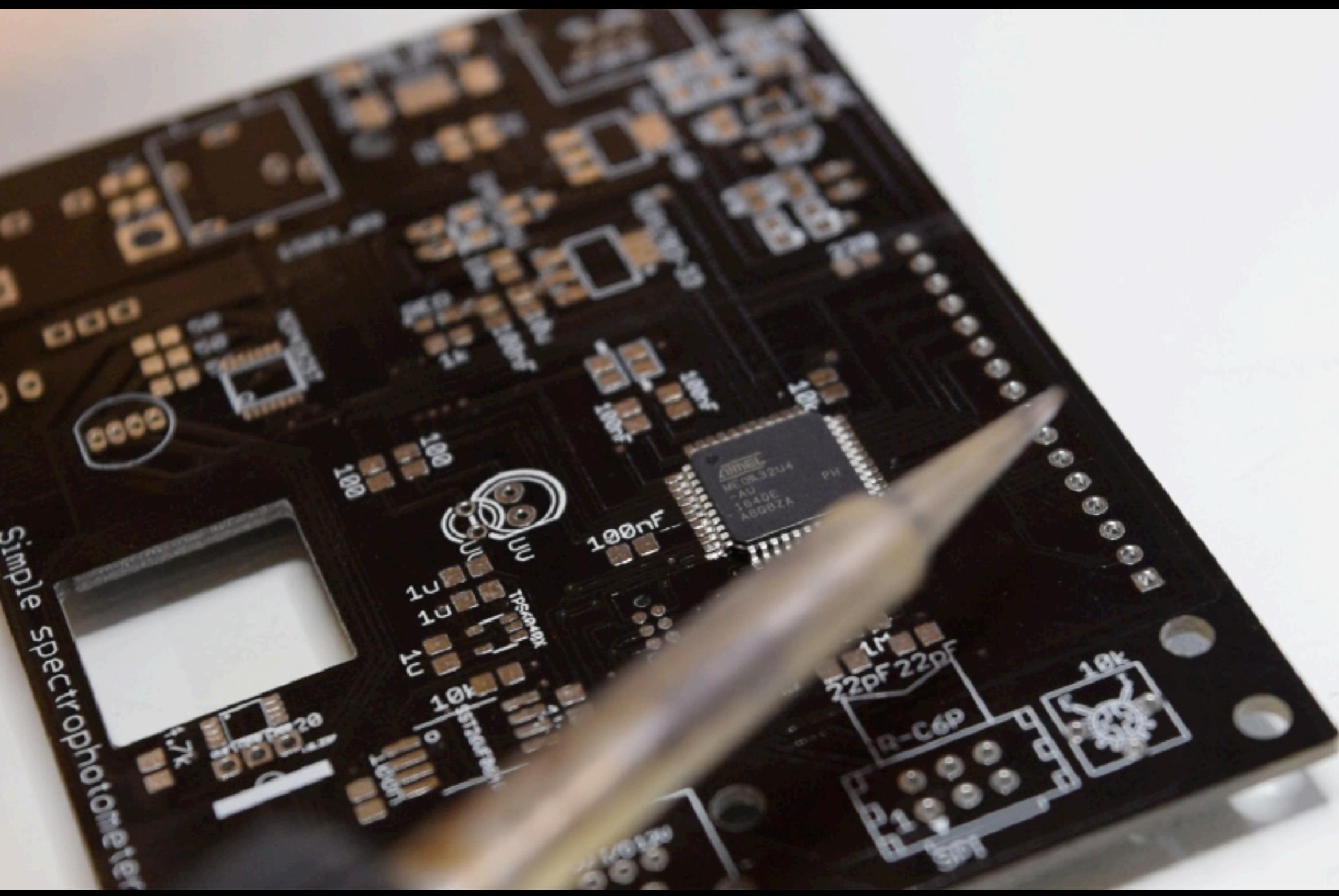
- Open Schematic: tutorial/eagle/tutorial.sch
 - Add 3 leds with corresponding resistors on pins A0, A1 and A2
 - Board
 - Routing
 - Check
 - Create Gerber files
 - Check Gerber : <https://gerber-viewer.eeasyeda.com/>



Soldering the PCB



Simple spectrophotometer



PCBA

Printed Circuit Board Assembly

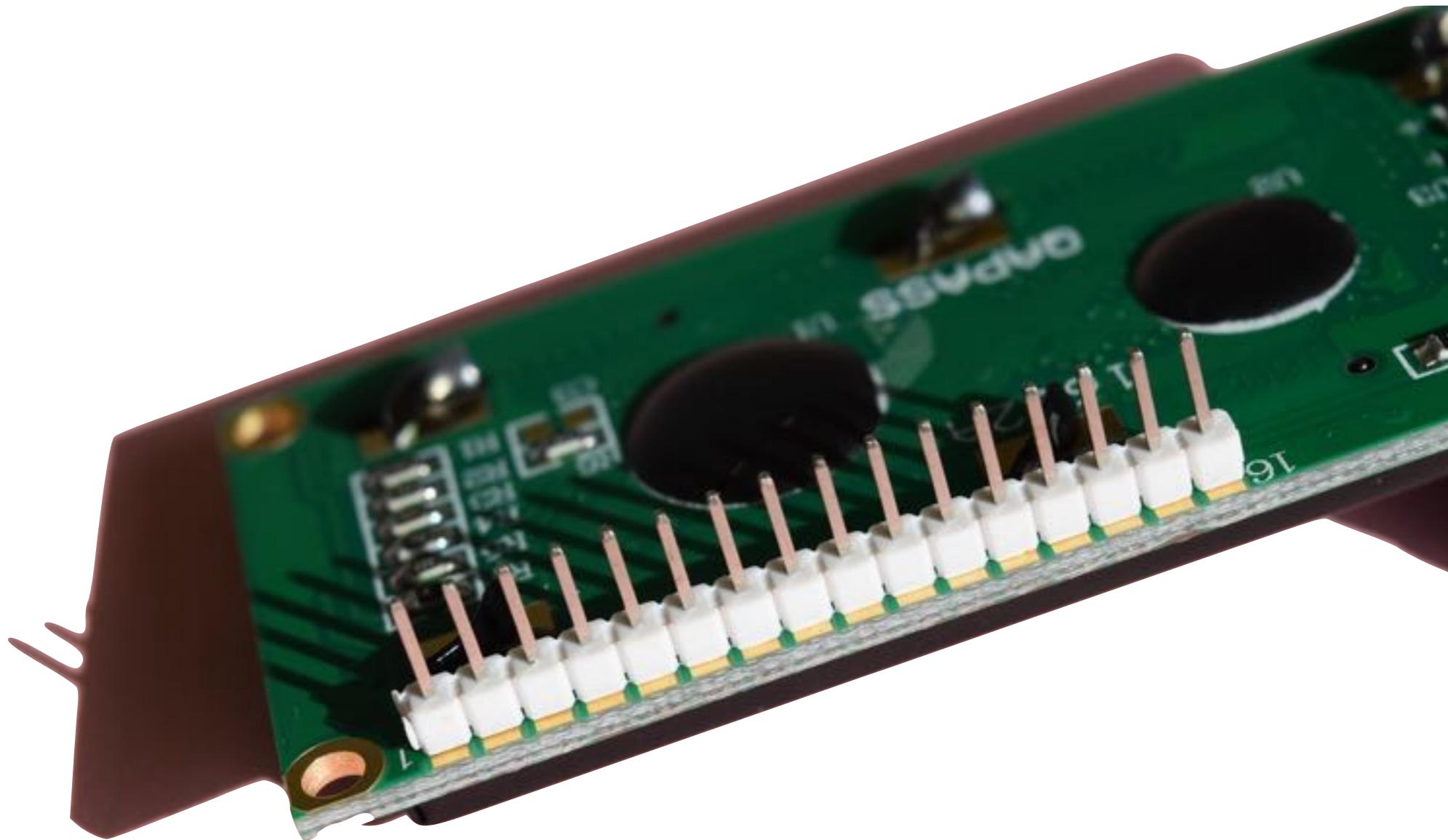
www.elecrow.com

- **Free components list**
 - <https://www.elecrow.com/pcb-assembly-p-366.html>
 - 120 SMD capacitors
 - 235 SMD resistors
- **Provider:** <https://lcsc.com/>
- **In Eagle:**
 - 'attr', add LCSC Part # (or free components)
 - 'run ULP ➔ bom', export as CSV
 - 'export ➔ mount SMD' : export .mnb and .mnt

www.elecrow.com

For PCB fabricate							
Project Name	Layers	Dimension/cm	Thickness/mm	Surface Finished	Solder Mask	Qty	Quotation (\$)
simple-spectro	2-layer	10*10	1.6	HASL leadfree	Green	20 100	\$26.90 \$123.78
Stencil for assembly						1	\$18.00
							20pcs Total with stencil: \$44.90 100pcs Total with stencil: \$141.78
For PCB Assembly							
Project Name	Pads	Qty	Price	Qty of Boards	Quotation	Remark	
simple-spectro	SMT	135	0.030	20	\$81.00		
				100	\$202.50	50% discount	
					20pcs Total : \$81.00 100pcs Total : \$202.50		
Engineer Start							
20pcs Total :	\$10.00						
100pcs Total :	\$0.00	Free					
Components purchased by Elecrow							
20pcs Total :	\$149.800	Remark 20\$ added for sourcing fee					
100pcs Total :	\$623.00						
Shipping							
Products	Shipping Method	Weight(g)	Quotation	Remark			
20PCBAs	DHL	2500.00	\$29.40				
100PCBAs		8000.00	\$71.35				
		20pcs Total :	\$29.40				
		100pcs Total :	\$71.35				
					20pcs Total Quotation(\$): \$315.10		
					100pcs Total Quotation(\$): \$1'038.63		

Through holes components



1. Solder pins on LCD screen
2. Check the screen !!!!

5

1

2

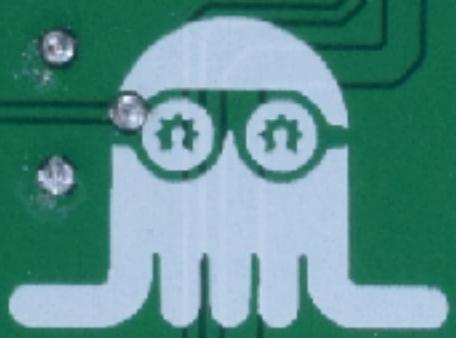
3

Simple spectro

4

6

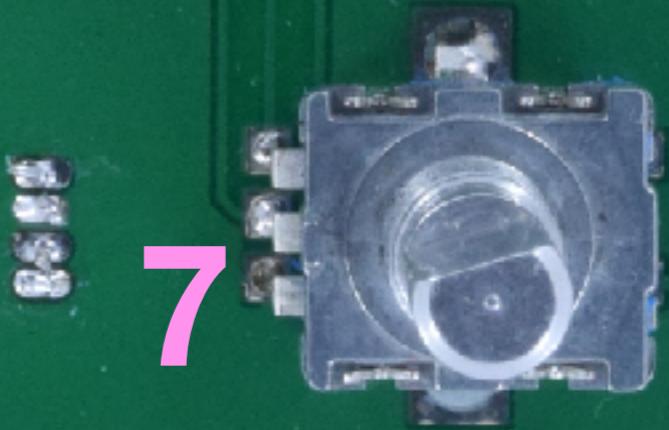
1 VSS VDD V0 RS RW E D0 D1 D2 D3 D4 D5 D6 D7 A/K 16



Hackuarium
Simple spectro

v 1.4.1

7



Mechanics



Various strategies

3D printing

- ✓ any shape
- ✗ slow
- ✗ not that cheap

Laser cutting

- ✓ fast and cheap
- ✗ limited shapes (2D)

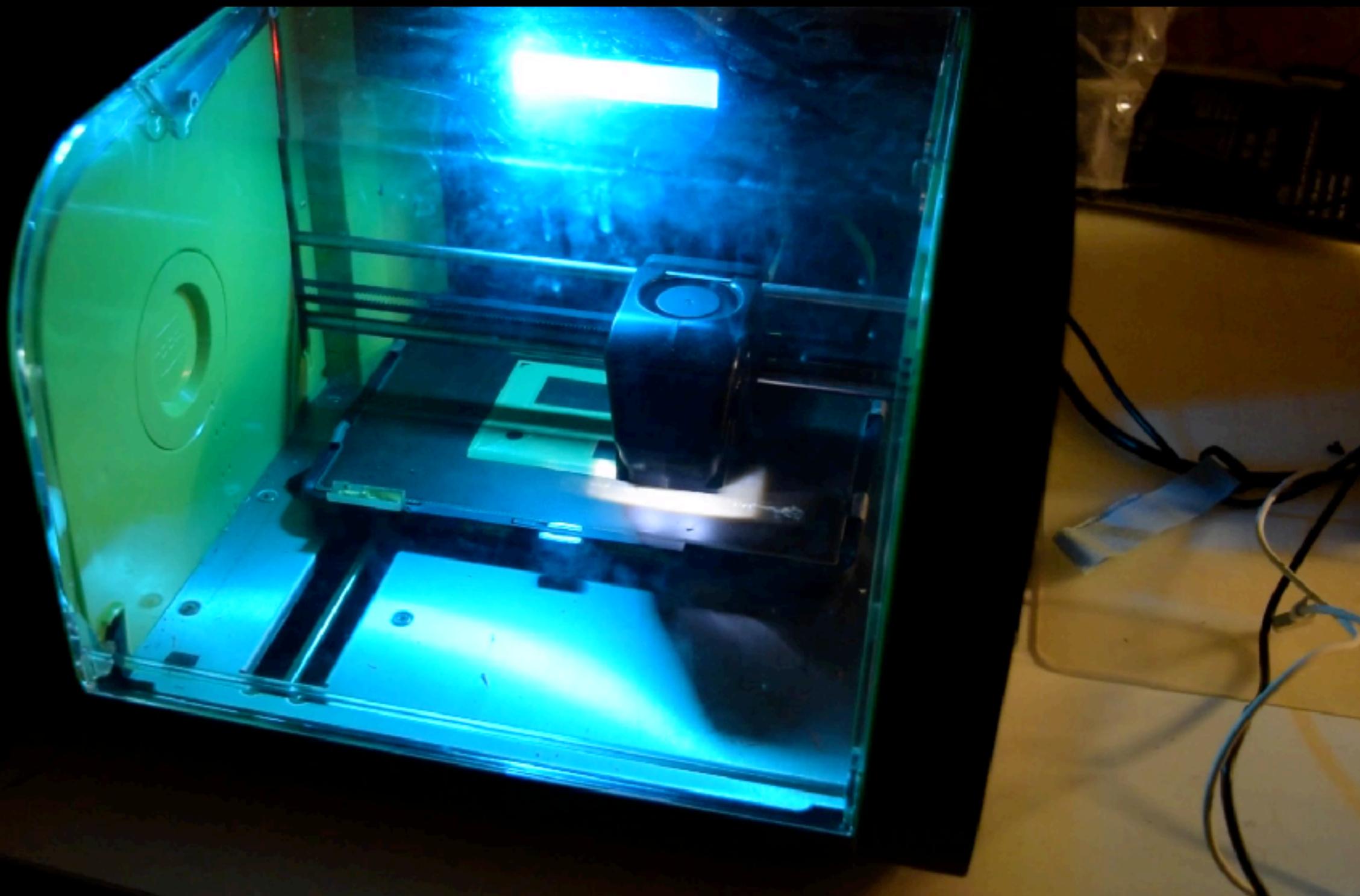
Milling

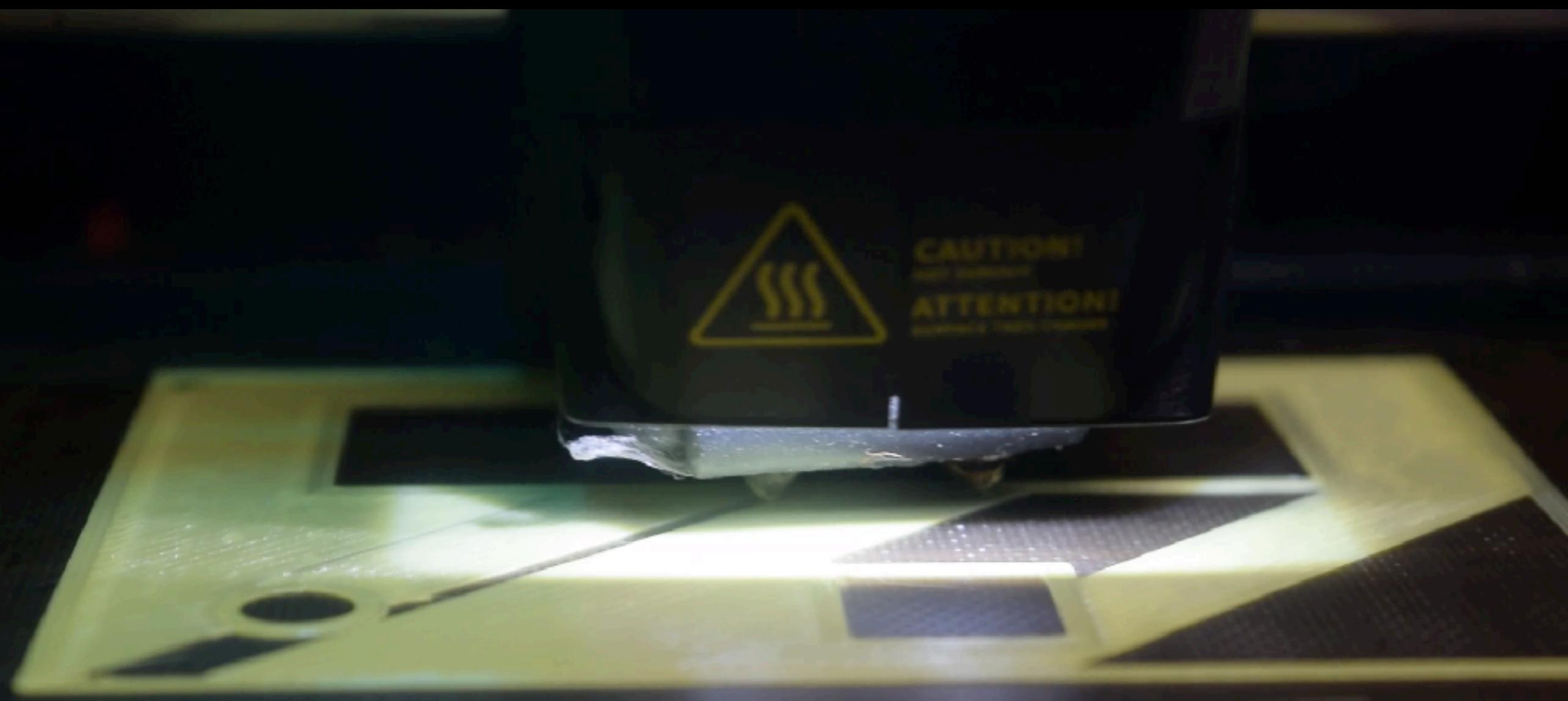
- ✓ perfect quality
- ✗ cost
- ✗ time

Molding

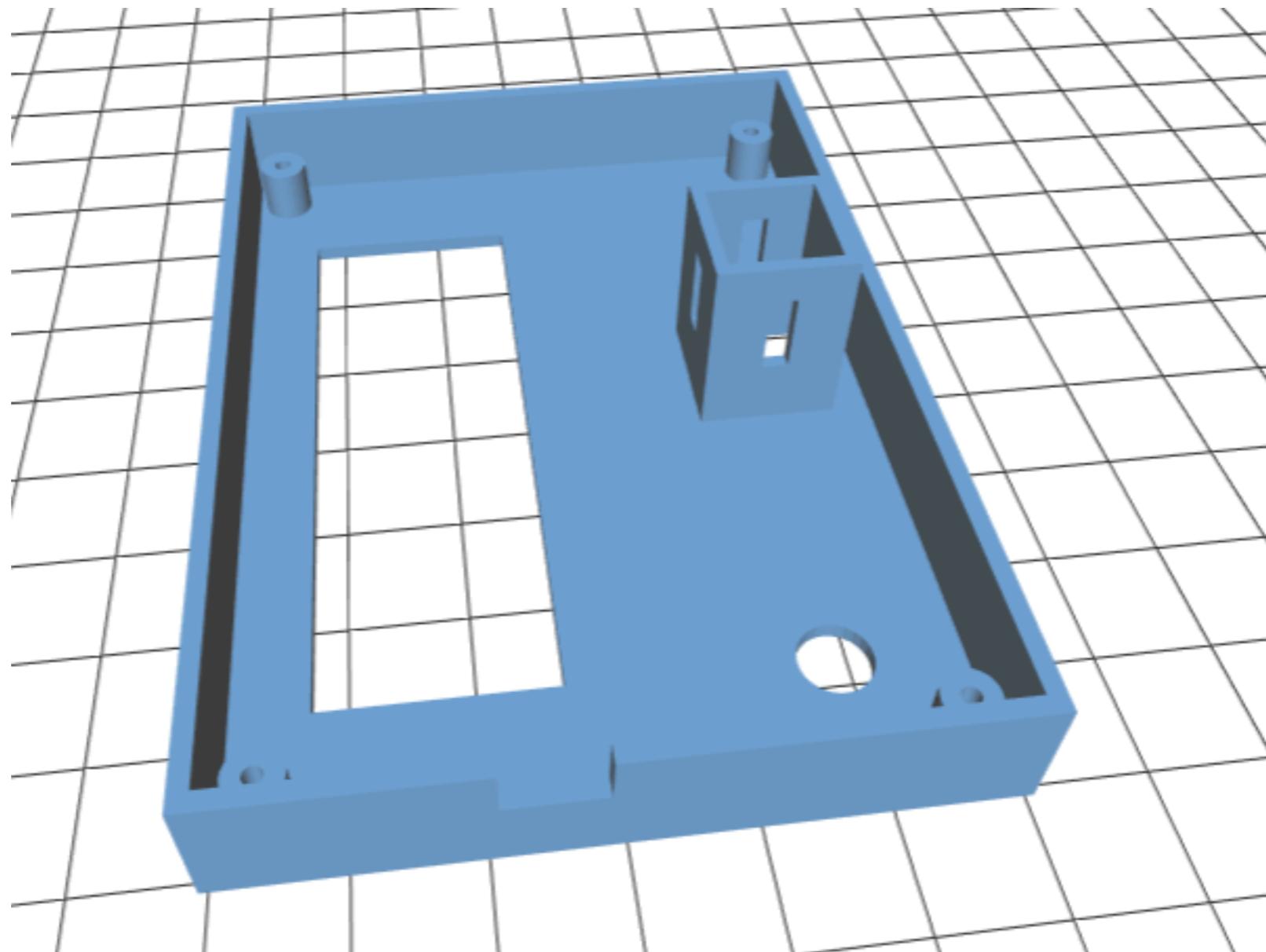
- ✓ cheap for large series
- ✗ setup cost
- ✗ time

3D printing





You need an **STL** file



<https://github.com/Hackuarium/simple-spectro/tree/master/CAD/open-box>

About



Robox : Desktop 3D Printer and Micro-Manufacturing Platform

[Portishead, UK](#) [3D Printing](#)

£280,891

pledged of £100,000 goal

435

backers

Pledge £700 or more

PRE-ORDER price.

Order now and we will ship your Robox® as soon as it first rolls off the production line. You will have the first Kickstarter production build. Dressed in the limited edition Kickstarter colours and supplied with 2 taster reels of filament. You'll also get a custom appearance in our community.

ESTIMATED DELIVERY

Mar 2014

SHIPS TO

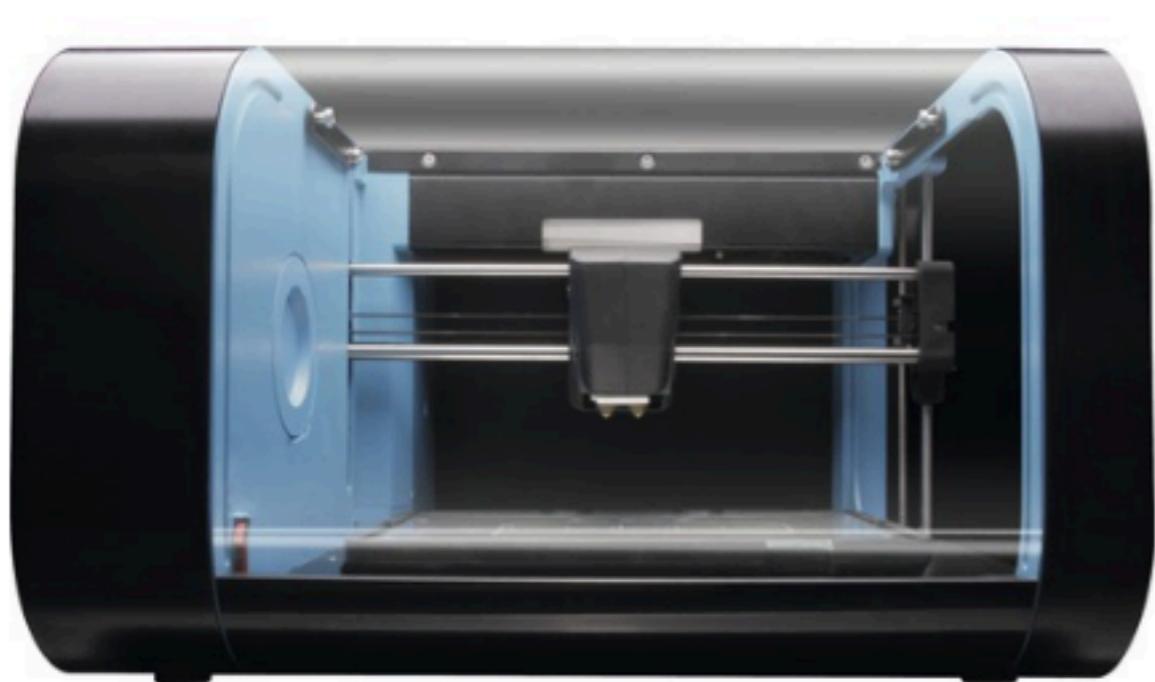
Anywhere in the world

Limited

259 backers

Funding period

Nov 21 2013 - Dec 21 2013 (30 days)



Imprimante 3D Robox RBX1

Art. 5843151

Pas encore évalué [Écrire une évaluation](#)

[Plus de détails sur l'article >](#)

990.00 CHF *

/ pce



Marquer
 Comparer

Filament Robox rose PLA

Pas encore évalué

36.00 CHF * / pce



Marquer
 Comparer

Filament Robox violet PLA

Pas encore évalué

36.00 CHF * / pce



Marquer
 Comparer

Filament Robox bleu PLA

Pas encore évalué

36.00 CHF * / pce



Marquer
 Comparer

Filament Robox vert PLA

Pas encore évalué

36.00 CHF * / pce

The cost of 3D printing

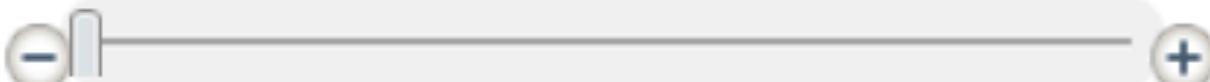
- Printer 1000 CHF
- Case 50g: 3 CHF



Consumable parts are not covered by this Limited Warranty (these include the printing head, extruder, ThermoSurface™ bed sheet, Bowden tube, filament feed path, filament, accessories (trimming kit, bed wipes, lubricant, tweezers, USB flash drive), power cable, USB cable and on-board microSD card). In particular, the warranty period for the printhead is 500 hours, as defined by the 'Head hours' counter on the chip of the printhead, or 100 days from the date of purchase – whichever is greater. Warranty services may be provided by CEL, an Affiliated/Authorised Reseller, or a third party service provider designated by CEL.



Double click on above image to view full picture



RBX01-S2 - Single Material Dual Nozzle Head- Version 2



Tweet



Like

Be the first of your friends to like this.

Email to a Friend

Be the first to review this product

Availability: In stock.

Quantity Available: 4

Available from:

£149.90

Qty:

ADD TO CART

or check out instantly with:

Check out with **PayPal**

-OR-

PayPal CREDIT

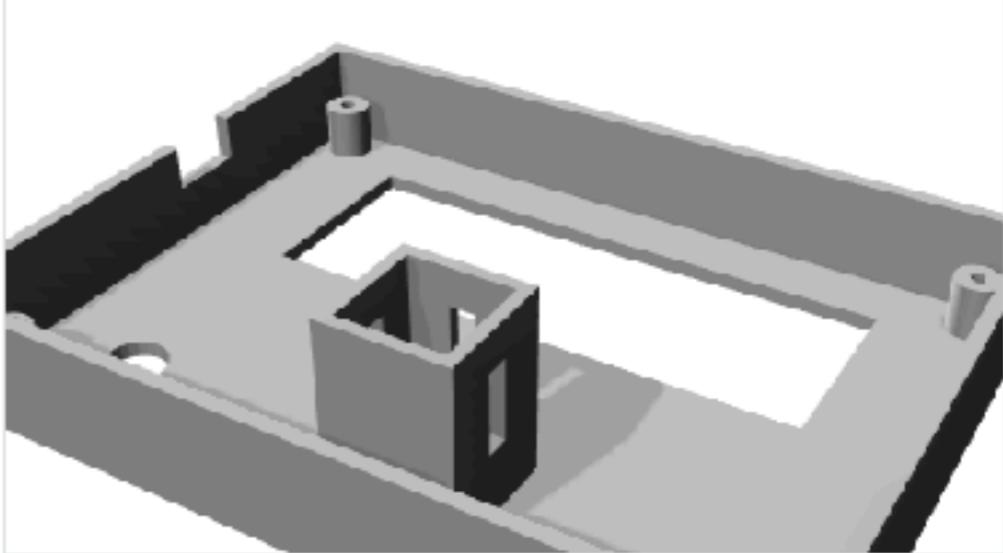
<https://www.shapeways.com/>

FILE
 [UPDATE](#)

SIZE (cm)
10.37 7.82 2.5 [RESIZE](#)
X Y Z

CATEGORY

[SHOW DETAILS ▾](#)



Materials Details History

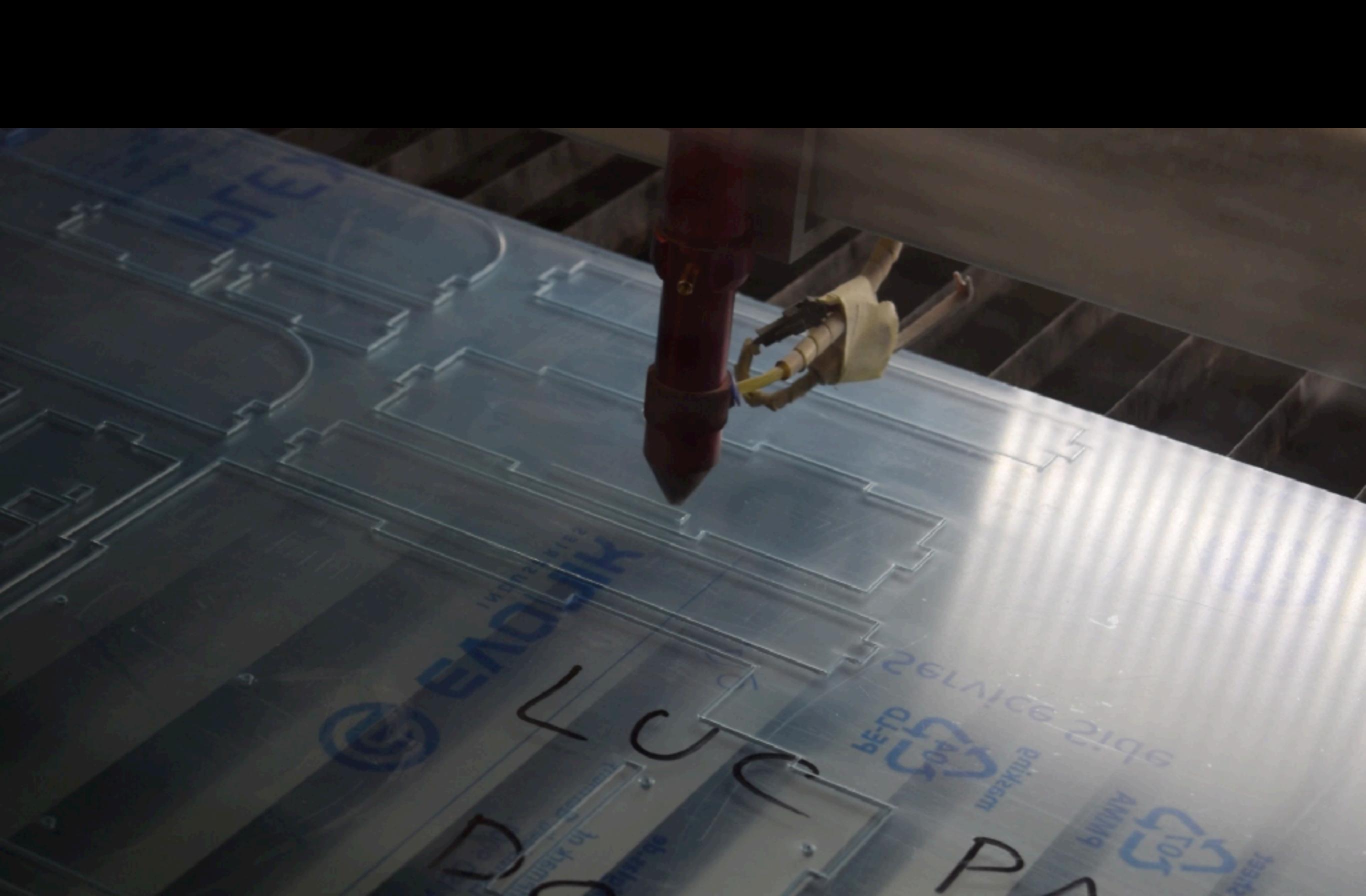
[Show All Materials](#) Strong & Flexible Plastic Metallic Plastic Frosted Detail Plastic Acrylic Plastic (Detail Plastic) Stainless Steel
Precious Metal Sandstone Wax Porcelain Aluminum High Definition Acrylate PLA HP Nylon Plastic

Strong & Flexible Plastic [SET 3D PRINTING ORIENTATION](#)

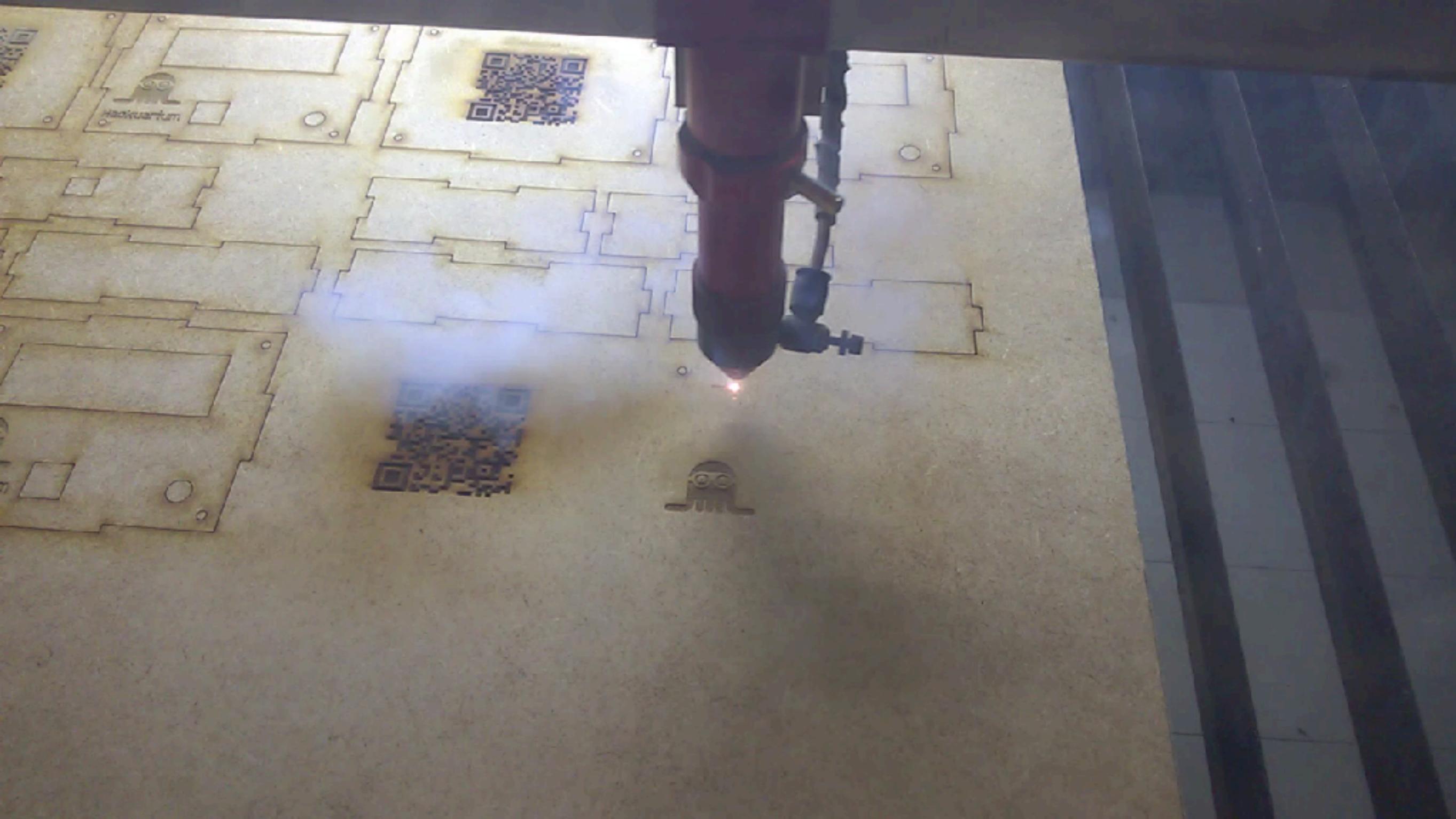
OVERVIEW	CHARACTERISTICS	COMMON USES	TECHNOLOGY
This nylon plastic is our most versatile material suggested for both functional and decorative products.	<ul style="list-style-type: none">• Strong and durable• Supports complex geometry	<ul style="list-style-type: none">• Phone cases• RC car chassis• Jewelry	Selective Laser Sintering

Material Finish	Auto Checks	Manual Checks	Success Rate	Price	Qty.	
 White View 3D tools	Loading	—	—	\$24.27	<input type="text" value="1"/>	ADD TO CART
 Black View 3D tools	Loading	—	—	\$25.27	<input type="text" value="1"/>	ADD TO CART

Laser cutting







The cost of laser cutting

- Machine 2000 CHF
- Plexiglas 3mm: 70 CHF / m²
 - <https://roehmschweiz.ch/fr/produits/plaques/plexiglas/gs-allround/>
- MDF 3mm: 10 CHF / m²



Condition: New

Quantity: 1 More than 10 available
51 sold / See feedback

Price: US \$1,999.00 [Buy It Now](#)

[Add to cart](#)

Add to watch list

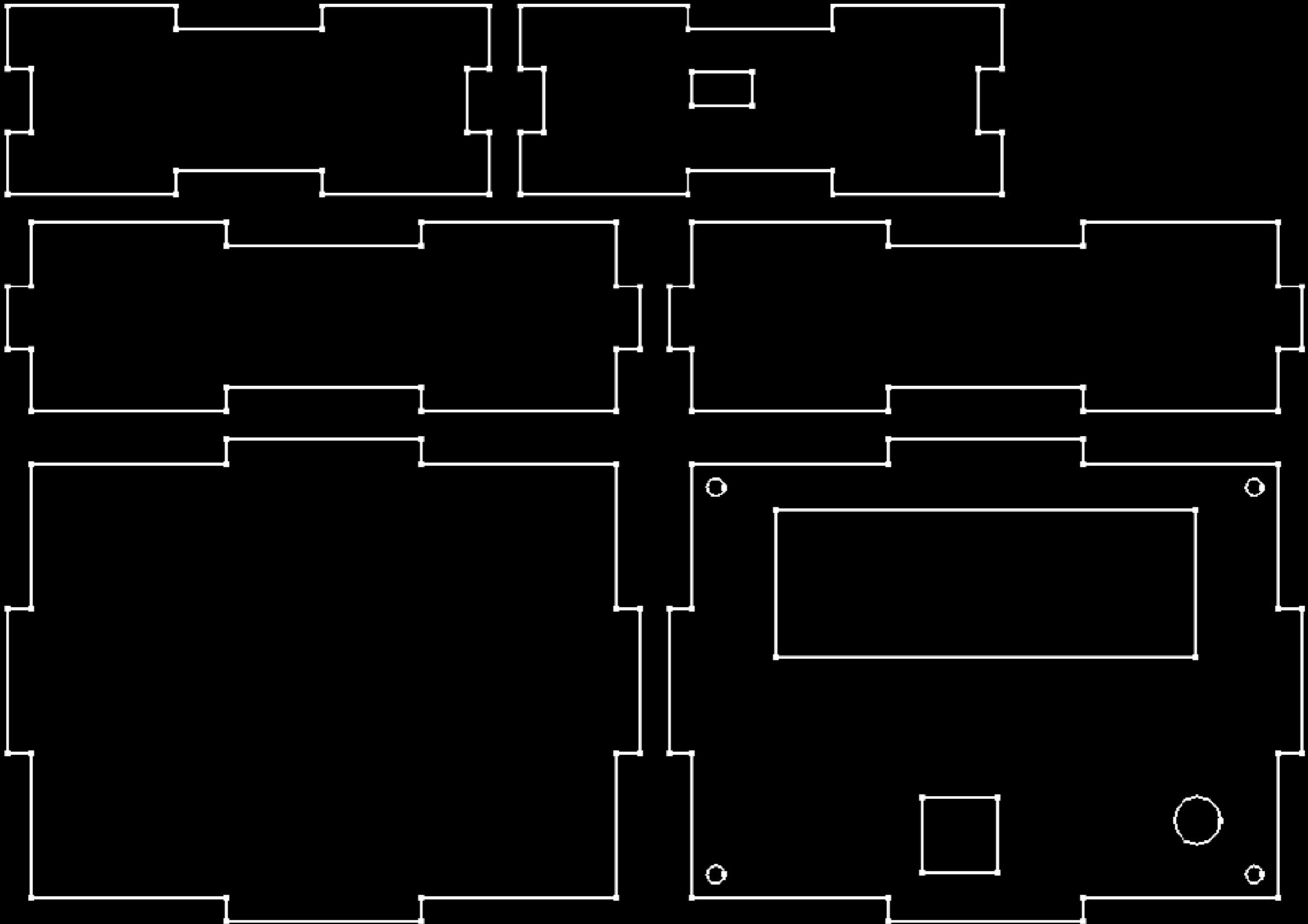
Add to collection

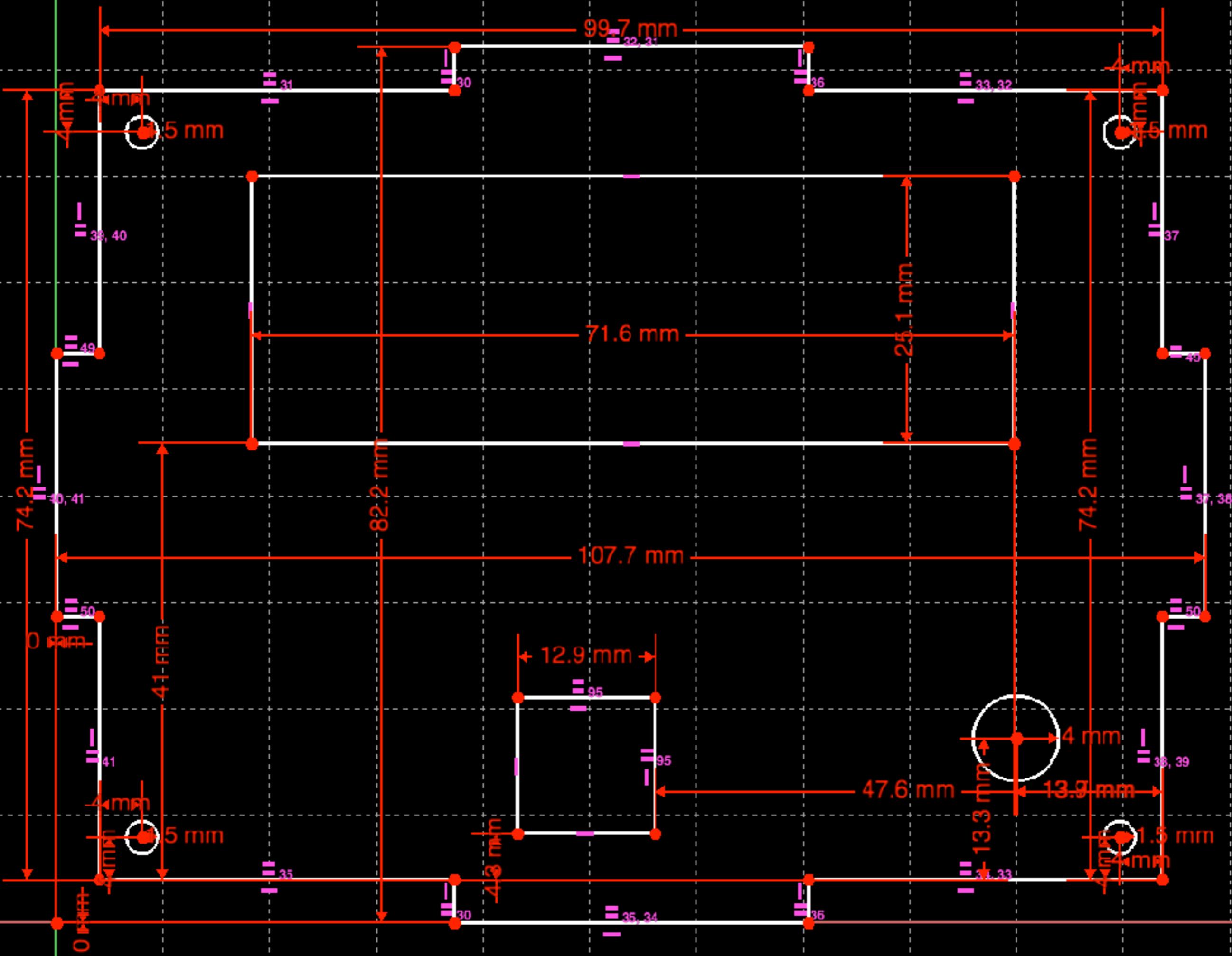
100% buyer satisfaction 51 sold More than 76% sold

Shipping: FREE Standard International Shipping | [See details](#).
See details about International shipping here. ⓘ

Item location: CN, China
Ships to: Worldwide

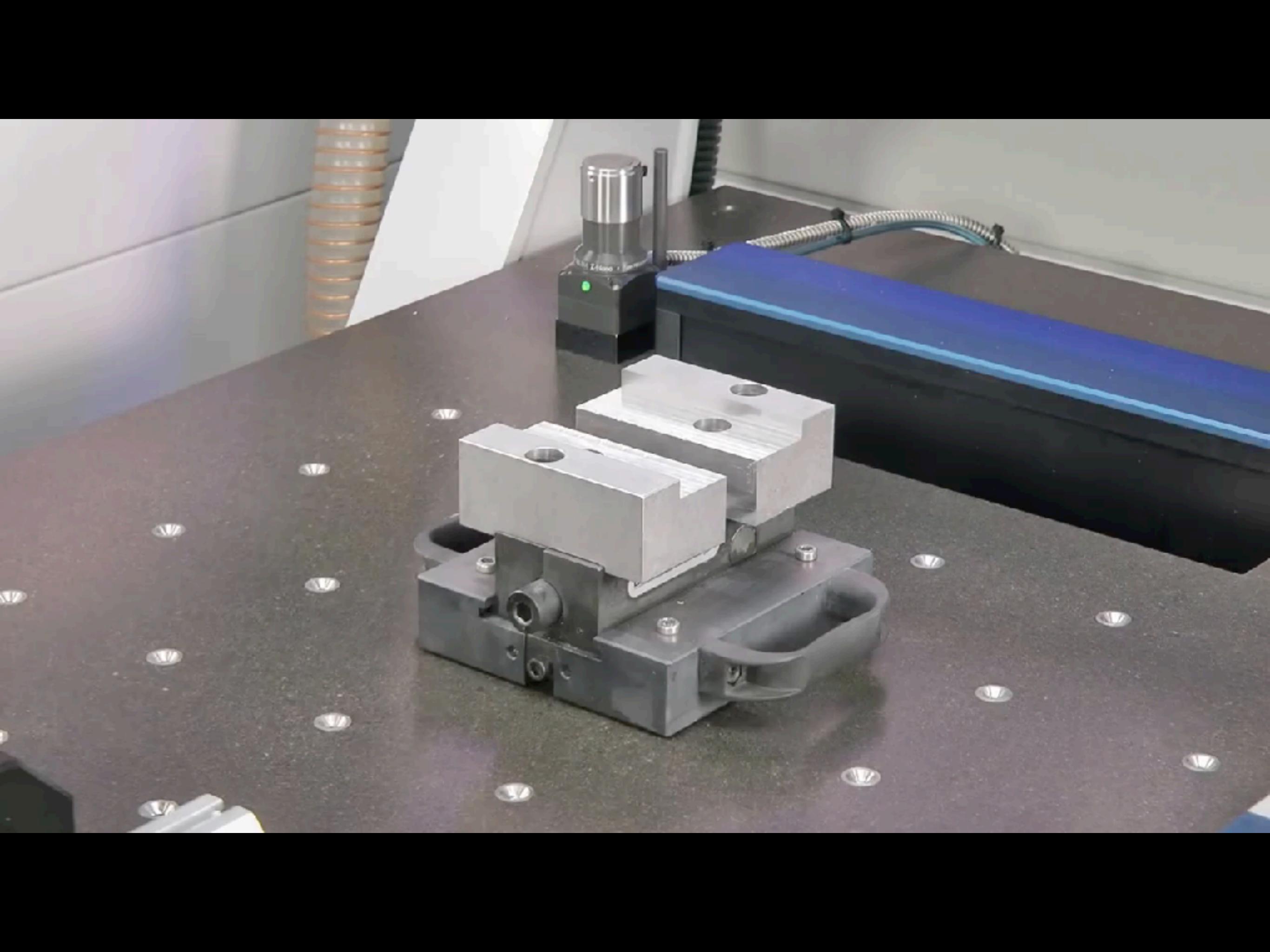
A screenshot of an eBay listing for a laser cutting machine. The listing shows the item as new, with one unit available. The price is listed as US \$1,999.00 with options to "Buy It Now" or "Add to cart". Below the price, there are links for "Add to watch list" and "Add to collection". A satisfaction guarantee of 100% buyer satisfaction is mentioned, along with 51 sold items and a note that more than 76% of buyers have sold. The shipping information indicates free standard international shipping, with a link to see details. The item is located in CN, China, and ships worldwide.





	A	B	C
1	width	107.7	mm
2	depth	82.2	mm
3	height	32	mm
4	thickness	4	mm
5	space	5	mm
6	pcbLength	98.7	mm
7	pcbWidth	73.2	mm
8	pcbSpace	0.5	mm
9	supportX	4	from box internal corner
10	supportY	4	from box internal corner
11	supportRadius	1.5	
12	holeWidth	12.9	
13	holeX	47.6	from box internal corner
14	holeY	4.3	from box internal corner
15	screenLength	71.6	
16	screenWidth	25.1	
17	screenX	13.9	from box internal corner
18	screenY	41	from box internal corner
19	rotaryX	13.7	
20	rotaryY	13.3	
21	rotaryRadius	4	
22	usbWidth	10	
23	usbHeight	6	
24	usbY	38.7	
25	usbZ	7	

Milling



Aluminum case

- **Aluminium milling**
- **Black anodizing**
- **Logo laser engraving**
- **ISO 10303 (STEP file, Standard for the Exchange of Product model data)**

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Sourcing Professionals and Engineers Can Quickly, Intelligently and Securely Perform Supplier Discovery,
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with ratings and performance
histories.



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Create RFQs in minutes and start
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manufactured parts today.



Integrated Part Library

Create your own part library to
manage your 2D/3D CAD files
online and instantly create RFQs
from your stored parts.



Patrick Neikes

Business Development | Central-Europe

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Web www.starrapid.com



[Facebook](#) | [Twitter](#) | [LinkedIn](#) | [Instagram](#)

** We have a new company name. All information can be found on our website **

- full.step - 20 pcs - EUR 1140,00 - 14 calendar-days production time
- full.step - 50 pcs - EUR 2245,00 - 16 calendar-days production time
- full.step - 100 pcs - EUR 3625,00 - 20 calendar-days production time



Quotation	- Shipping Included
Quote Number:	69996
Date:	2017-10-27
Sales Person:	Jennifer Hurd
Valid Until:	2017-11-06
Phone:	1-866-849-3911
Email:	jhurd@protocase.com
Website:	www.protocase.com

69996-1 Group004 Rev(-) Quantity 20 Lead Time: 7-8 business days

Quantity	Product	Unit Price	Ext. Price
20	Group004 Rev(-)	\$77.40	\$1548.00
1	Setup Fee	\$70.00	\$70.00
1	Design Services Fee	\$80.00	\$80.00
1	Black Anodize (Mil-A-8625 Type II, Class 2)	\$409.67	\$409.67

Part Details (quantities are per assembly)

1 of COVER

- Bar Stock, Aluminum 6061-T6, 1in x 4in x 20ft

-

1 of BASE

- Bar Stock, Aluminum 6061-T6, 1in x 6in x 20ft

-

Subtotal: \$2107.67
Currency: USD

ZXM Technology Co., Ltd.

Hua feng industry ,Songgang Town, Shengzhen City, Guangdong Province , China

FAX :86-0755-27154623 Mobile :86-13556671200

Contact person :Patrick zhu Website :<http://www.cnc-machiningservices.com>

Mail address :zxm@cnc-machiningservices.com/zxmprecision66@gmail.com

Skype :Patrick85858 QQ:597145002

Quotation List

Date :Oct/24/2017

Products name (Drawings NO)	Material	Surface treatment	Quantity (pcs)	unit price (usd)	total price	shipping
Box (include two parts)	AL-5052	Black anodized	20	\$36. 20	\$724. 00	DHL
			50	\$33. 00	\$1, 650. 00	
			100	\$31. 00	\$3, 100. 00	
Total value						

NOTES:

USD:RMB=1.0:6.5

1. This price is DOOR TO DOOR PRICE and keeps valid for 30 days .
2. Delivery is 20-25days upon confirmation of purchasing Oder and down payment
3. The payment term is 100% deposit by T/T.

Molding

Molding

<http://www.emold.net/>

Part Information

Product Size : 10.00 cm * 8.00 cm * 2.50 cm

Cavity : 1

Life : <5000

Plastic : PTFE (teflon)

Mold Price Calculation

Mold Frame : 121.21 USD

Mold Core : 90.91 USD, p20 China Made

Copper Electrode : 90.91 USD

Total material : 303 USD

Production Cost : 400 USD

Hot Runner : 0.0 USD

Management Cost : 20%

Tax : 68.0 USD

Total Mold Price : 912 USD

Product Price Calculation

Material Unit Price : 10.61 USD/kg

Product Material Cost : 0.53 USD

Production Speed : 60 seconds

Chosen Injection Machine : 600 Ton

Production Cost : 0.48 USD

Profit : 10%

Tax : 10%

Product weight : 0.05 kg

Product Unit Price : 1.25 USD (Note)

Generating the files

Alternatives to Fusion 360

<https://www.autodesk.com/products/fusion-360>

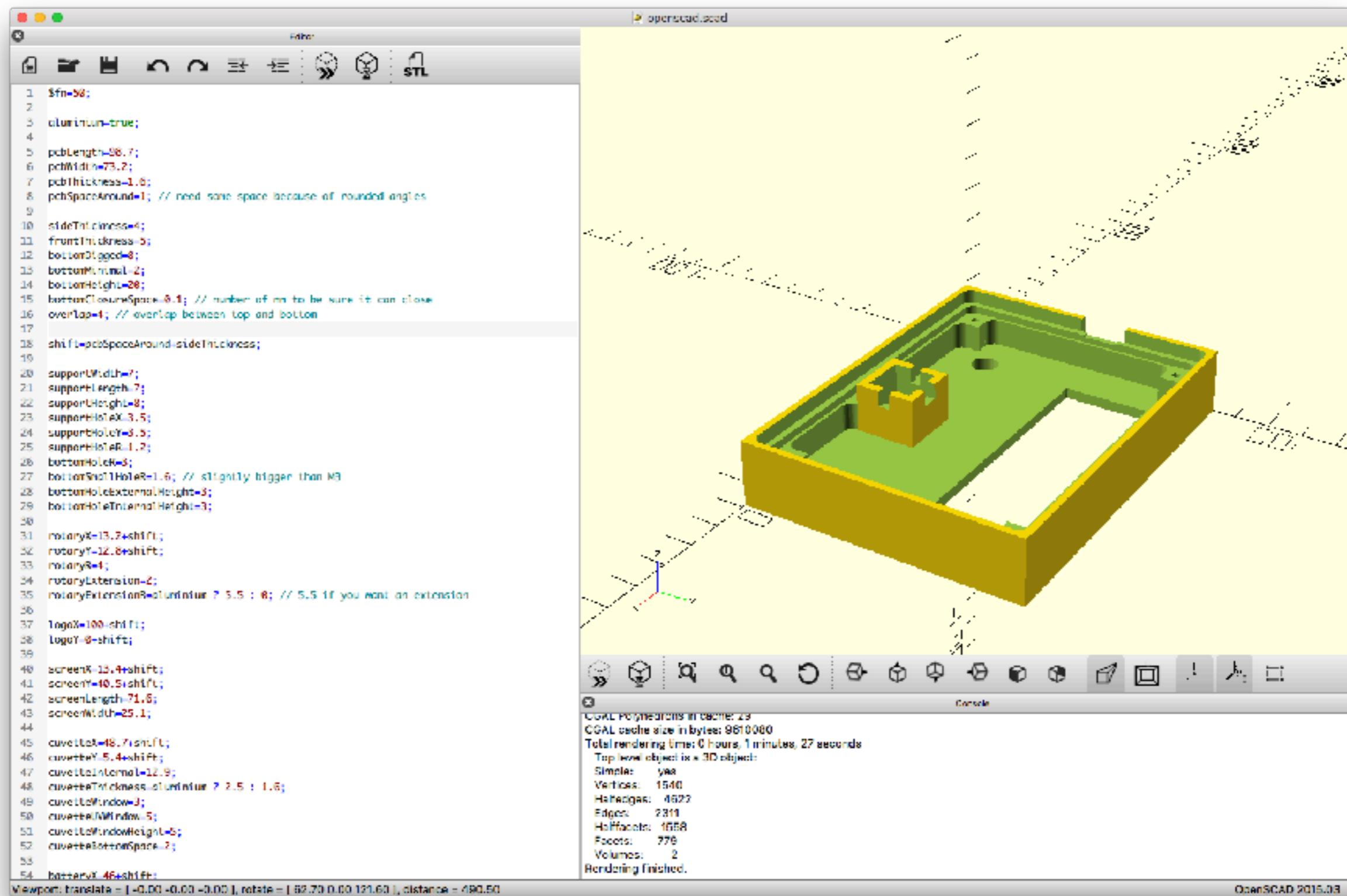
FreeCAD

- **2D**
- **3D**
- **open-source**
- **STL file (Standard Triangle Language)**
- **<https://www.freecadweb.org>**

OpenSCAD

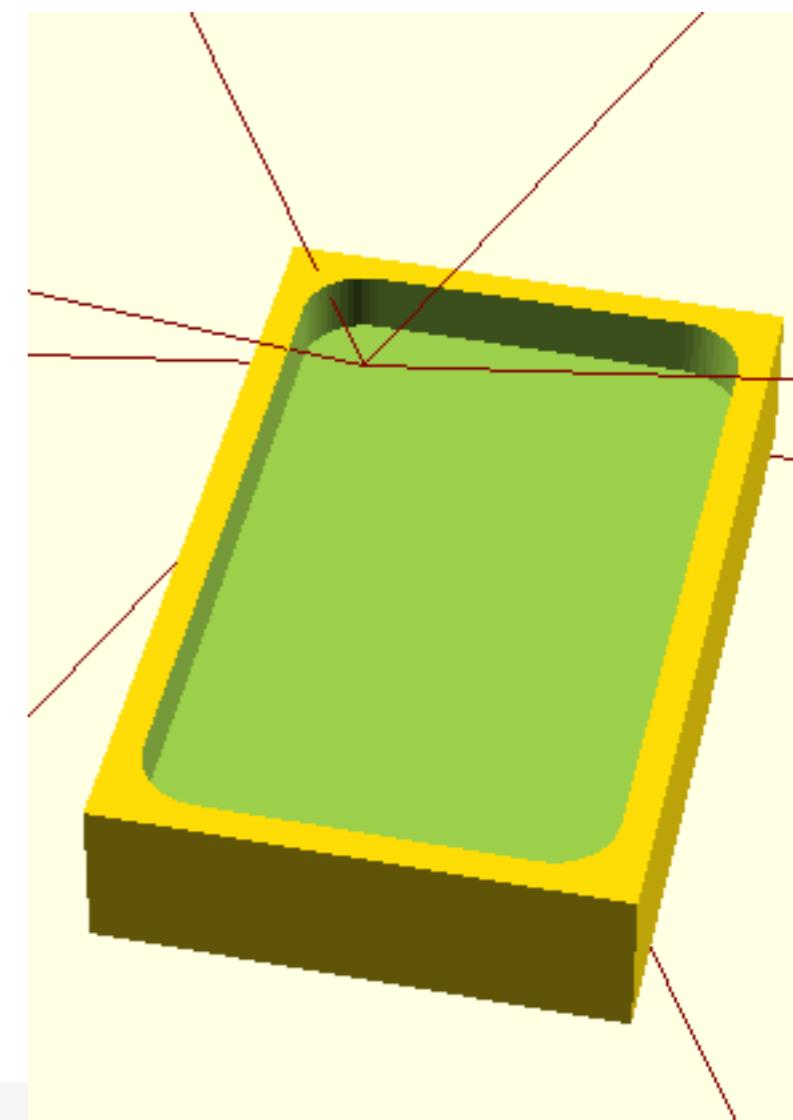
- **2D**
- **3D**
- **open-source**
- **command line**
- **<http://www.openscad.org>**
- **full integration in FreeCAD**

OpenSCAD



OpenSCAD

```
height=2;  
width=20;  
depth=10;  
radius=2;  
thickness=3;  
  
difference() {  
    translate([-thickness, -thickness, -thickness])  
    cube([width+2*thickness, depth+2*thickness, height+thickness]);  
  
    hull() {  
        translate([0,0,0]) cylinder(h=height, r=radius);  
        translate([width,0,0]) cylinder(h=height, r=radius);  
        translate([0,depth,0]) cylinder(h=height, r=radius);  
        translate([width,depth,0]) cylinder(h=height, r=radius);  
    }  
}
```



Exercise

- Create a millable box with 4 holes for the screws
- <http://www.openscad.org/cheatsheet/>
-

Programming

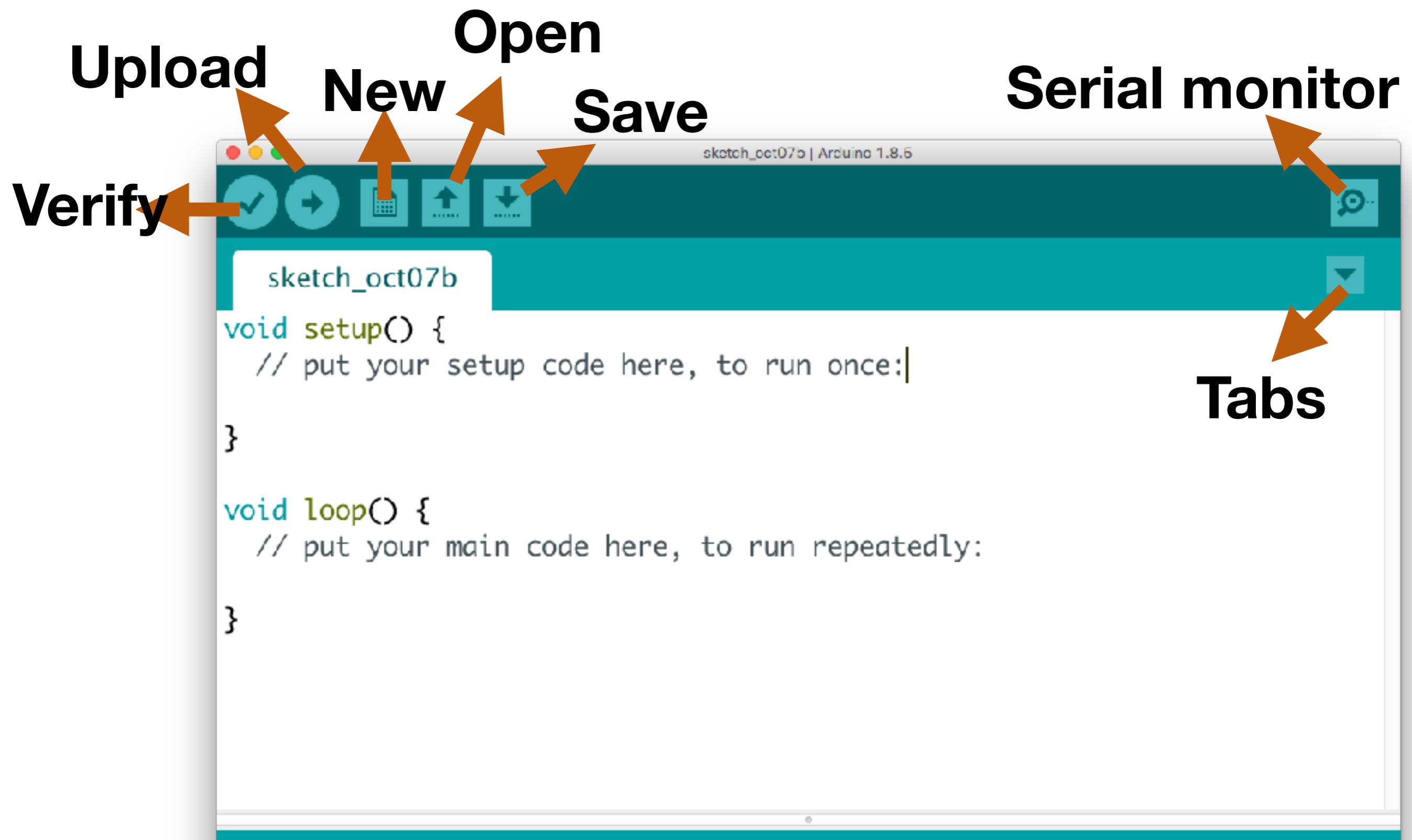
<https://www.arduino.cc/en/Main/Software>

Arduino: the basics

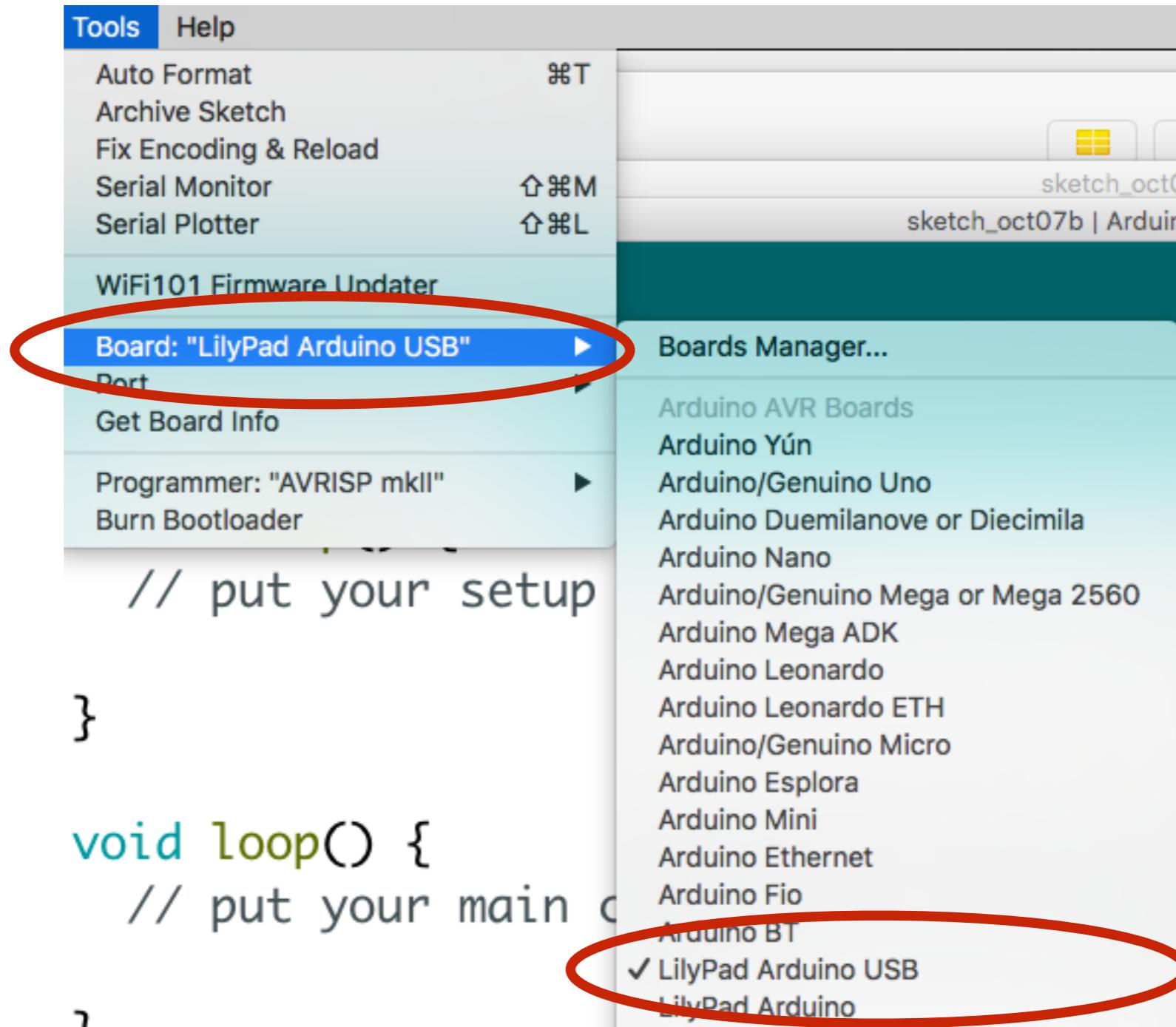
Install the software:

<https://www.arduino.cc/en/Main/Software>

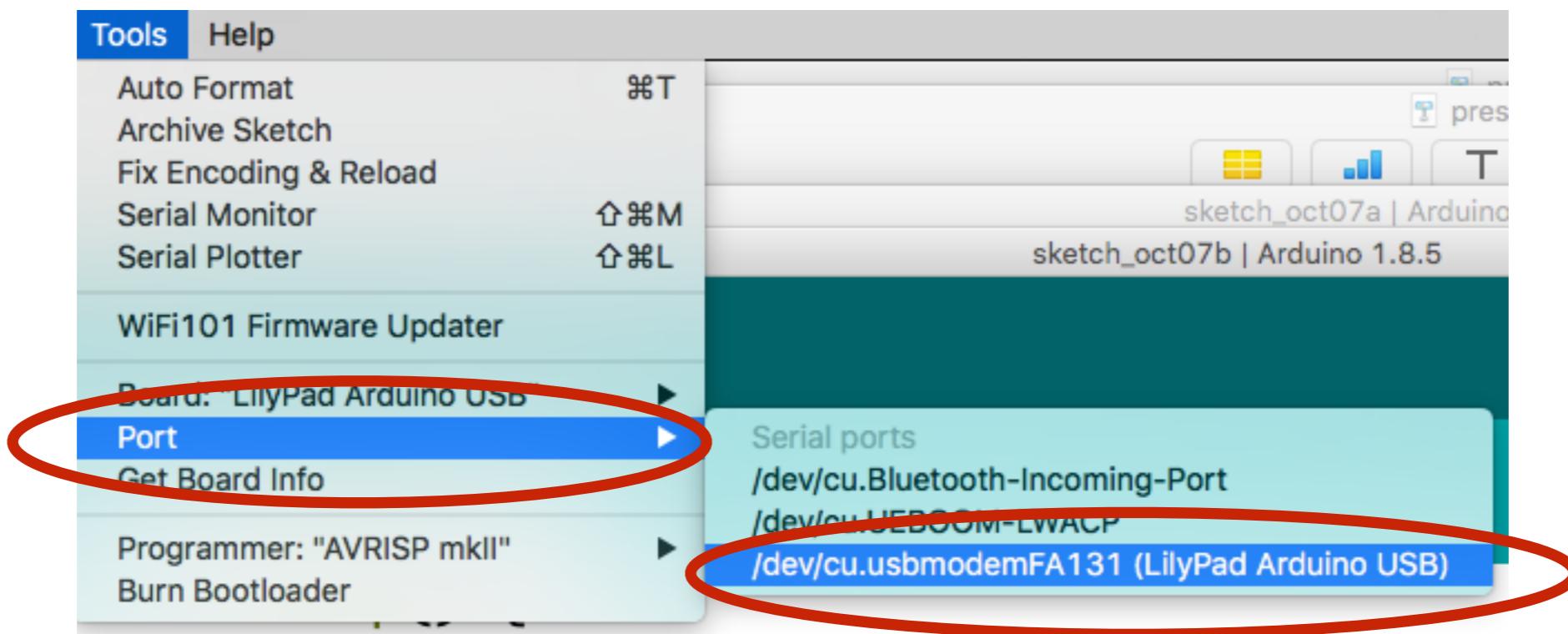
Arduino IDE (Integrated Development Environment)



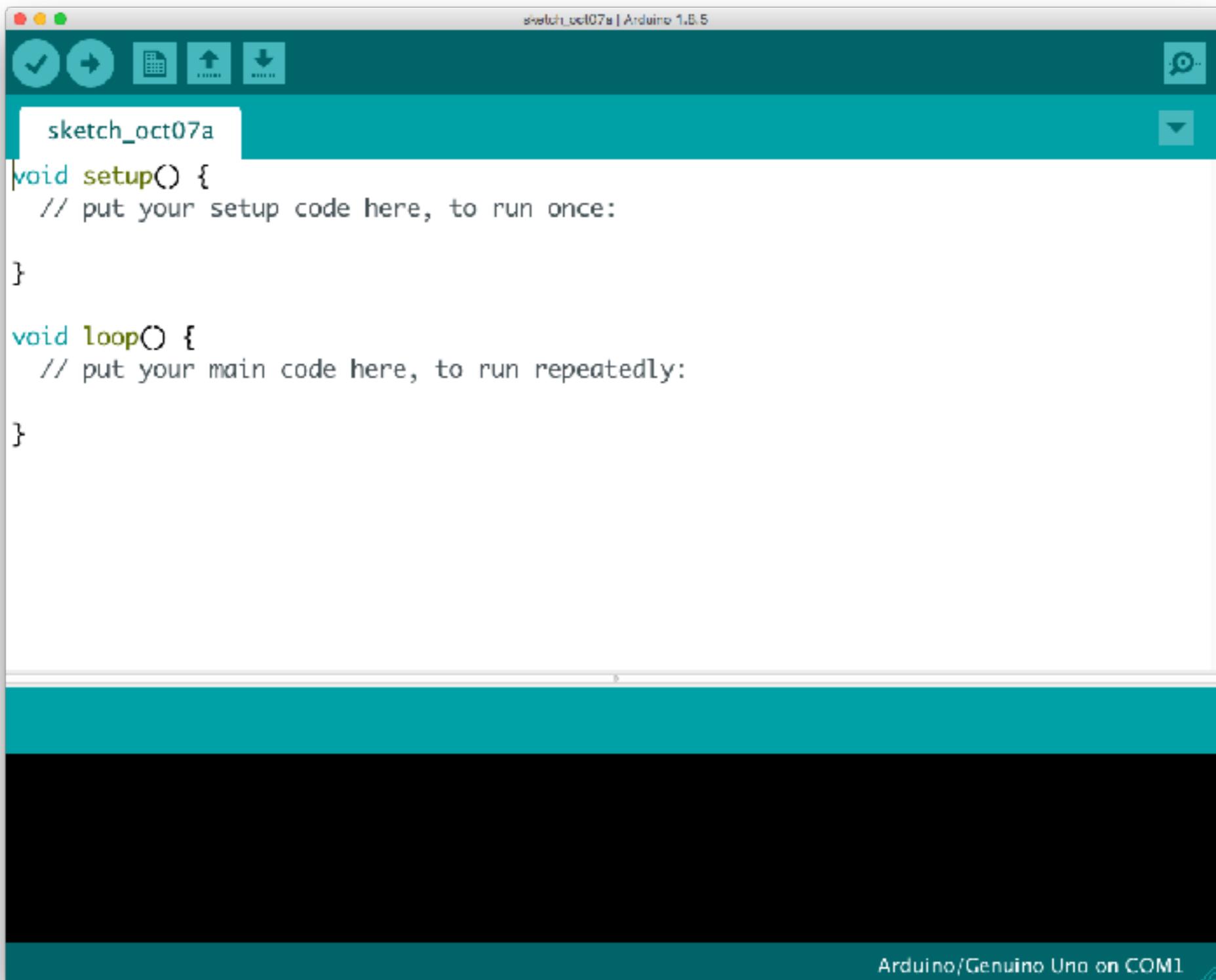
Select the right Arduino



Select the connected Arduino



Arduino IDE: setup and loop



The screenshot shows the Arduino IDE interface with the following details:

- Title Bar:** sketch_oct07a | Arduino 1.8.5
- Toolbar:** Includes icons for checkmark, refresh, file, upload, and download.
- Sketch Name:** sketch_oct07a
- Code Area:** Displays the following code:

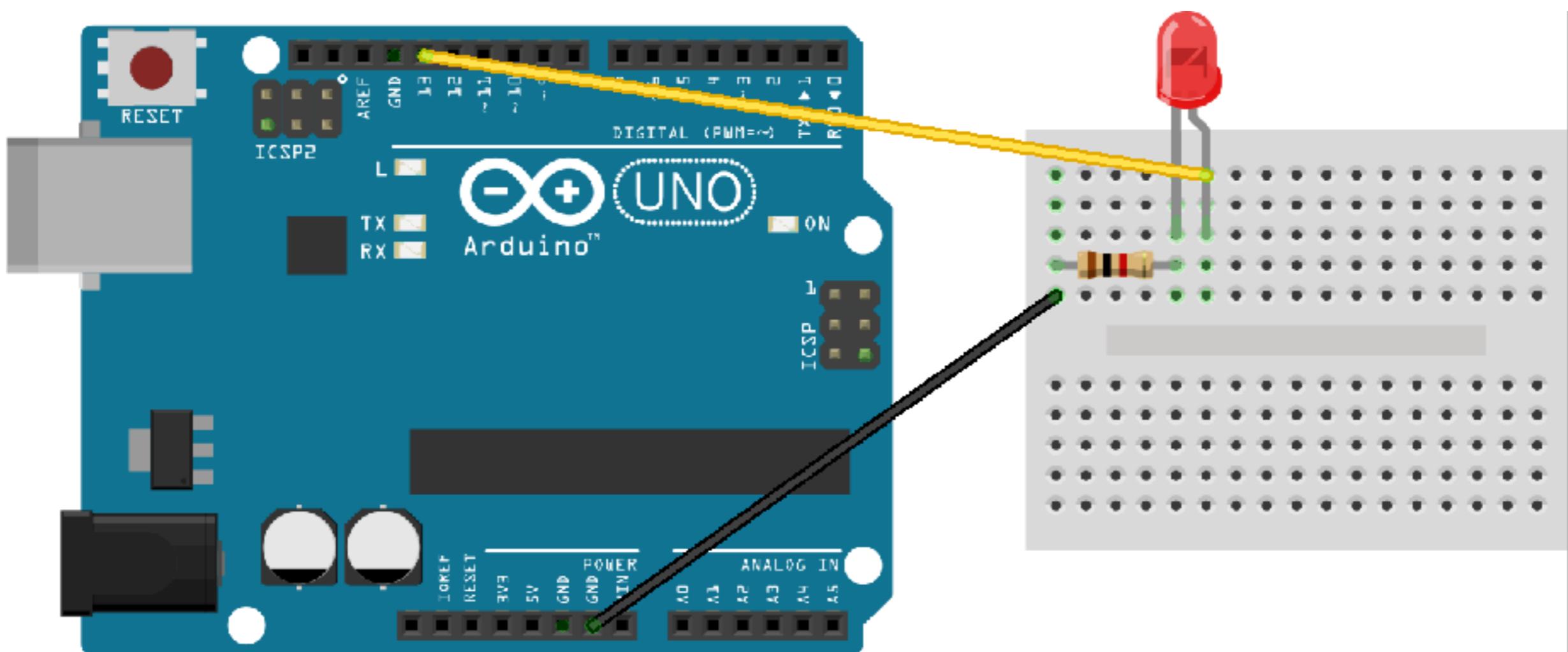
```
void setup() {
  // put your setup code here, to run once:

}

void loop() {
  // put your main code here, to run repeatedly:

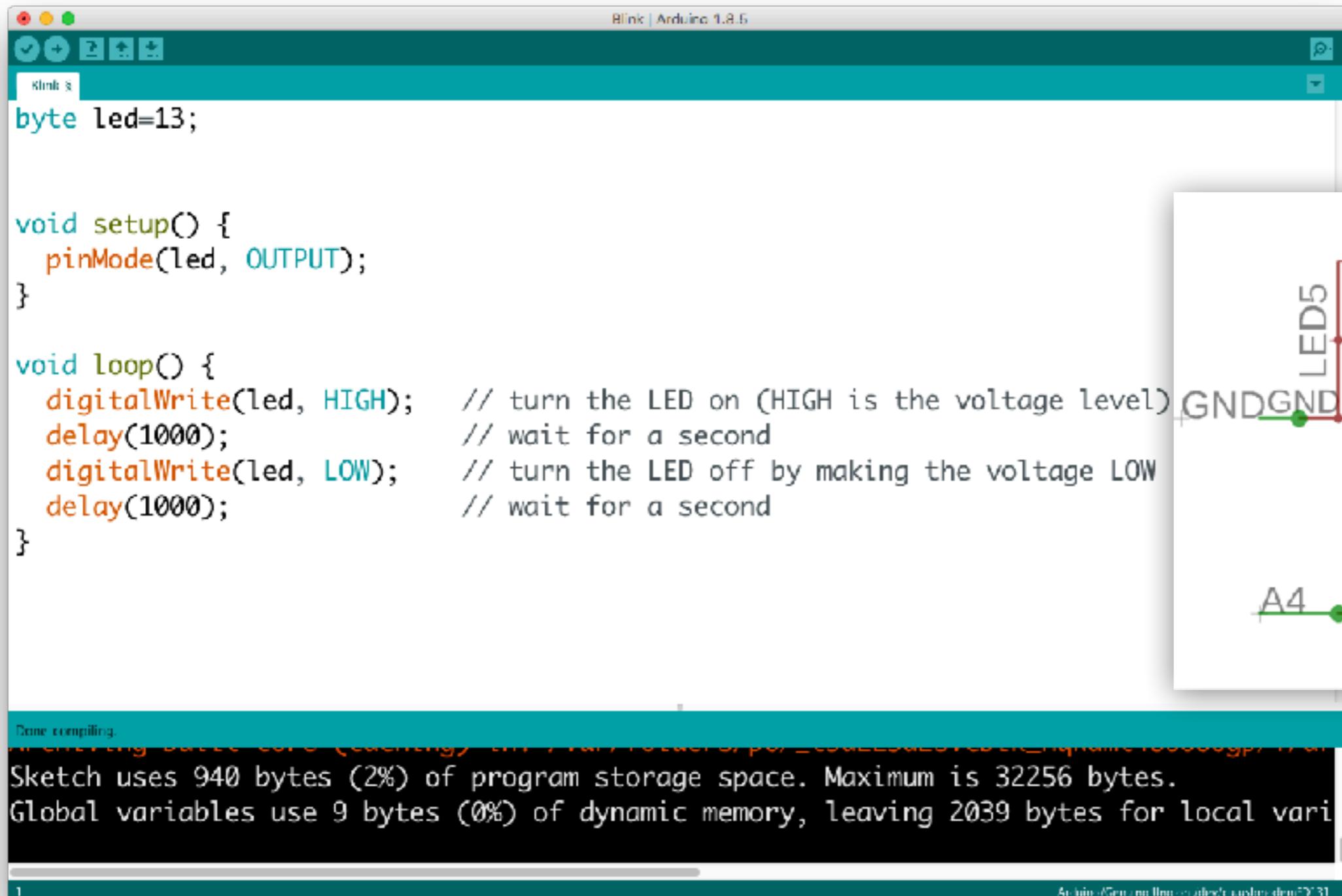
}
```
- Status Bar:** Shows Arduino/Genuino Uno on COM1.

Blink



Made with Fritzing.org

Testing the LEDs



The image shows the Arduino IDE interface. The top bar says "Blink | Arduino 1.8.6". The code area contains the classic "Blink" sketch:

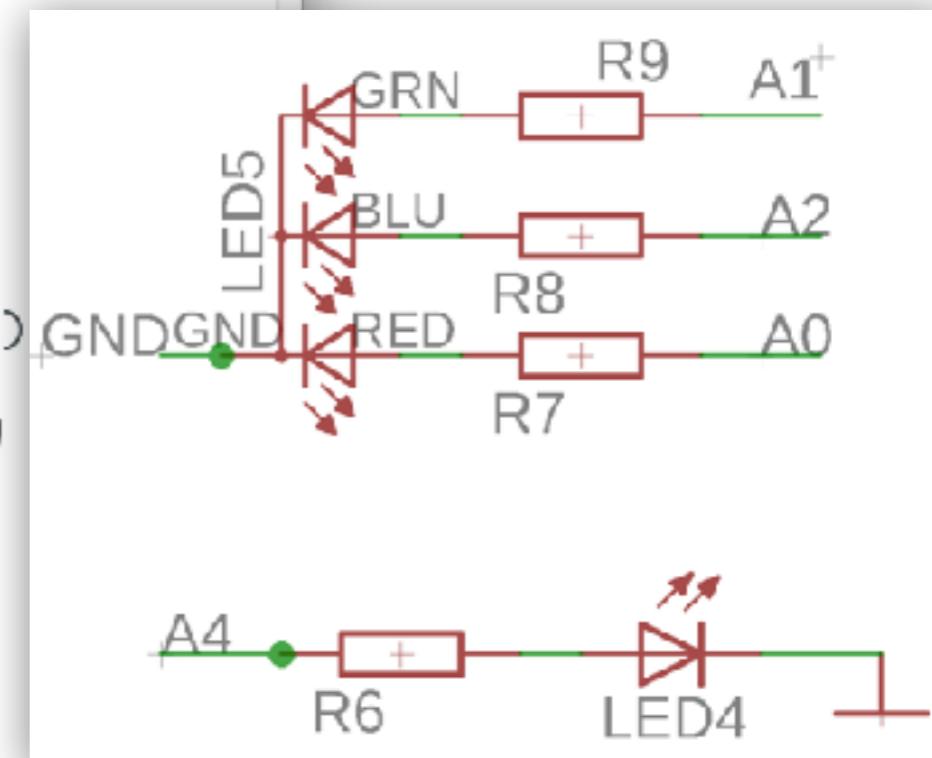
```
byte led=13;

void setup() {
  pinMode(led, OUTPUT);
}

void loop() {
  digitalWrite(led, HIGH); // turn the LED on (HIGH is the voltage level)
  delay(1000); // wait for a second
  digitalWrite(led, LOW); // turn the LED off by making the voltage LOW
  delay(1000); // wait for a second
}
```

The bottom status bar shows the compilation results:

```
Done compiling.
Sketch uses 940 bytes (2%) of program storage space. Maximum is 32256 bytes.
Global variables use 9 bytes (0%) of dynamic memory, leaving 2039 bytes for local vari
```



Exercise: Create an RGB sequence

More advanced

Microcontroller : addressing pins

- **3 registers: DDRx, PORTx, and PINx**
- **DDR_x: 0=INPUT, 1=OUTPUT**
- **PORT_x:**
 - INPUT: pull-up if 1
 - OUTPUT: 1: drive pin HIGH, 0, drive pin LOW
- **PIN_x: toggle the pin**

DDRB: input / output ?

DDR: Data direction register

Initial:

7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0

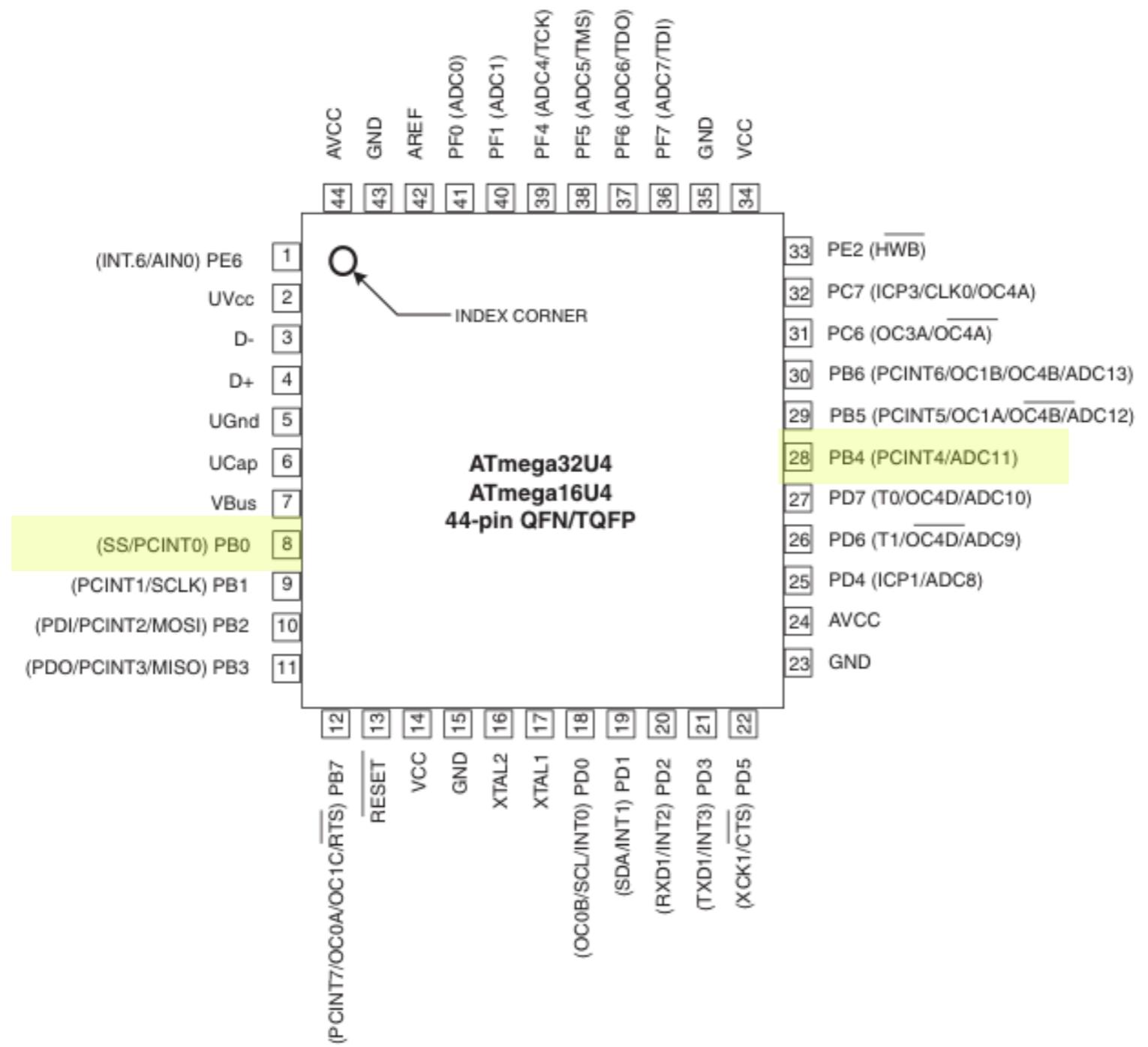
DDRB = (1 << DDB4) | (1 << DDB0);
or **bit shift**

7	6	5	4	3	2	1	0
0	0	0	1	0	0	0	0
0	0	0	0	0	0	0	1

=

7	6	5	4	3	2	1	0
0	0	0	1	0	0	0	1

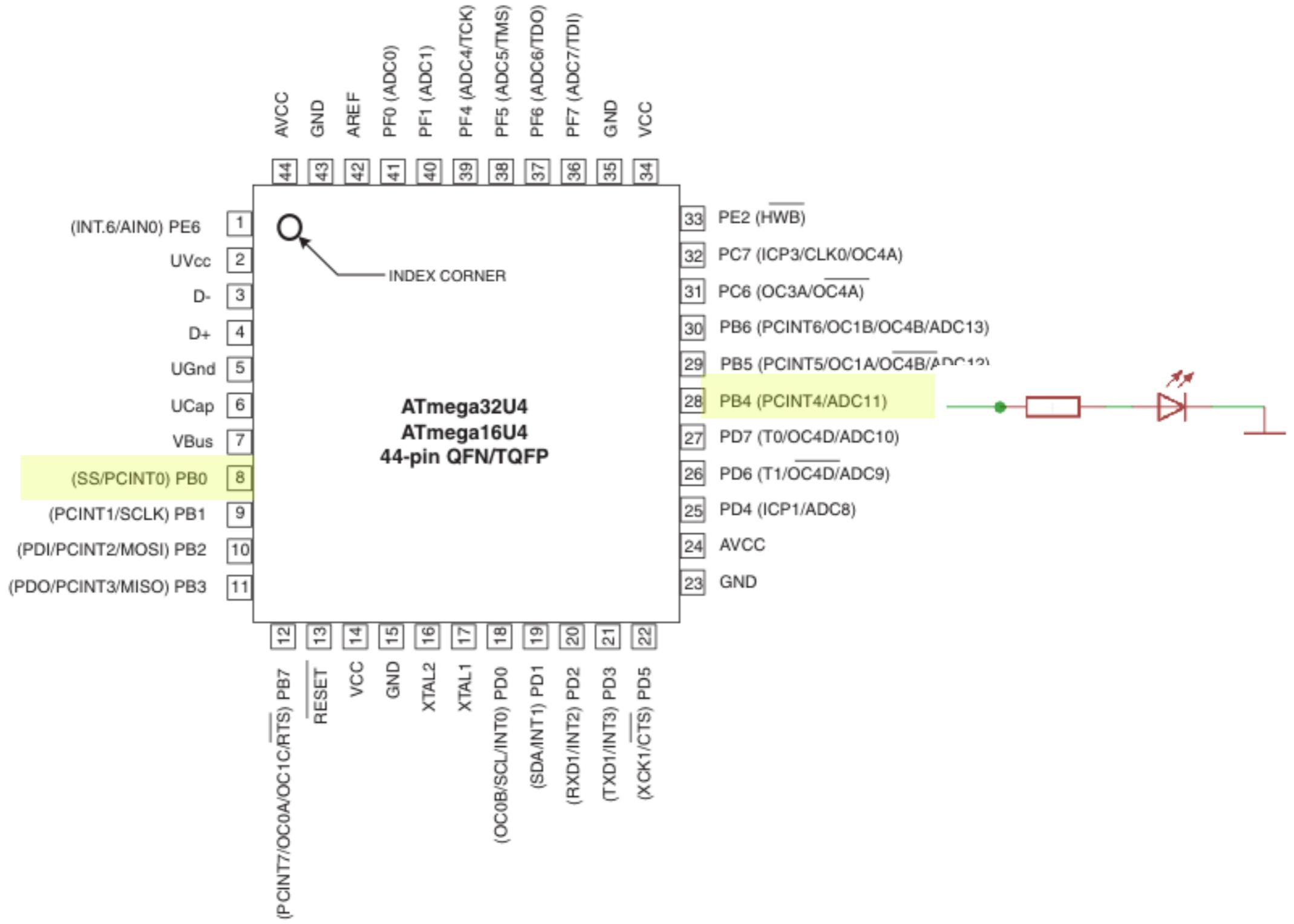
Microcontroller : ATMEGA32U4



Microcontroller : addressing pins

```
// pin 0 and 4 of PORT B to output  
DDRB = (1 << DDB4) | (1 << DDB0);  
  
// drive pin 0 and 4 of PORT B to HIGH  
PORTB = (1 << PB4) | (1 << PB0);
```

Microcontroller : ATMEGA32U4



THE DEFINITIVE ARDUINO LEONARDO PINOUT DIAGRAM

This provides a logic reference voltage for shields that use it. It is connected to the 5V bus.

Not Connected

IOREF

RESET

13 RESET

3V3

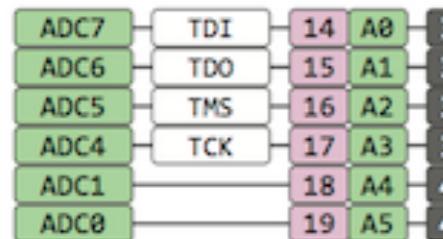
5V

GND

GND

VIN

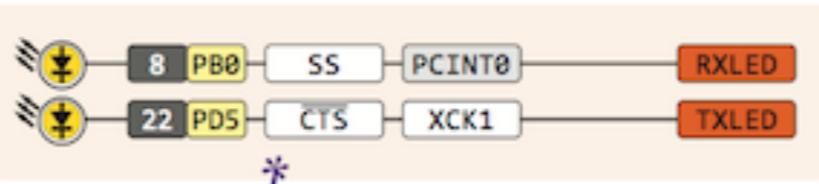
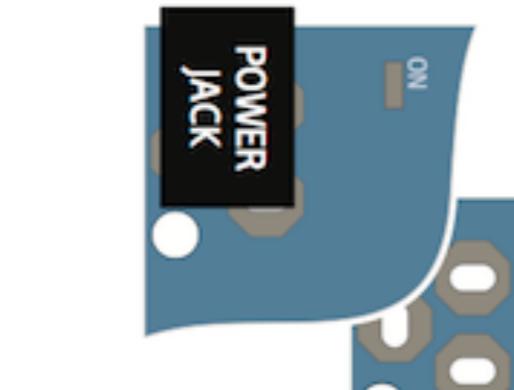
The input voltage to the Arduino board when it is running from external power.
Not USB bus power.



PWM type

- PWM 18bit
- PWM 8/16bit
- PWM 16bit
- PWM HS
- PWM 8bit

7-12V Depending on current drawn
2.1mm



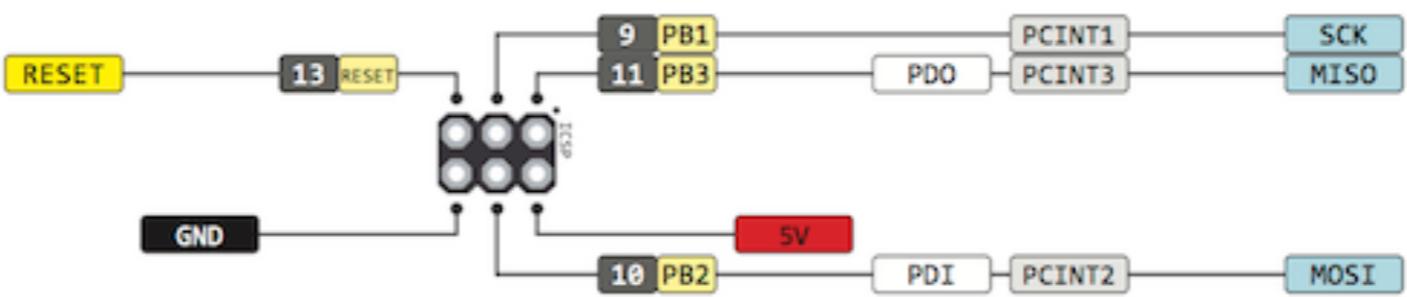
USB JACK Type Micro-B

⚠ Absolute max per pin 40mA recommended 20mA

⚠ Absolute max 200mA for entire package

SCL same as PIn3
SDA same as PIn2

SCL	18 PD0	SCL	INT0	OC0B	PWM	SCL
SDA	19 PD1	SDA	INT1	OC1B	ADC9	SDA
AREF	42 AREF			OC0A	ICP3	CLKO
GND				OC1C	PWM	T1
				ADC13	PWM	PCINT7
13				OC1B	PWM	RTS
12				ADC12	PWM	OC4B
-11				OC1A	PWM	OC4B
-10				ADC11	PWM	PCINT5
-9						PCINT4
8						
DIGITAL (PWM)						
7	1 PE6	7	INT6	AIN0		
6	27 PD7	6	A7	OC4D	ADC10	T0
5	31 PC6	5	OC3A	OC4A	PWM	
4	25 PD4	4	A6	ICP1	ADC8	
3	18 PD0	3	INT0	OC0B	PWM	SCL
2	19 PD1	2	INT1	OC0A	SDA	TX
-1	21 PD3	1	INT3	TXD1		RX
0	20 PD2	0	INT2	RXD1		



www.pihiixx.com



08 MAR 2013

ver 2 rev 0 - 08.03.2013

Legend:

- GND
- Power
- Control
- Physical Pin
- Port Pin
- Pin Function
- Digital Pin
- Analog Related Pin
- PWM Pin
- Serial Pin
- IDE

sketch_oct07a | Arduino 1.8.5

```
sketch_oct07a §

void setup() {
  pinMode(13, OUTPUT);
}

void loop() {
  digitalWrite(13, HIGH);
  digitalWrite(13, LOW);
}
```

Auto Format finished.

Arduino/Genuino Uno on COM1

Hantek



A T

H



W

8.00us

0.000s

Measure X

Frequency

46.55KHz

Period

21.48us

Mean

-1.60V

►Pk-Pk

4.32V

Minimum

-3.68V

Maximum

640mV

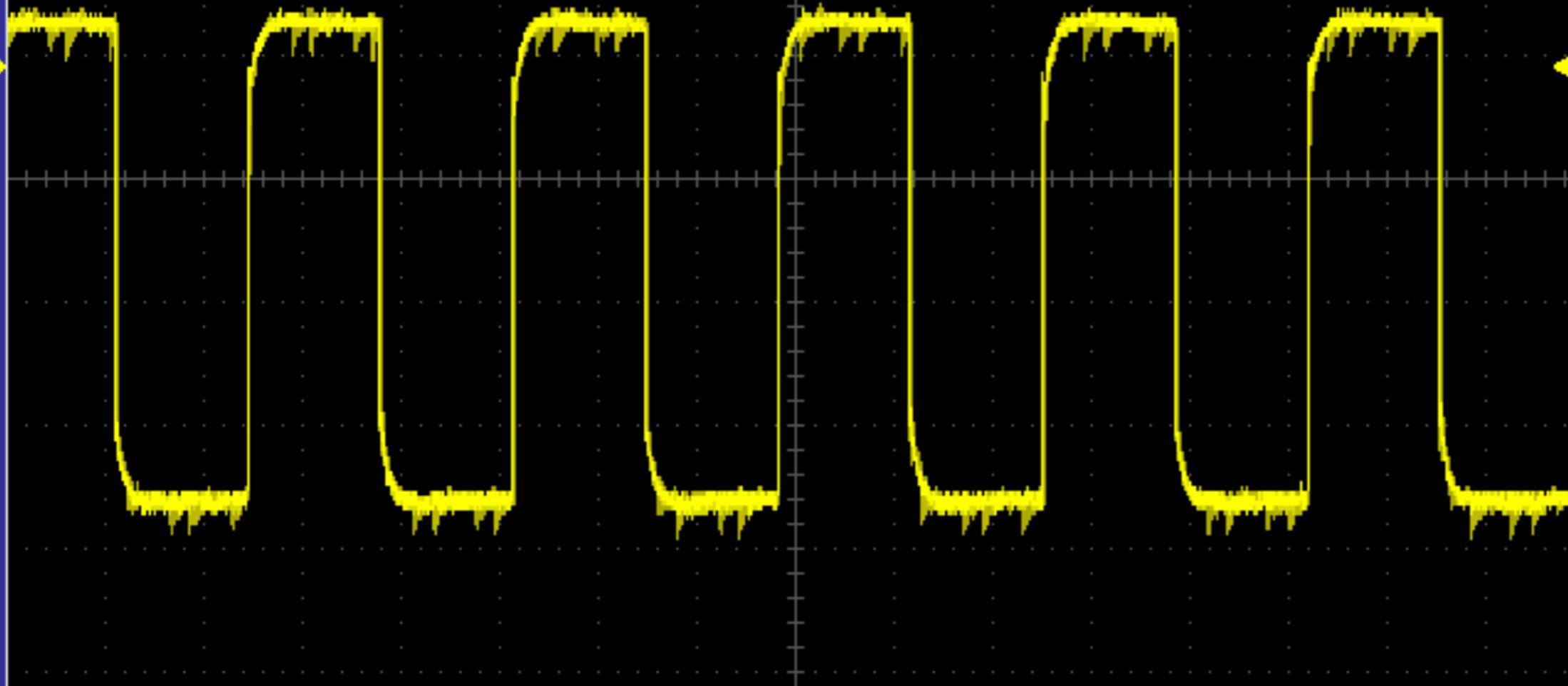
+Pulse Width

10.72us

Rise Time

960.0ns

Modify



DC 20 mV 1.00V

CH1 0.00V

45.8360KHz

The screenshot shows the Arduino IDE interface. The title bar reads "sketch_oct07a | Arduino 1.8.5". The toolbar at the top includes icons for file operations (checkmark, arrow, file, upload, download) and a search function. The main code editor window displays the following C++ code:

```
sketch_oct07a §

void setup() {
  pinMode(13, OUTPUT);
}

void loop() {
  PORTC |= 1 << 7;
  PORTC &= ~ (1 << 7);
}
```

A message in the status bar at the bottom left says "Auto Format finished." The status bar also indicates the connection is "LilyPad Arduino USB on COM1".

Hantek



T



400ns

Measure



Frequency

1.000MHz

Period

1.000us

Mean

-2.24V

Pk-Pk

4.16V

Minimum

-3.48V

►Maximum

680mV

+Pulse Width

252.5ns

Rise Time

25.00ns

Modify

0.000s



1.00V

CH1 0.00V

960.964KHz

sketch_oct07a | Arduino 1.6.5

```
sketch_oct07a §

void setup() {
  pinMode(13, OUTPUT);
}

void loop() {
  PORTC = 255;
  PORTC = 0;
}
```

Auto Format finished.

Hantek



T



W

400ns

Measure X

Frequency

1.333MHz

Period

750.0ns

Mean

-2.68V

Pk-Pk

4.16V

Minimum

-3.60V

►Maximum

560mV

+Pulse Width

125.0ns

Rise Time

22.50ns

Modify



DC 20mV 1.00V

CH1 0.00V

1.08623MHz

sketch_oct07a | Arduino 1.6.5

```
sketch_oct07a §

void setup() {
  pinMode(13, OUTPUT);
}

void loop() {
  while (true) {
    PORTC = 255;
    PORTC = 0;
  }
}
```

Auto Format finished.

Hantek



T



400ns

Measure X

Frequency

2.000MHz

Period

500.0ns

Mean

-2.28V

Pk-Pk

4.00V

Minimum

-3.44V

►Maximum

560mV

+Pulse Width

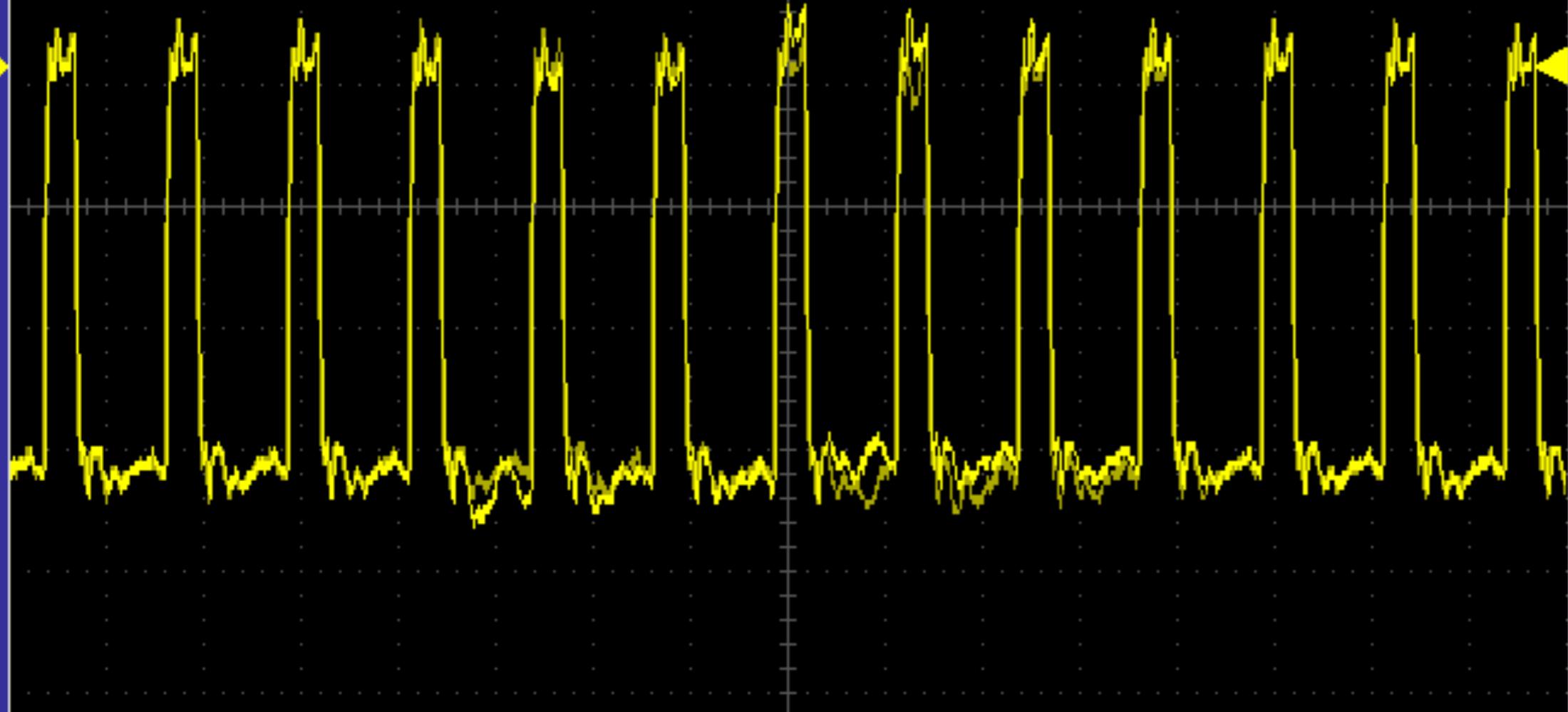
127.5ns

Rise Time

25.00ns

Modify

0.000s



DC 20mV 1.00V

CH1 0.00V

1.68150MHz

Debug using Serial.println

The image shows the Arduino IDE interface. The top bar indicates the project is named "Blink" and is using version 1.8.5. The left sidebar shows the file structure: "Blink §". The main code editor contains the following sketch:

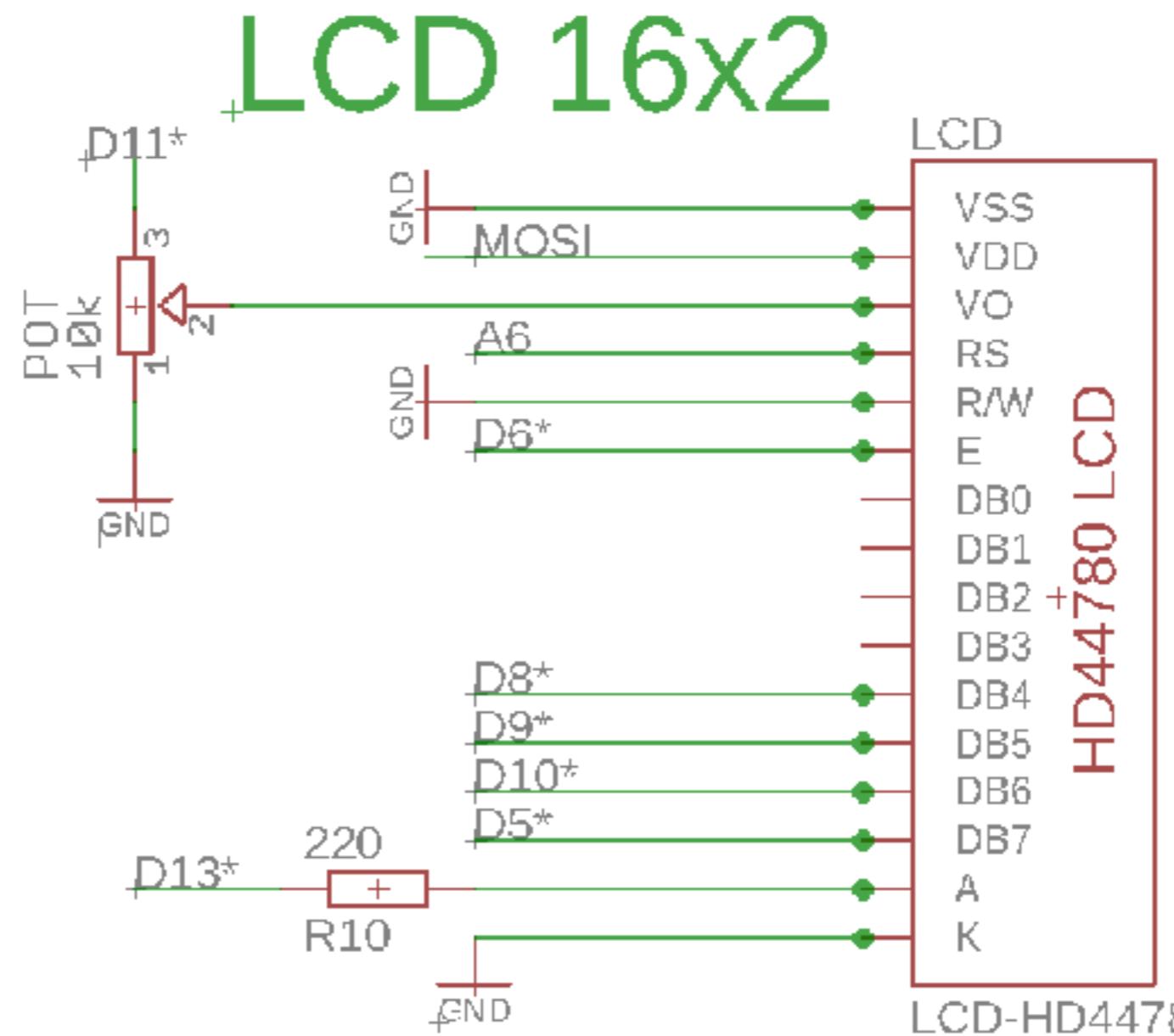
```
void setup() {
  Serial.begin(9600);
}

void loop() {
  Serial.print("Millis: ");
  Serial.println(millis());
  delay(1000);
}
```

In the bottom status bar, it says "Done uploading.". To the right of the IDE, a separate terminal window is open, showing the serial output for the Arduino Leonardo connected via "/dev/cu.usbmodemFA131". The output displays the current millisecond value every second:

```
Millis: 5001
Millis: 6001
Millis: 7002
Millis: 8001
Millis: 9001
Millis: 10002
Millis: 11002
Millis: 12003
Millis: 13002
```

Test all the functionalities

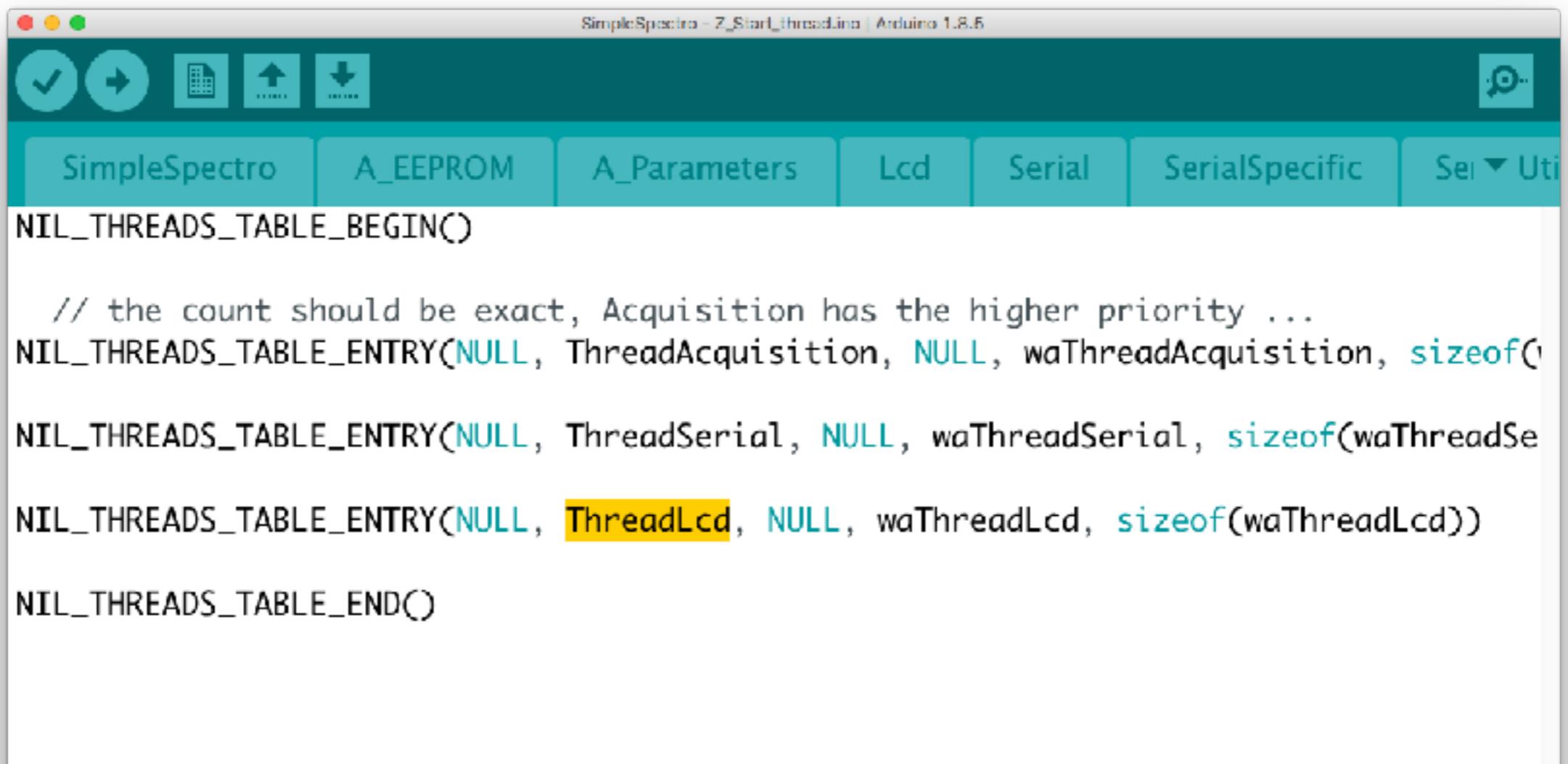


Exercise: Test LCD display

Multithread

Scalable way of programming

- Tabs
- NilRTOS (multi-thread)



The screenshot shows the Arduino IDE interface with the title bar "SimpleSpectro - Z_Start_thread.ino | Arduino 1.8.6". The top menu bar includes File, Edit, Tools, Sketch, Help, and a search bar. Below the menu is a toolbar with icons for Save, Undo, Redo, Open, Upload, and Download. The main window displays the following C++ code:

```
SimpleSpectro A_EEPROM A_Parameters Lcd Serial SerialSpecific Sei ▾ Util
NIL_THREADS_TABLE_BEGIN()

// the count should be exact, Acquisition has the higher priority ...
NIL_THREADS_TABLE_ENTRY(NULL, ThreadAcquisition, NULL, waThreadAcquisition, sizeof(waThreadAcquisition))

NIL_THREADS_TABLE_ENTRY(NULL, ThreadSerial, NULL, waThreadSerial, sizeof(waThreadSerial))

NIL_THREADS_TABLE_ENTRY(NULL, ThreadLcd, NULL, waThreadLcd, sizeof(waThreadLcd))

NIL_THREADS_TABLE_END()
```



BasicNil

```
#include <NilRTOS.h>

void setup() {
  nilSysBegin();
}
void loop() {}

NIL_WORKING_AREA(waThread1, 16);
NIL_THREAD(Thread1, arg) {
  const uint8_t LED_PIN = 10;
  pinMode(LED_PIN, OUTPUT);
  while (TRUE) {
    digitalWrite(LED_PIN, HIGH);
    digitalWrite(LED_PIN, LOW);
    nilThdSleep(1); // need to use this method otherwise next thread will not be executed
  }
}

NIL_WORKING_AREA(waThread2, 128);
NIL_THREAD(Thread2, arg) {
  Serial.begin(9600);
  while (TRUE) {
    Serial.println(millis()); // really bad to nilThdSleep
  }
}

NIL_THREADS_TABLE_BEGIN()
NIL_THREADS_TABLE_ENTRY("thread1", Thread1, NULL, waThread1, sizeof(waThread1))
NIL_THREADS_TABLE_ENTRY("thread2", Thread2, NULL, waThread2, sizeof(waThread2))
NIL_THREADS_TABLE_END()
```

Hantek



T



W

2.00ms

Measure



Frequency

487.8Hz

Period

2.050ms

Mean

40.0mV

Pk-Pk

4.12V

Minimum

-120mV

►Maximum

4.00V

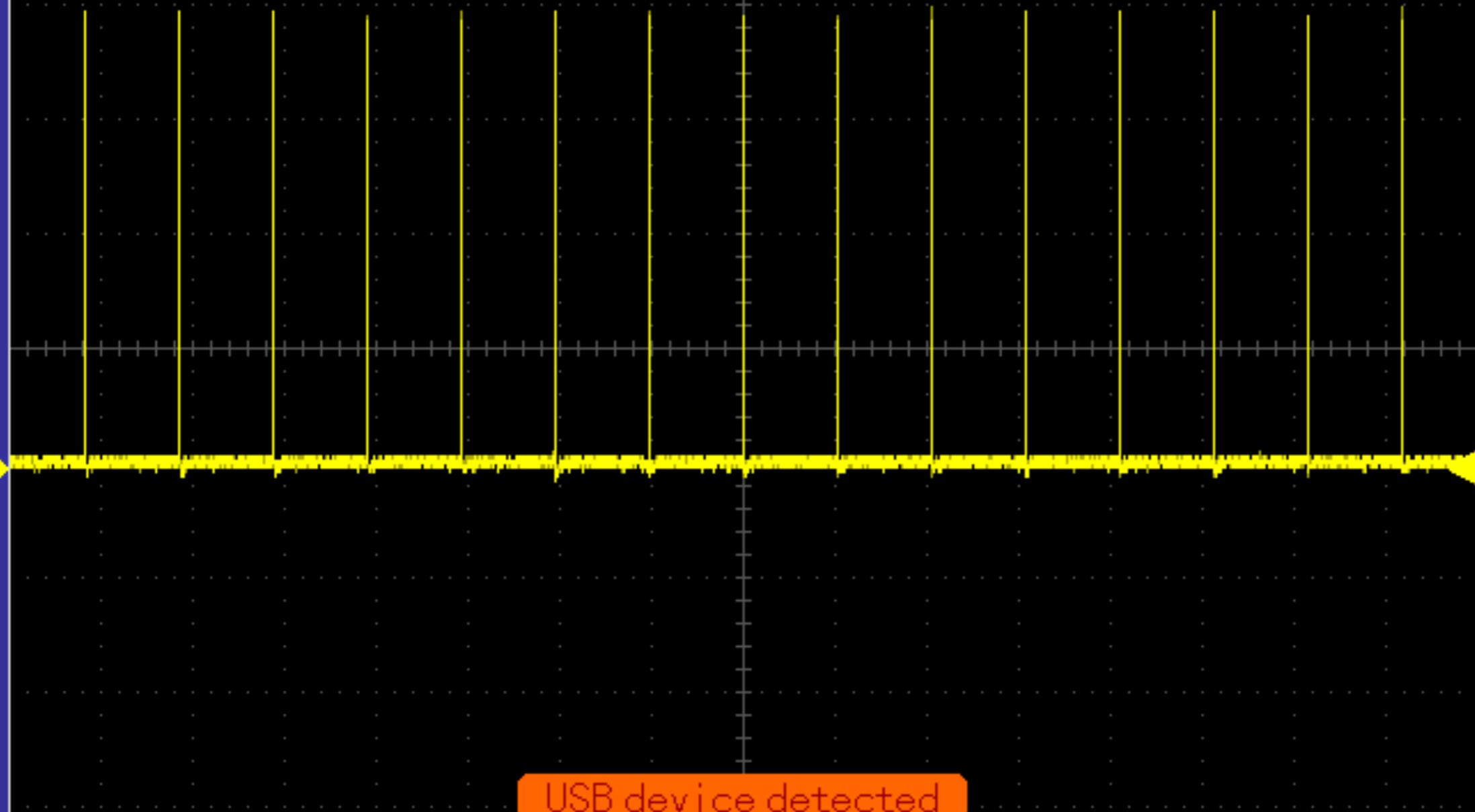
+Pulse Width

10.00us

Rise Time

10.00us

0.000s



USB device detected

DC 20 1.00V

CH1 0.00V

488.000Hz

Modify

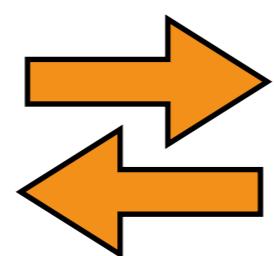
Multithread with Shared parameters

Parameters

`getParameter(x)`
`setParameter(x, value)`
`setAndSaveParameter`

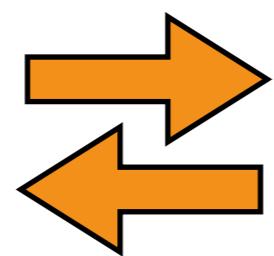
- A
- B
- C
- ...

Parameters
accessible from all the
Thread and saved in
EEPROM.



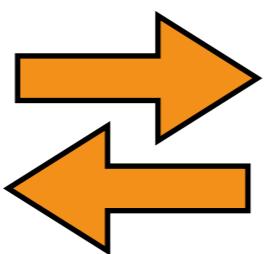
ThreadAcquisition

*Process taking care of the acquisition based
on the parameters*



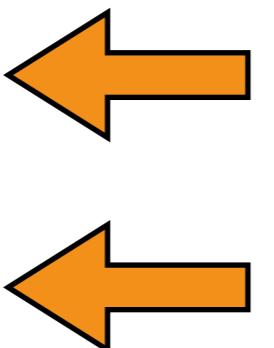
ThreadSerial

*General process allowing communication
over Serial (Bluetooth, Zigbee, Lora, ...)*



ThreadLcd

*Process allowing to control the simple-
spectra from a LCD display*



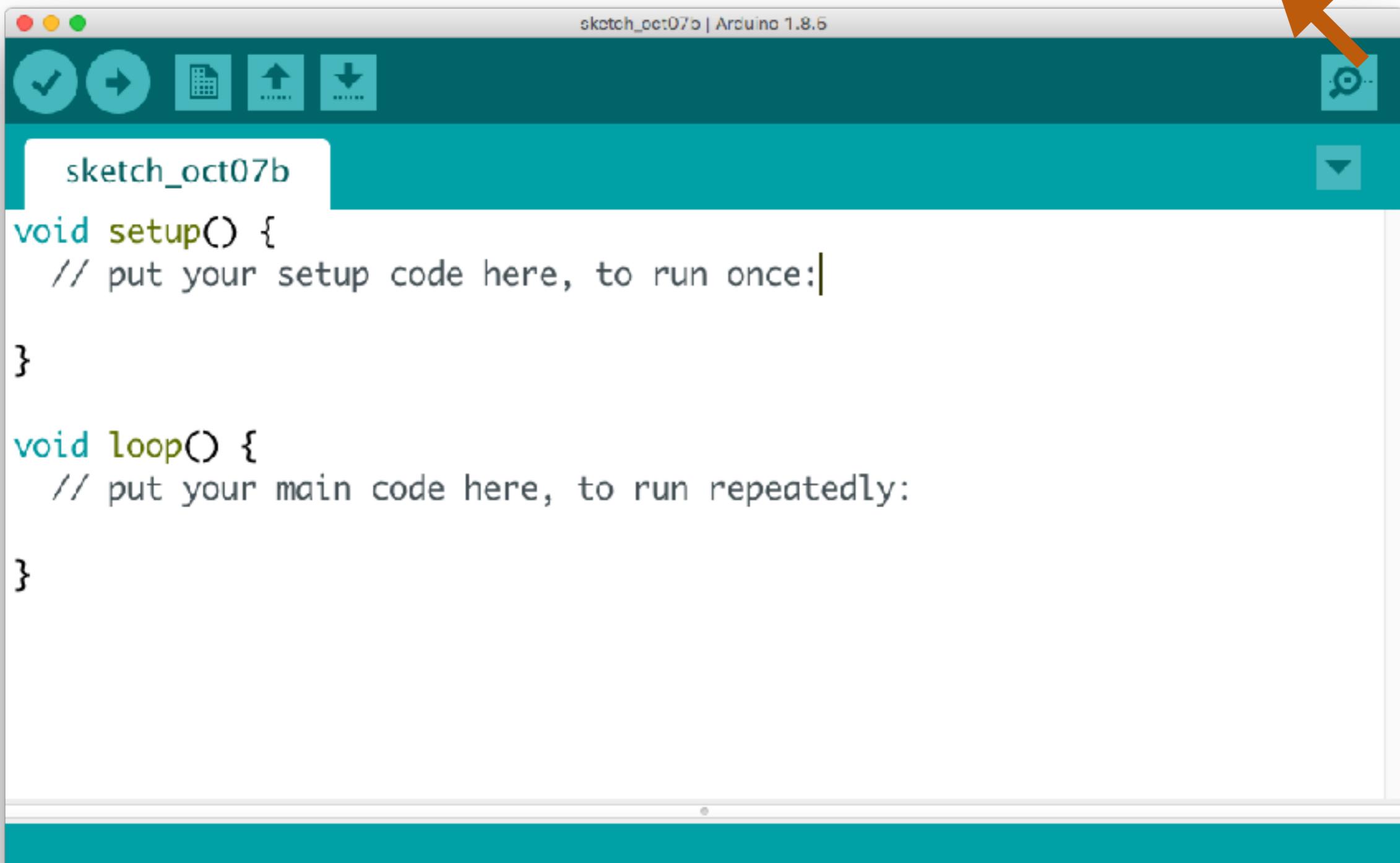
ThreadTemperature

ThreadBattery

0	A	COLOR_1	Red value for sample
1	B	COLOR_2	Green value for sample
2	C	COLOR_3	Blue value for sample
3	D	COLOR_4	UV value for sample
4	E	COLOR_5	Not used
5	F	BLANK_1	Red value for blank
6	G	BLANK_2	Green value for blank
7	H	BLANK_3	Blue value for blank
8	I	BLANK_4	UV value for blank
9	J	BLANK_5	Not used
10	K	BEFORE_DELAY	Delay before taking blank
11	L	FIRST_DELAY	Delay between blank and first experiment
12	M	INTER_DELAY	Delay between experiments
13	N	NUMPER_EXP	Number of experiments
14	O	NEXT_EXP	Next experiment, 0 blank and then for kinetic
15	P	WAIT	Current time to wait
16	Q	NUMBER_ACQ	number of acquisition of 100ms that will be taken
17	R	INVERT_ROTARY	invert rotary direction
18	S	BATTERY	battery voltage (hundredths of volt)
19	T	TEMPERATURE	temperature (hundredths of degree)
21	V	ACTIVE_LEDS	as a binary code (red, green, blue, uv, temperature, battery)

Connecting to spectro

Serial monitor



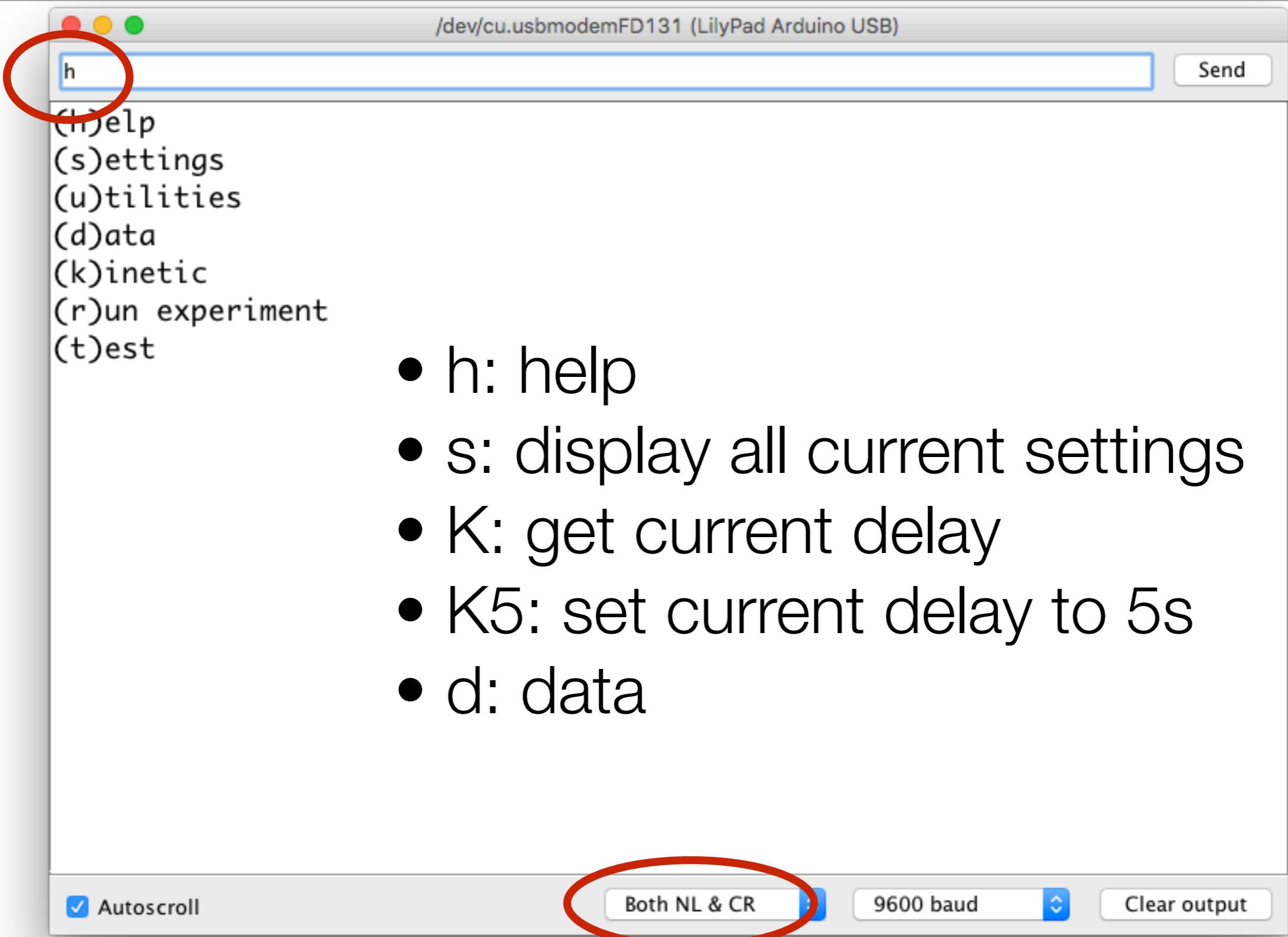
The screenshot shows the Arduino IDE interface. The title bar reads "sketch_oct07b | Arduino 1.8.6". Below the title bar is a toolbar with various icons: a checkmark, a play button, a file icon, an upload icon, a download icon, and a magnifying glass. To the right of the toolbar is a small dropdown menu. The main area contains the following code:

```
sketch_oct07b
void setup() {
  // put your setup code here, to run once:
}

void loop() {
  // put your main code here, to run repeatedly:
}
```

An orange arrow points to the magnifying glass icon in the toolbar, which typically represents the Serial monitor function.

Arduino IDE (Integrated Development Environment)



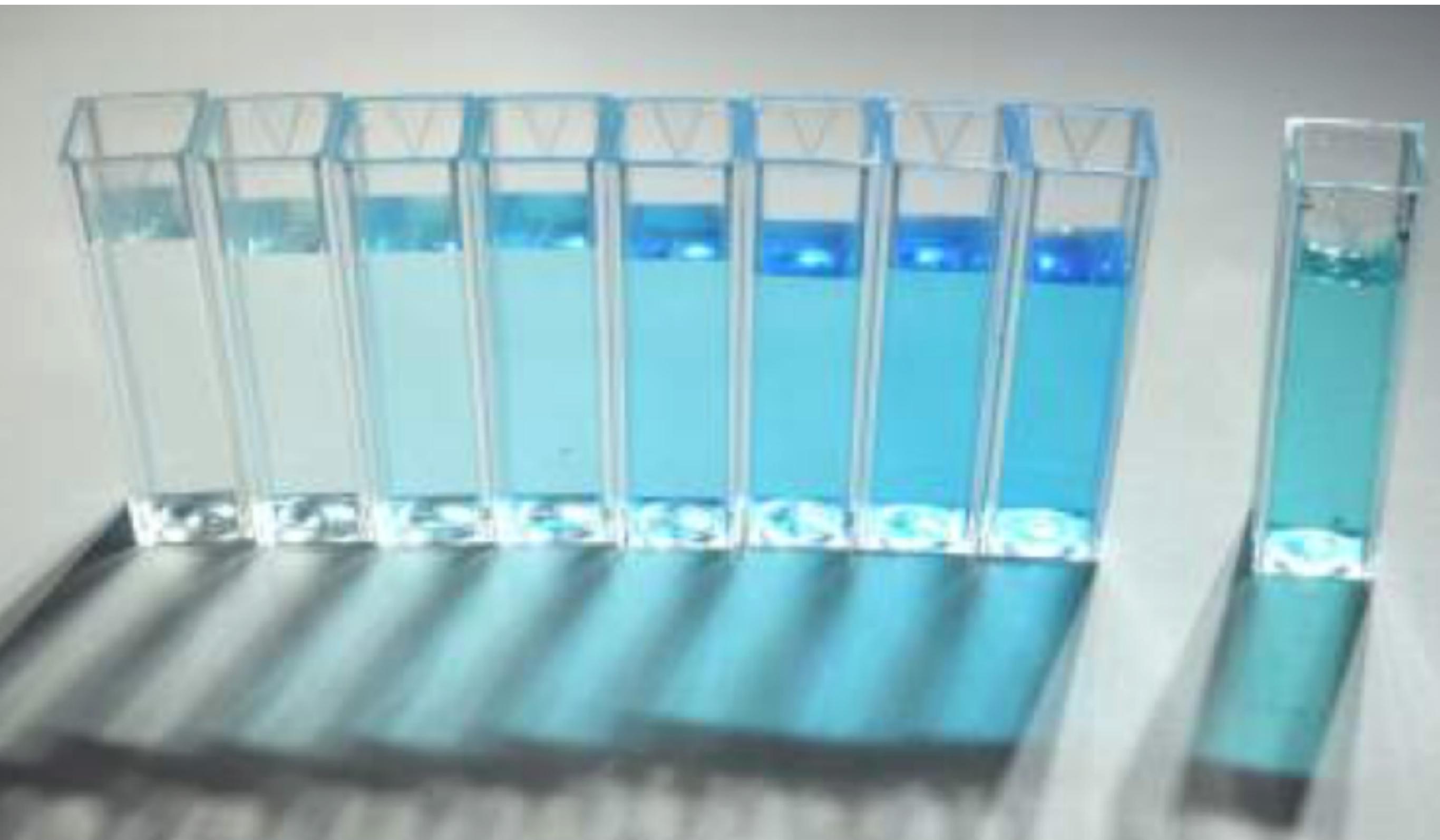
Plot data

Experiments

E131 in Gummy blue sharks

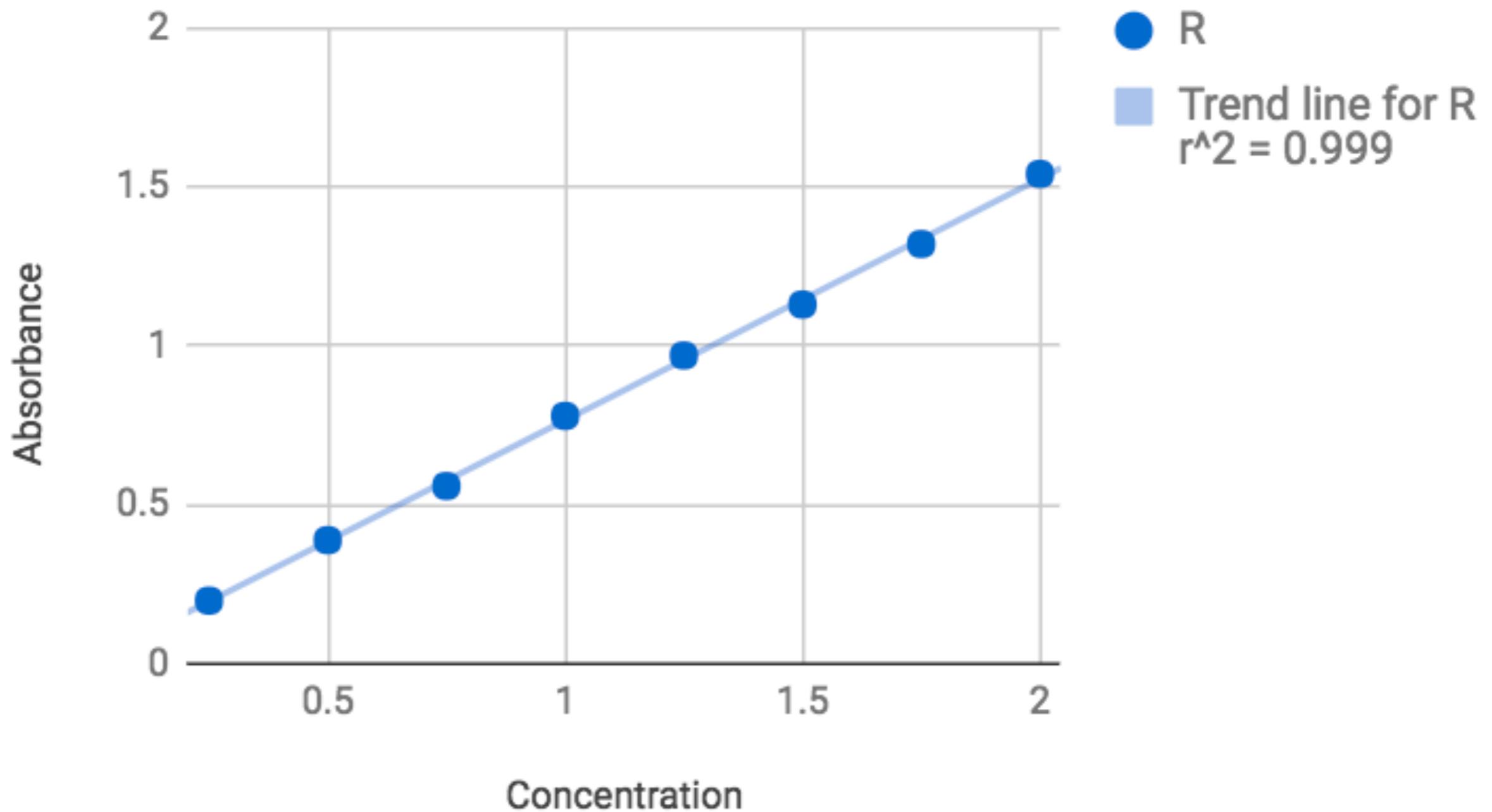


Left: known [], right: Haribo

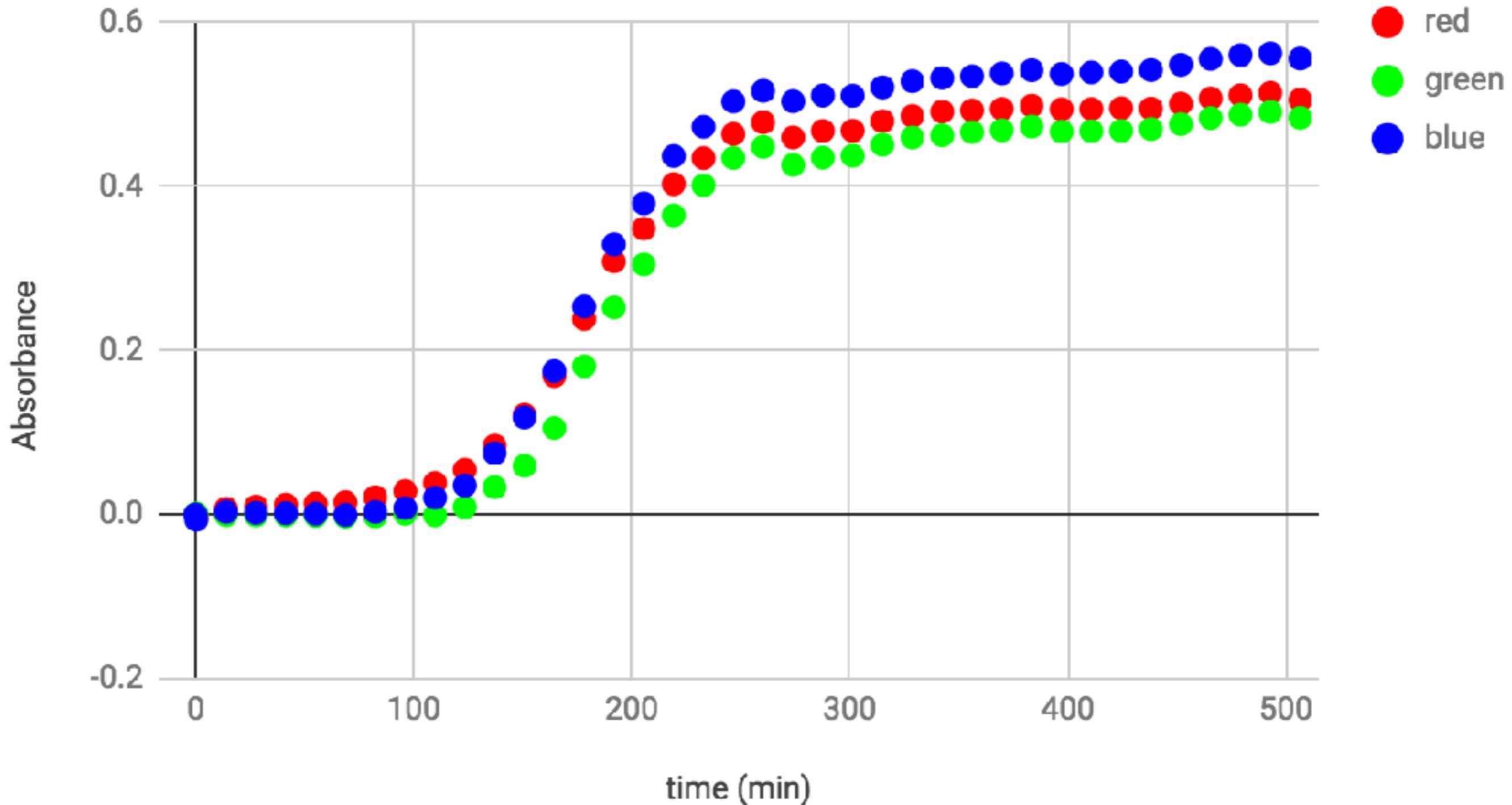




Absorbance versus concentration



OD versus time



Determine [] of E131

- **Mother solution:**
 - 10mg of E131 in 25mL of water
- **Diluted solutions**
 - 0 mL → 5 mL of mother solution in 20mL of water
 - 0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0 mL

Analyse data

What's next ?

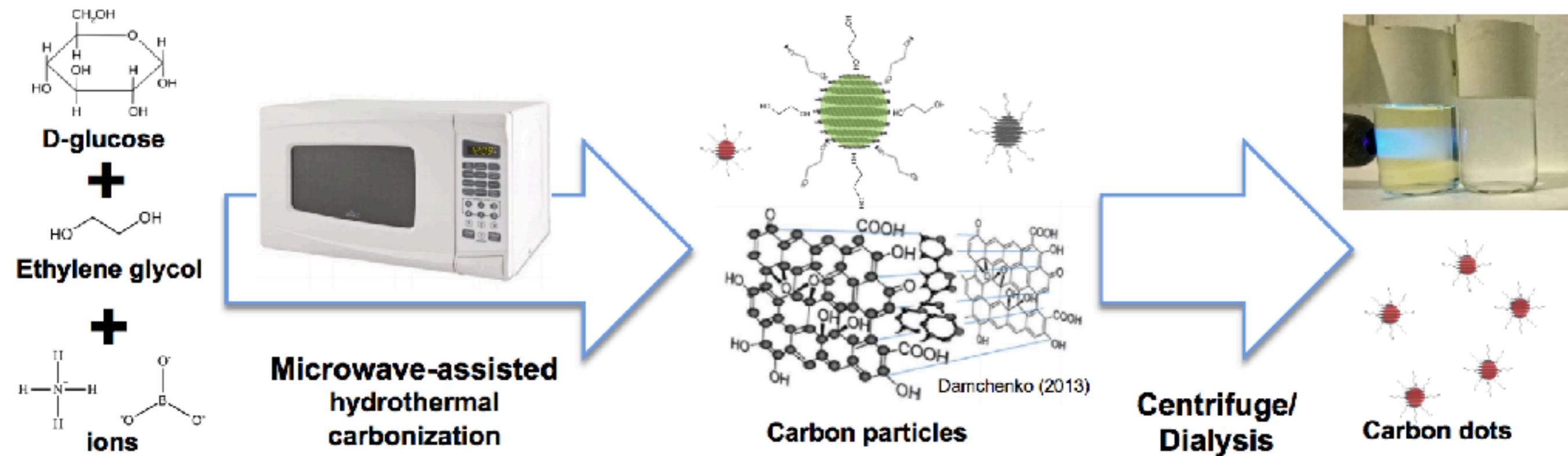
Hardware

- **Electronic**
 - reduce power consumption (we went from 5mA to 250µA)
 - hard reset (to check, now software reboot)
- Mechanics
 - Good solution for the screen (glued plexiglass)
- **Stability / reproducibility**
 - <https://hackuarium.github.io/simple-spectro/>

Applications

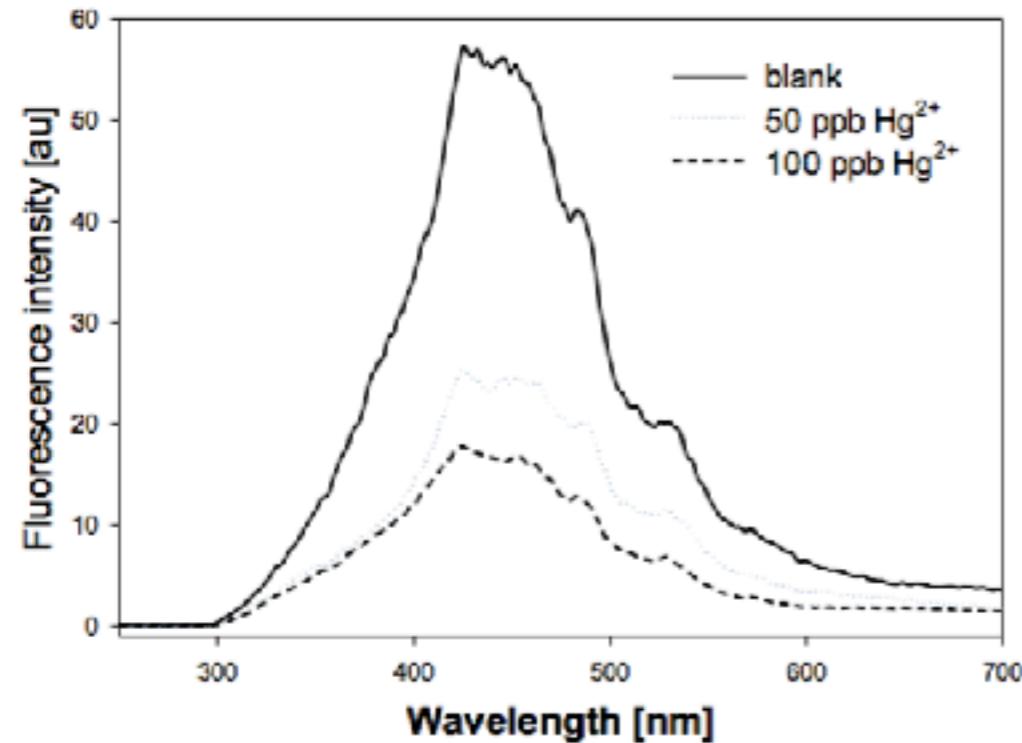
- determination of pH ?
- kinetic reaction
- bacteria growth versus temperature
- various bacteria
- consortium growth
- mercury water contamination using quantum dots

Carbon quantum dots

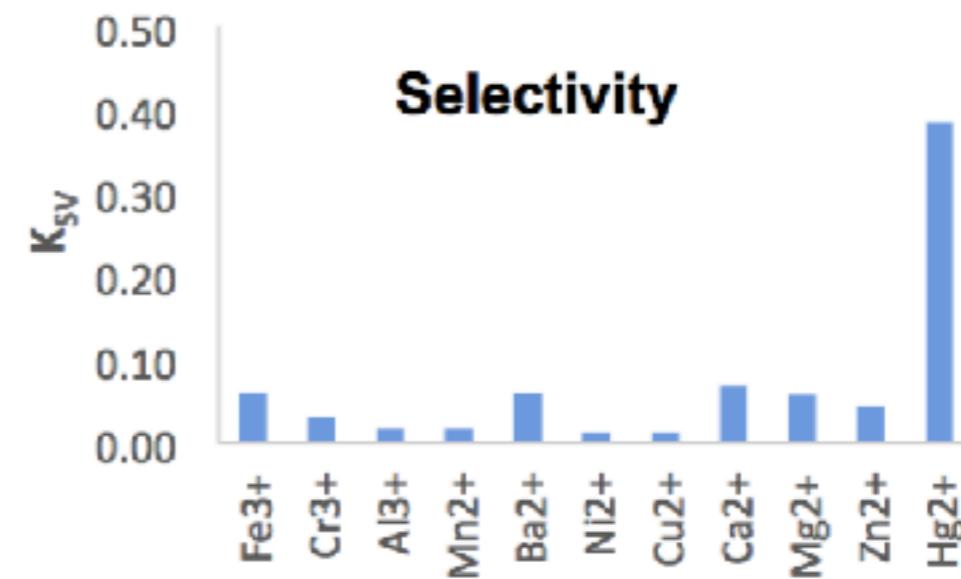
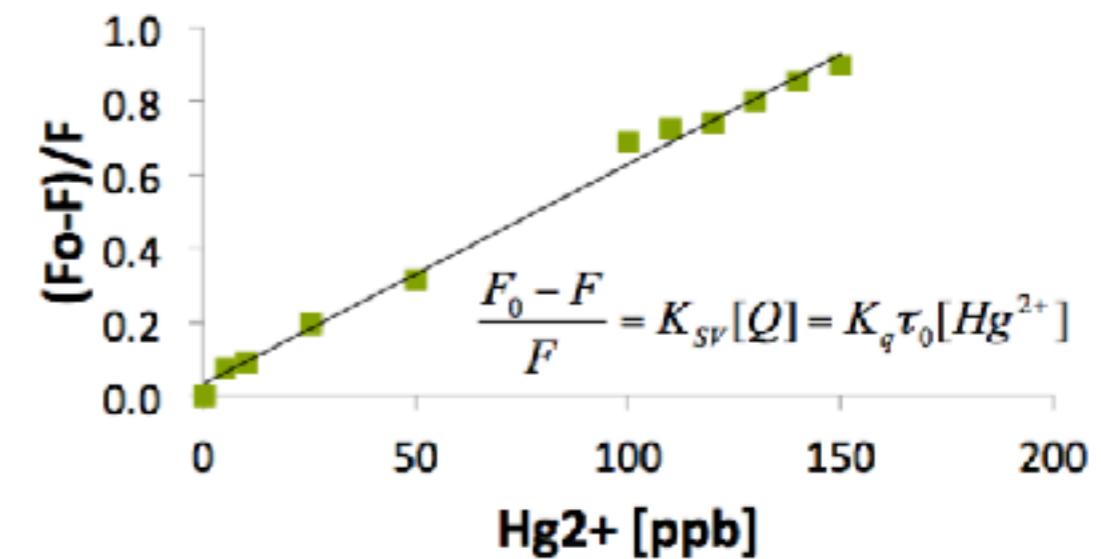


Results

Calibration and selectivity



Limit of Detection: 10.5 ppb
Response time: 5 sec
Selectivity: >98%
Sensitivity: .006/ppb- Hg^{2+}



Currently studying CQD response in mixtures. Early field trials were successful (confirmed by AAS)



