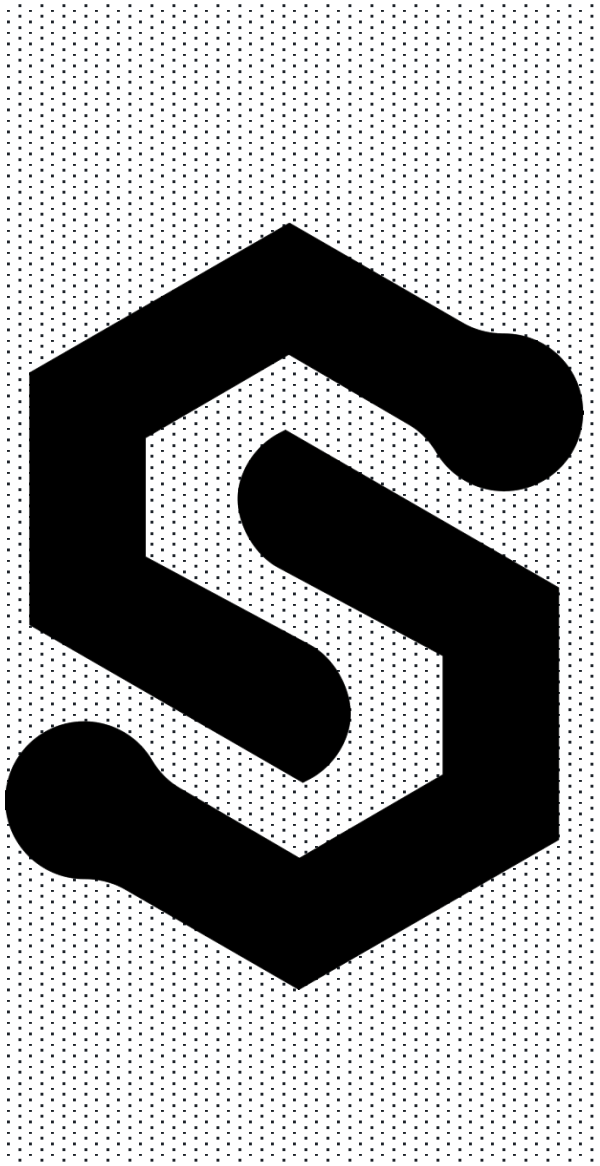
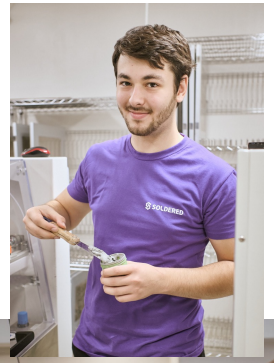
IoT product lifecycle
Open Source Hardware

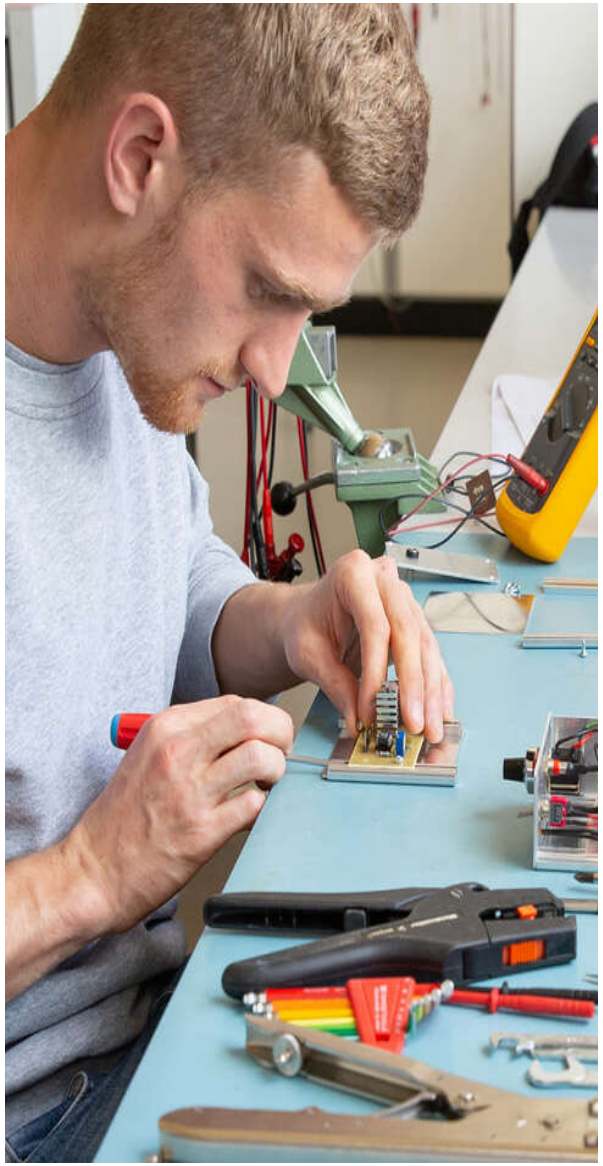
November 2022.



Who are we?

- Soldered Electronics
- Engineering-oriented company
- We design and manufacture electronic products (Arduino-compatible) for makers
- Completely open-source, for everything we do
- 10 people and a lot of machines





What is maker culture?

- Modern version of Do It Yourself movement, focused on electronics, in both hobby and educational area
- The person involved is called a maker, and she/he uses her hands to create and modify electronics projects, while learning how it all works
- It is huge - $3B market in electronics and technology-oriented STEM toys by 2025

Why do we exist?

To become the

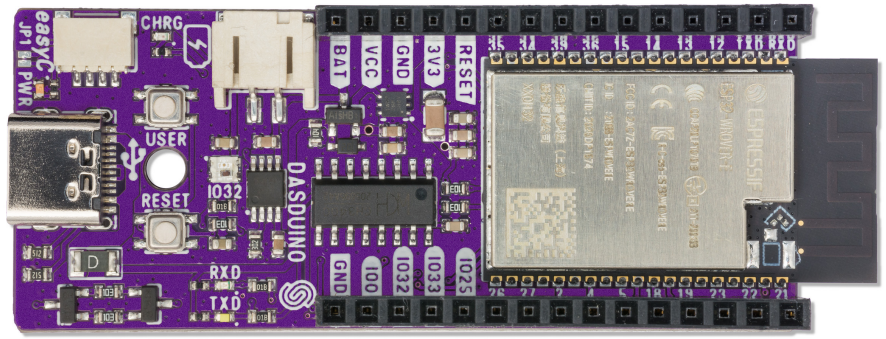
- platform
- go-to-place
- ecosystem
- community
- marketplace

for makers.

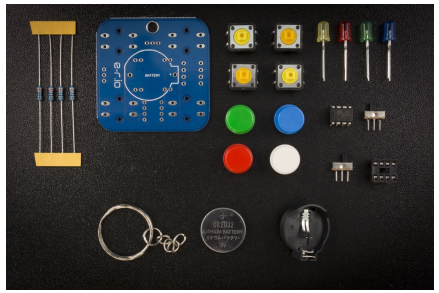
Products overview

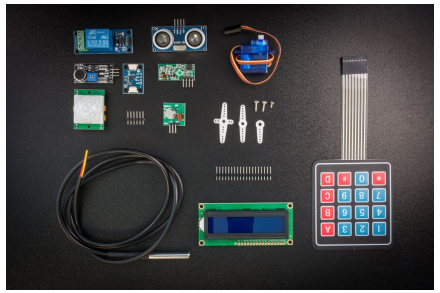
Inkplate - the simplest e-paper display for makers, made from recycled Kindles

Everything else a maker would need: components, tools, equipment, consumables…



Dasduino – microcontroller boards

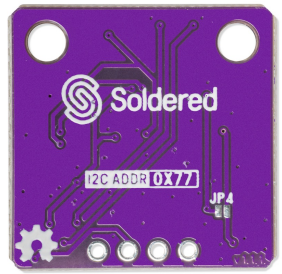


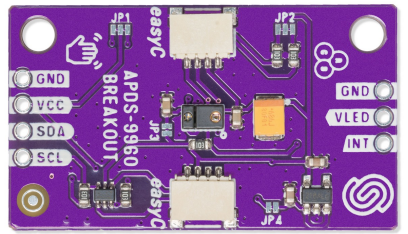


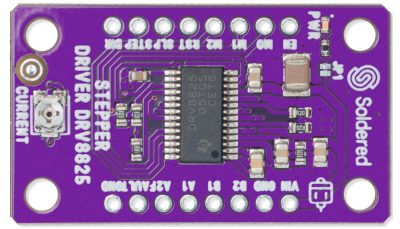
Beginner & educational kits

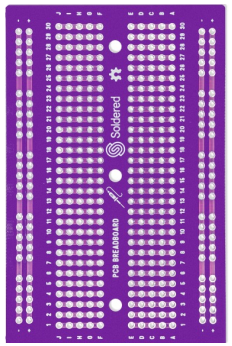
170+ products

Every product has the same electrical and mechanical aspects, making it easy to work with





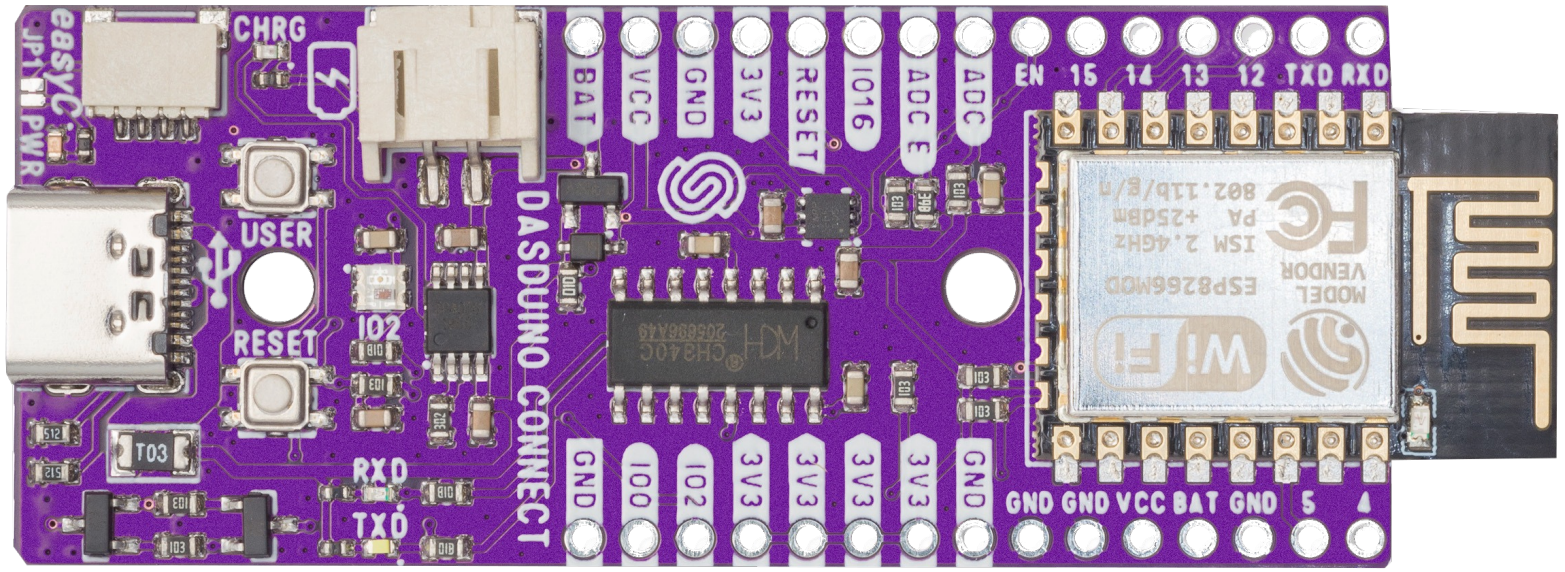


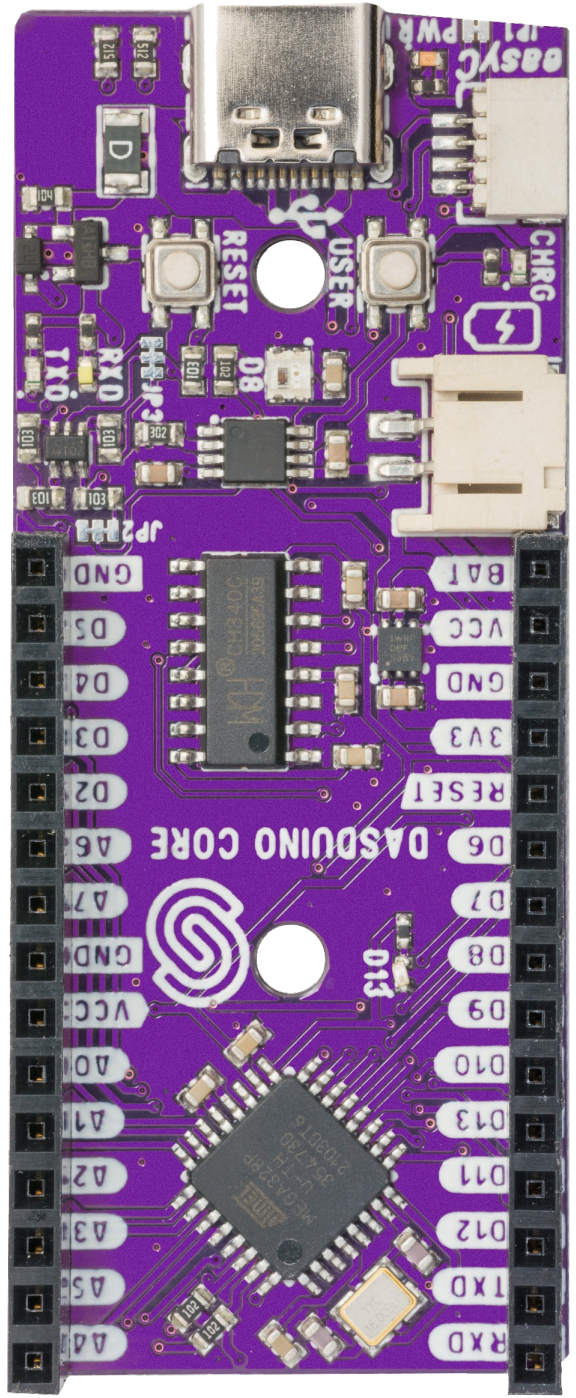


Various sensors, actuators, drivers and other electronic boards for makers

Dasduino

100% Arduino kompatibilna pločica
dizajnirana i proizvedena u Osijeku





How do we do it?

Products

Well-designed, easy to use, innovative & affordable; in-house manufactured

Support

Fast customer support & free technical support

Content

Top-quality, engaging & unique: courses, quizzes, loyalty…

Community

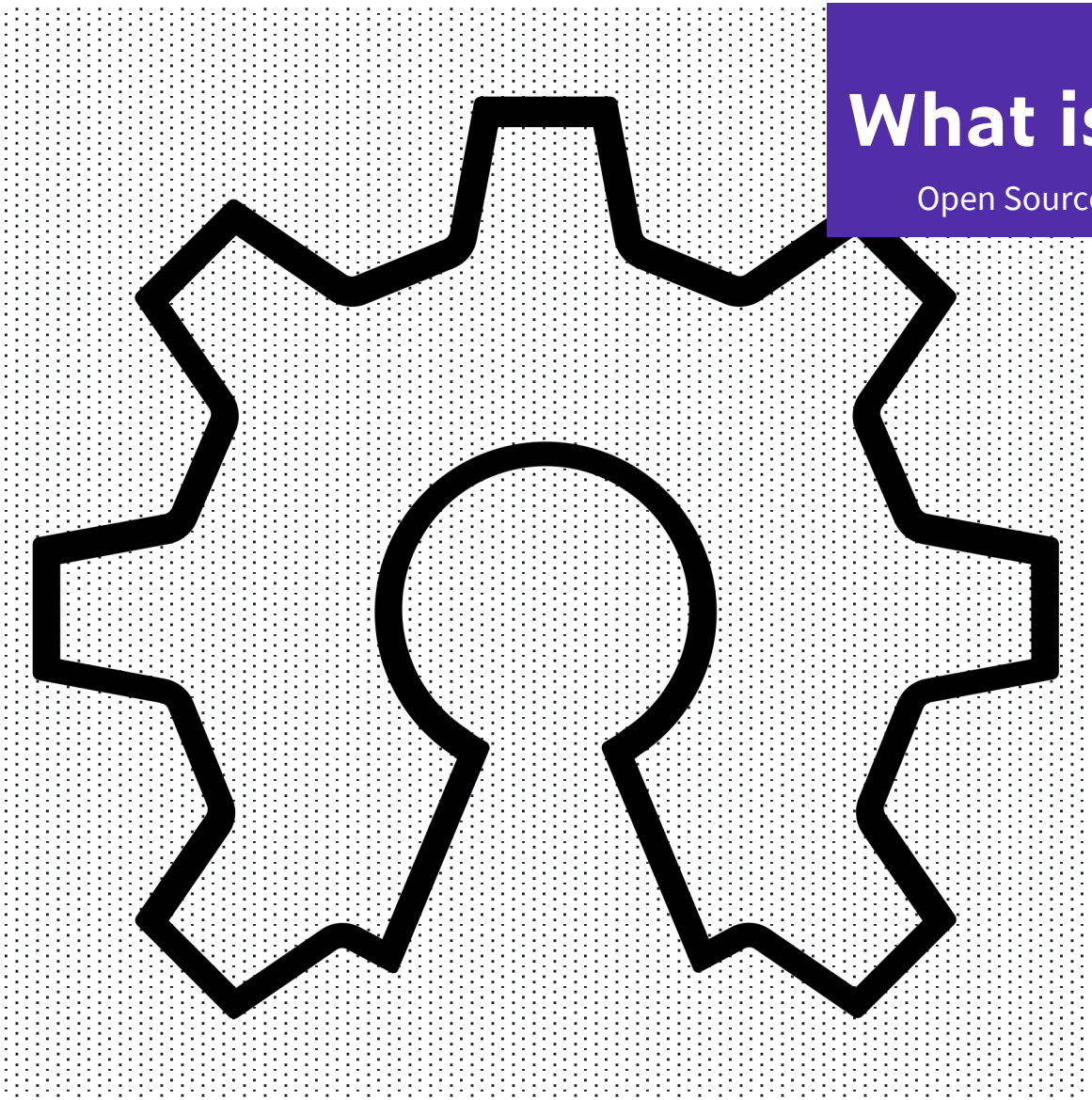
A platform for the people of the same interest to talk

The coolest fact?

It is all

- created in
- manufactured in
- designed in
- prototyped in
- shipped from

Osijek, Croatia.



What is OSH?

Open Source Hardware

Part of open-movement, to be applied on hardware, make it accessible to everyone

Although most often, it’s not necessarily only electronics; it can be mechatronics or any other physical aspect of project

Goes well with OSS

How is OSH applied in practice?

If you were an OSH company, for your OSH product you would make publicly available:

01

Schematics

Source CAD files and .pdf of the schematics.

02

Board

Source CAD files and gerber files (used for PCB production).

03

Bill of Materials

Full list of components used, including part number for each.

04

Documentation

Various useful documents, such as pinout or assembly instructions

05

Mechanical

Source CAD files and 3D-printable files, usually for enclosures.

06

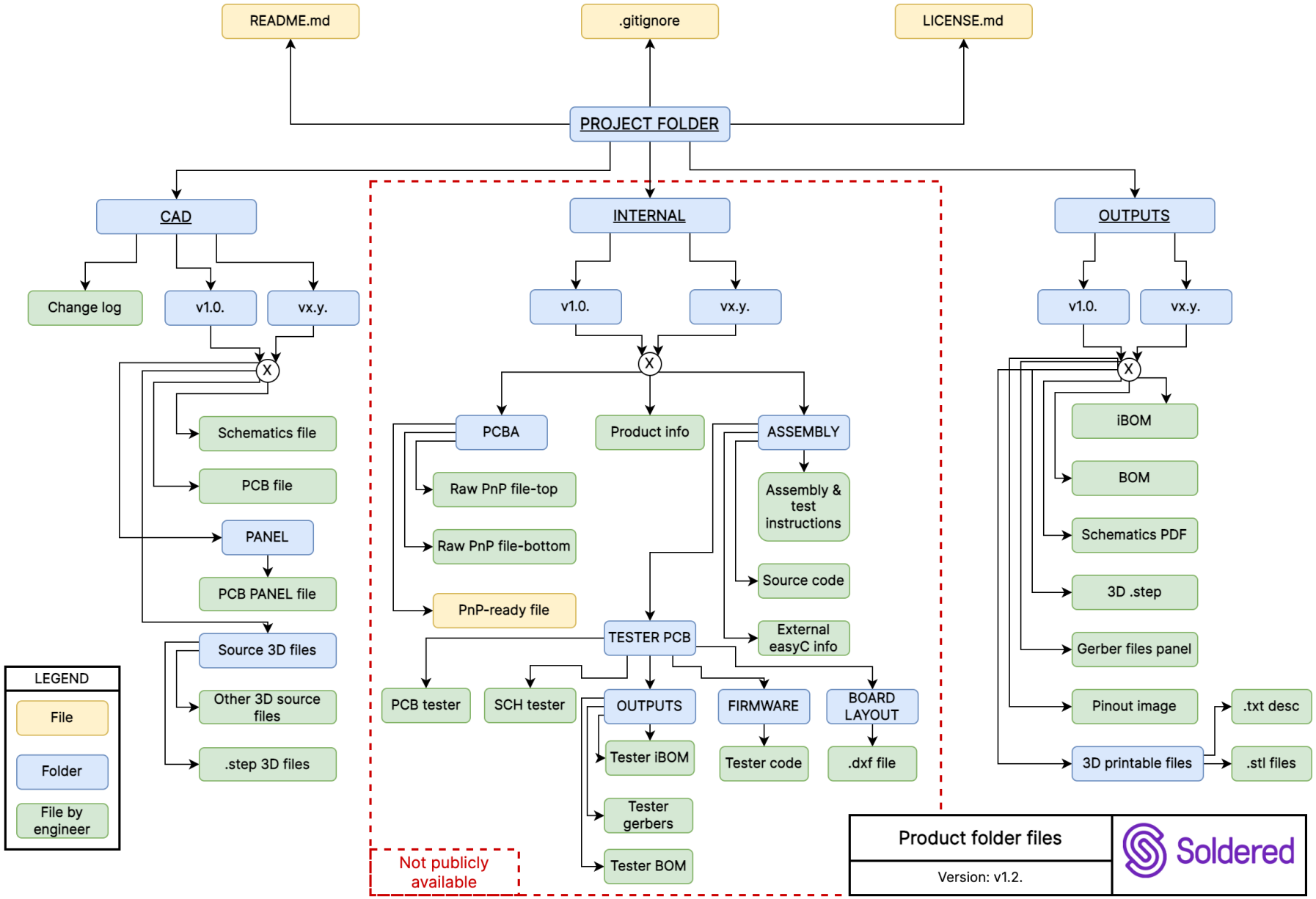
Other

Panel CAD files, board 3D model, and everything else.

+ OSS

+ LICENSE *

Example – Soldered product folder

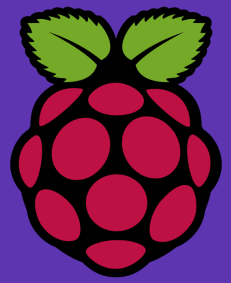


OSH projects that are popular because of OSH

OSH gave boost in popularity to many OSH projects, especially electronics ones

Arduino

Made microcontrollers easy & available to everyone.



Raspberry Pi

Super-popular & affordable single board computer. Charity.

adafruit

Maker electronics bits & piece

Reprap, Makerbot

Gave boost to 3D printers popularity.

Anyone can make a product, but can’t call it “Arduino”

OSHWA

The Open Hardware Observatory

Open Source Ecology Germany

What are OSH certification programs?

OSHW

OSHWA

OPEN SOURCE HARDWARE ASSOCIATION

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Example – OSHWA certificate

INKPLATE 6

TAVU D.O.O.

OSHWA UID

HR000003

PROJECT WEBSITE

CERTIFICATION DATE

April 17, 2020

COUNTRY

Croatia

A powerful, Wi-Fi enabled ESP32 microcontroller makes this six-inch e-paper display – recycled from a Kindle e-reader – incredibly easy to control. Just plug in a USB cable, open Arduino IDE or start micropython, and change the contents of the screen with few lines of code. Its ultra-low-power sleep mode enables it to be run for ages on a battery.

VERSION

v1.0

Licenses

HARDWARE

TAPR

SOFTWARE

GPL

DOCUMENTATION

CC BY-SA

VIEW DOCUMENTATION

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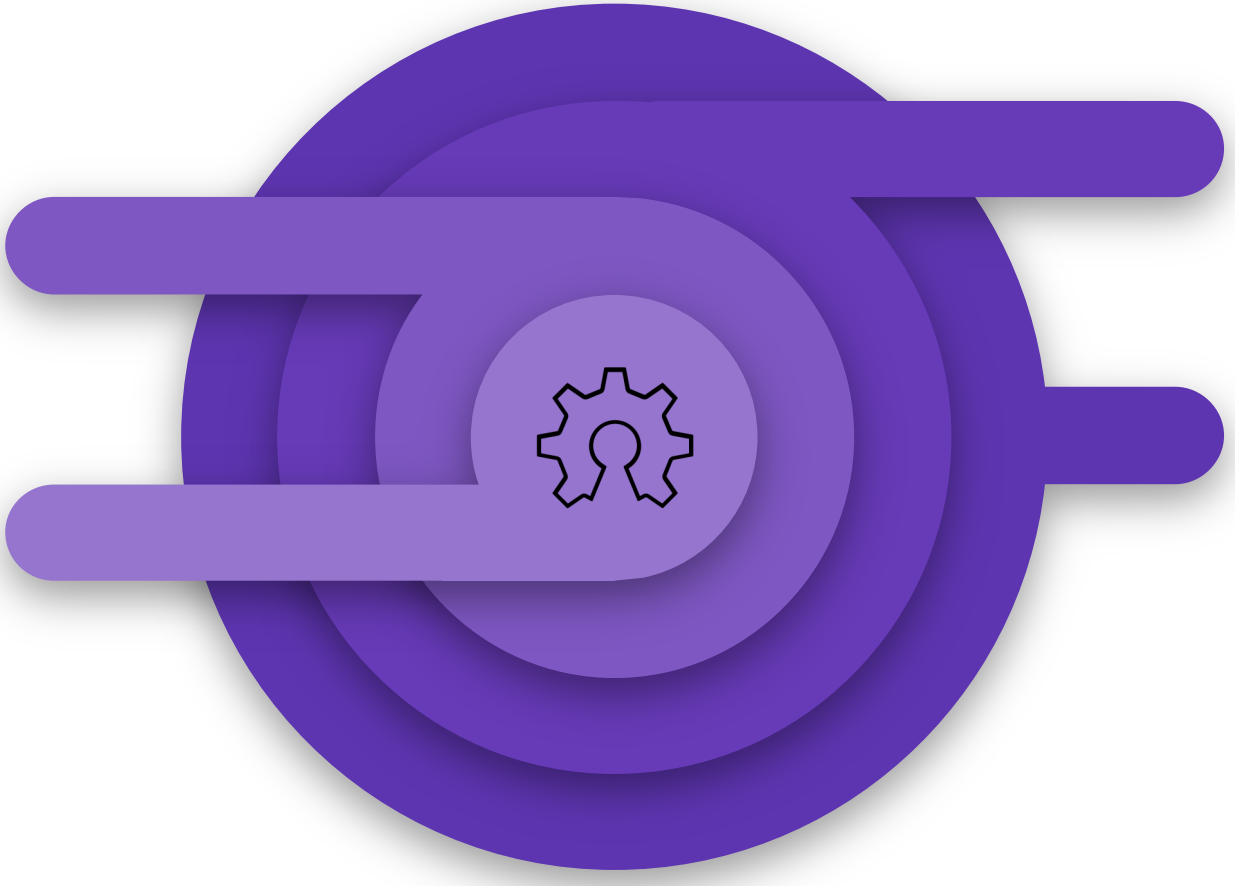
Why use OSH for commercial products?

Marketing

Open-sourcing gets the word out about your product and/or brand.

Customers love it

Some people simply appreciate the openness and buy the product because of it.



Free improvements

Since they love it, they tend to use as their own, therefore improve it.

Return the favor

You have used and profited from others open-source, why not give back? It's just feels good.

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So, how's this working for us?

So far, pretty well!

9k Customers

4.7 Average review score

60 Countries on our customer list

85% Average YoY growth since founding

40k Products delivered in 2021.

100k Total delivered products so far

$ 350k Successfully crowdfunded

< 0.05% Return rate

Q&A

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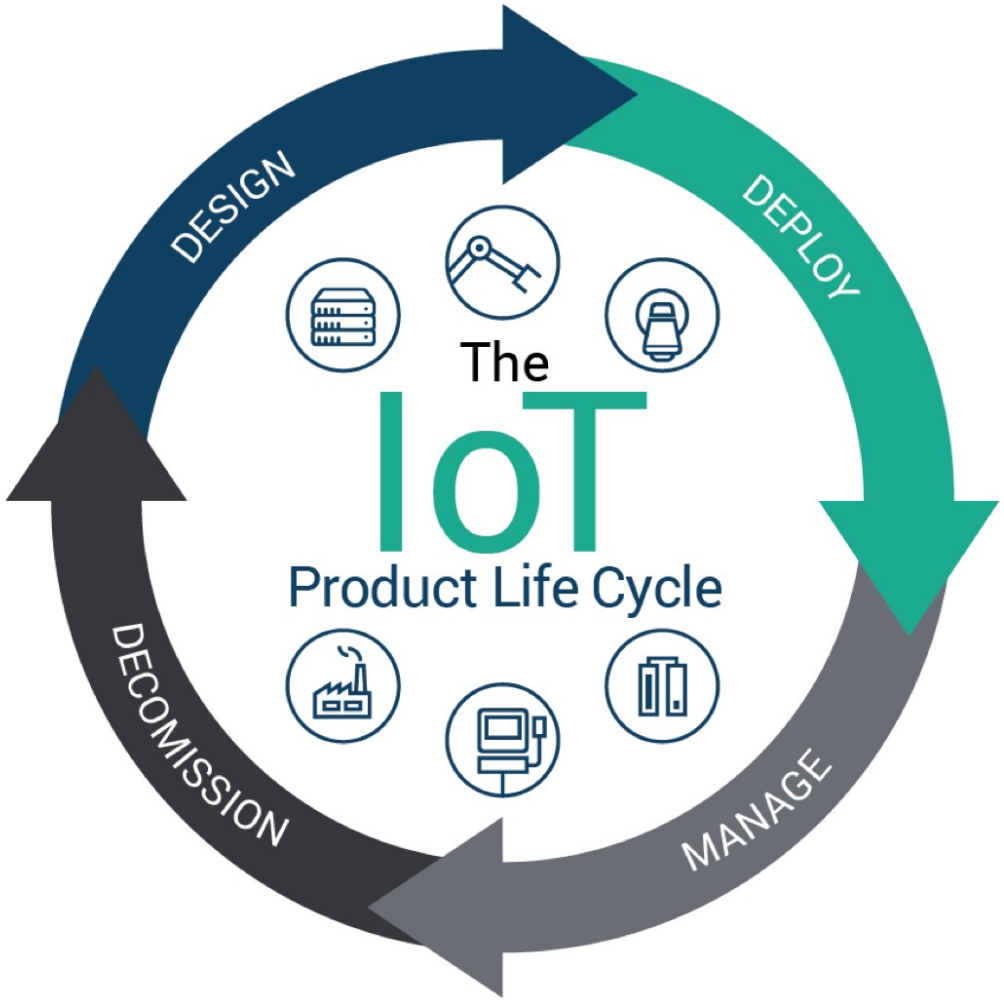
IoT device lifecycle

IoT device lifecycle

- Not necessarily different from any other electronic device
  - Design
  - Deploy
  - Manage
  - Decommission



https://www.lantronix.com/wp-content/uploads/pdf/Product_Life_Cycle_in_the_Age_of_IoT_Final_04-1.pdf

1. Design

- The most important step, and the longest one
- Starts with clear understanding of the device and written specification
- At some times it’s enhancement of the existing device where the connectivity is added
- Specification is crucial – its definition is a key to a successful project

Specifications

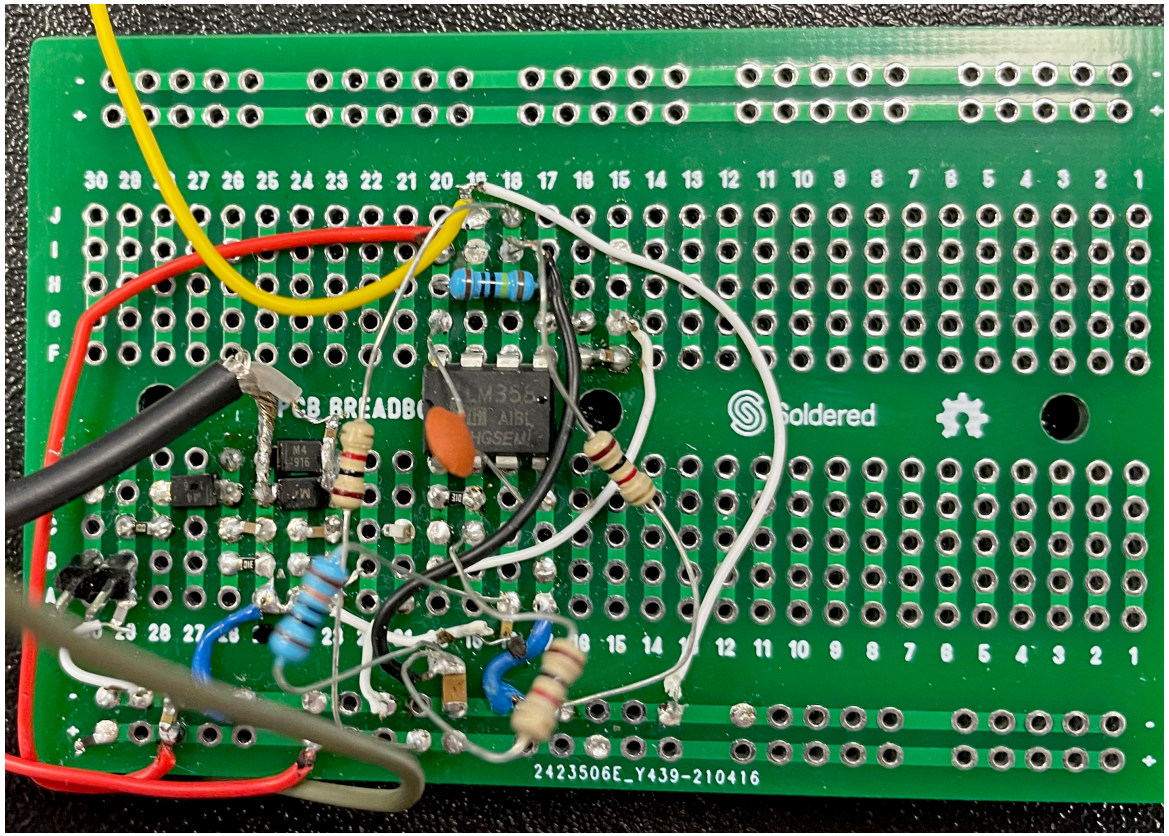
- Changing the specification along the project should be avoided
- It must be defined in a exact and precise way
- For example:

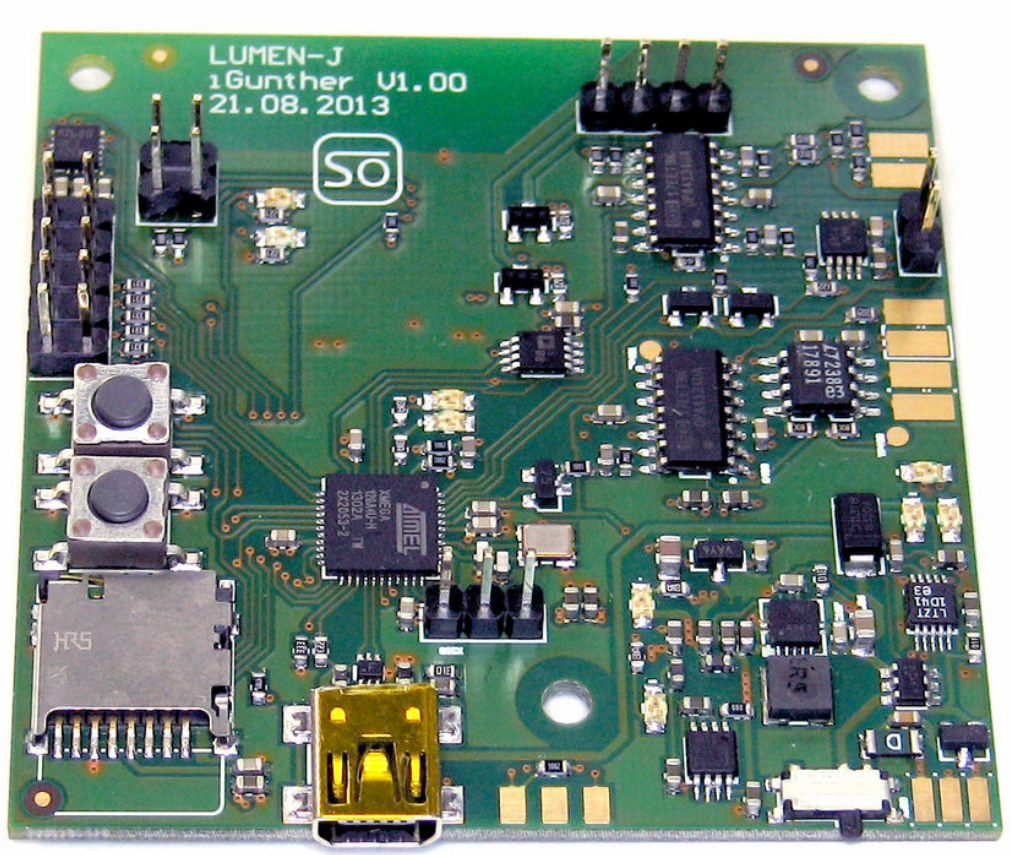
Karakteristika	Vrijednost	Mjerna jedinica
Dimenzije uređaja	67 x 63 x 36	mm
Masa	115 / 210 *	g
Temperaturni opseg	-40C - +70C	C
Geolokacijski sustav	GPS, GLOANASS, GALILEO	-
Greška geolokacije	7	m
Frekvencija	1575.42	MHz
Komunikacijski sustav	2G (GSM)	-

Research, Experiment & SCH

- After we know what we need to achieve (specifications), it's time to research, design & prototype
- The most demanding and challenging part of every project
- Research is inevitable – it's actually a lot of Googling, reading datasheets, reference designs, application notes, understanding other's designs and so on
- Some prototyping can be done on a breadboard to prove the concept, otherwise, the board is prototyped on a PCB
- Schematics is drawn in a specialised CAD tool: Altium Designer, Eagle, KiCAD…

Research, Experiment & SCH

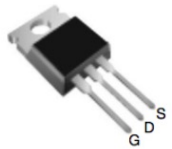


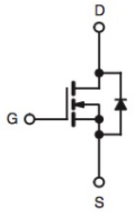


Power MOSFET

PRODUCT SUMMARY		
V_{DS} (V)	100	
$R_{DS(on)}$ (Ω)	V_{GS} = 10 V	0.077
Q_g (Max.) (nC)	72	
Q_{gs} (nC)	11	
Q_{gd} (nC)	32	
Configuration	Single	

TO-220AB





N-Channel MOSFET

FEATURES

- Dynamic dV/dt Rating
- Repetitive Avalanche Rated
- 175 °C Operating Temperature
- Fast Switching
- Ease of Paralleling
- Simple Drive Requirements
- Compliant to RoHS Directive 2002/95/EC

Available
RoHS* COMPLIANT

DESCRIPTION

Third generation Power MOSFETs from Vishay provide the designer with the best combination of fast switching, ruggedized device design, low on-resistance and cost-effectiveness.

The TO-220AB package is universally preferred for all commercial-industrial applications at power dissipation levels to approximately 50 W. The low thermal resistance and low package cost of the TO-220AB contribute to its wide acceptance throughout the industry.

ORDERING INFORMATION	
Package	TO-220AB
Lead (Pb)-free	IRF540PbF
	SiHF540-E3
SnPb	IRF540
	SiHF540

ABSOLUTE MAXIMUM RATINGS (T_C = 25 °C, unless otherwise noted)

PARAMETER			SYMBOL	LIMIT	UNIT
Drain-Source Voltage			V_{DS}	100	V
Gate-Source Voltage			V_{GS}	± 20	
Continuous Drain Current	V_{GS} at 10 V	T_C = 25 °C	I_D	28	A
		T_C = 100 °C		20	
Pulsed Drain Current[a]			I_{DM}	110	
Linear Derating Factor				1.0	W/°C
Single Pulse Avalanche Energy[b]			E_{AS}	230	mJ
Repetitive Avalanche Current[a]			I_{AR}	28	A
Repetitive Avalanche Energy[a]			E_{AR}	15	mJ
Maximum Power Dissipation	T_C = 25 °C		P_D	150	W
Peak Diode Recovery dV/dt[c]			dV/dt	5.5	V/ns
Operating Junction and Storage Temperature Range			T_J, T_{stg}	- 55 to + 175	°C
Soldering Recommendations (Peak Temperature)	for 10 s			300[d]	
Mounting Torque	6-32 or M3 screw			10	lbf · in
				1.1	N · m

Notes

a. Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11).
b. V_{DD} = 25 V, starting T_J = 25 °C, L = 440 µH, R_G = 25 Ω, I_{AS} = 28 A (see fig. 12).

HIGH SIDE

This chapter discusses solutions for high side current sensing. With these circuits the total current supplied to a load is monitored in the positive power supply line.

LT6100 Load Current Monitor (Figure 4)

This is the basic LT6100 circuit configuration. The internal circuitry, including an output buffer, typically operates from a low voltage supply, such as the 3V shown. The monitored supply can range anywhere from V_{CC} + 1.4V up to 48V. The A2 and A4 pins can be strapped various ways to provide a wide range of internally fixed gains. The input leads become very Hi-Z when V_{CC} is powered down, so as not to drain batteries for example. Access to an internal signal node (Pin 3) provides an option to include a filtering function with one added capacitor. Small-signal range is limited by V_{OL} in single-supply operation.

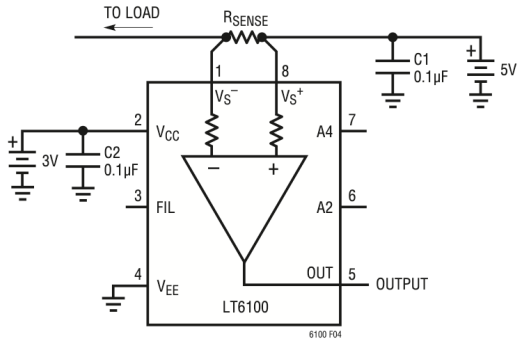


Figure 4. LT6100 Load Current Monitor

"Classic" Positive Supply Rail Current Sense (Figure 5)

This circuit uses generic devices to assemble a function similar to an LTC6101. A rail-to-rail input type op amp is required since input voltages are right at the upper rail

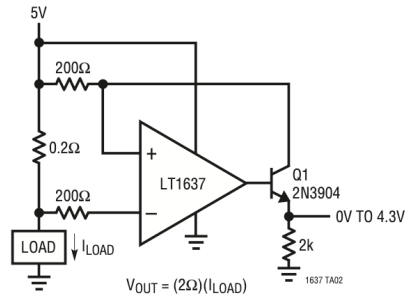


Figure 5. "Classic" Positive Supply Rail Current Sense

Over-The-Top Current Sense (Figure 6)

This circuit is a variation on the "classic" high side circuit, but takes advantage of Over-the-Top input capability to separately supply the IC from a low voltage rail. This provides a measure of fault protection to downstream circuitry by virtue of the limited output swing set by the low voltage supply. The disadvantage is V_{OS} in the Over-the-Top mode is generally inferior to other modes, thus less accurate. The finite current gain of the bipolar transistor is a source of small gain error.

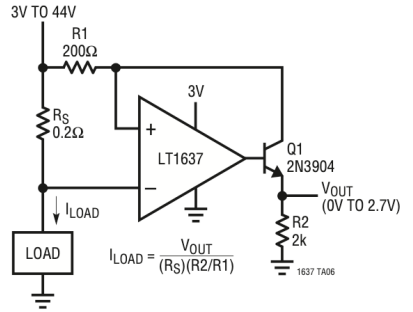
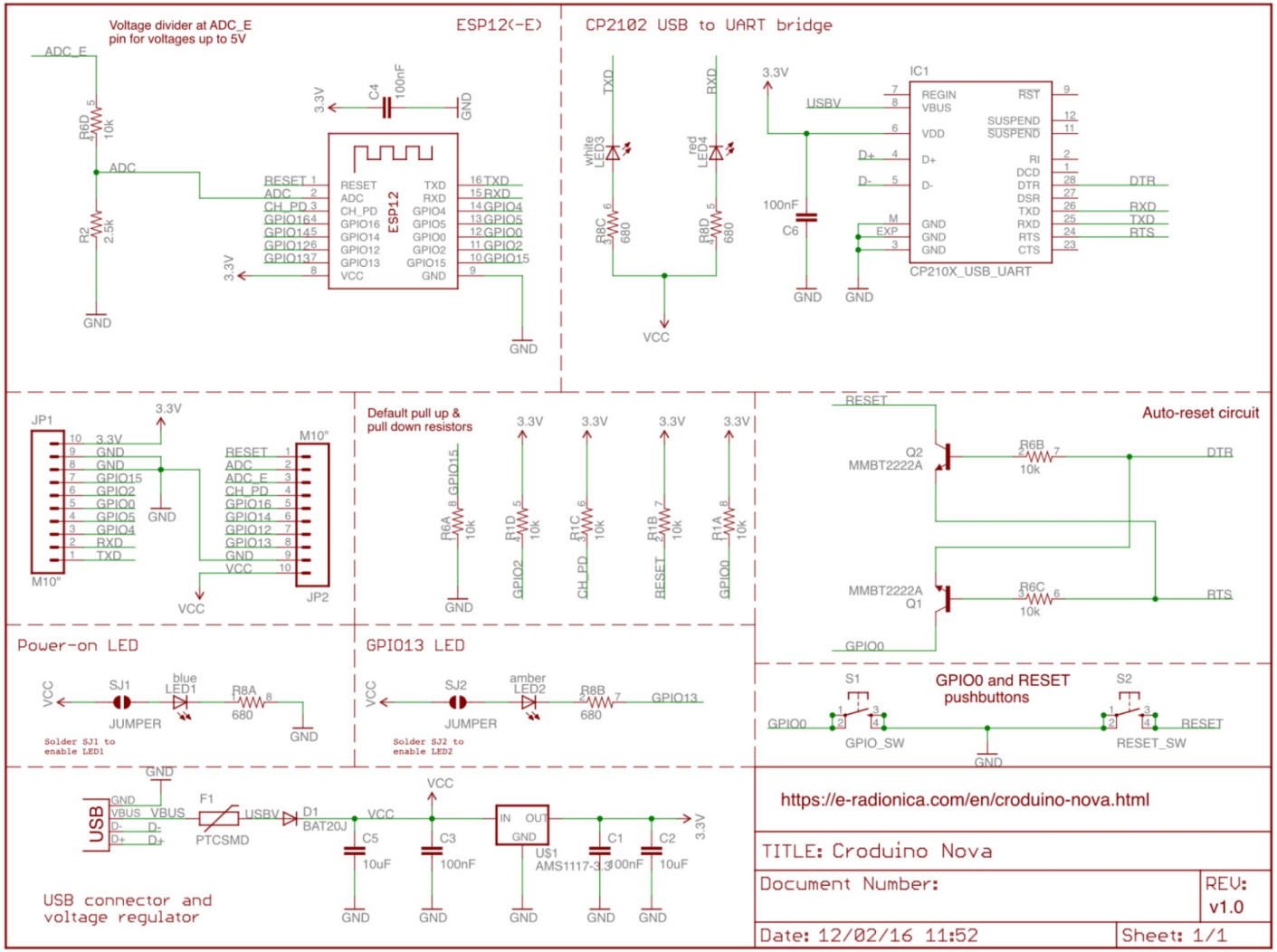


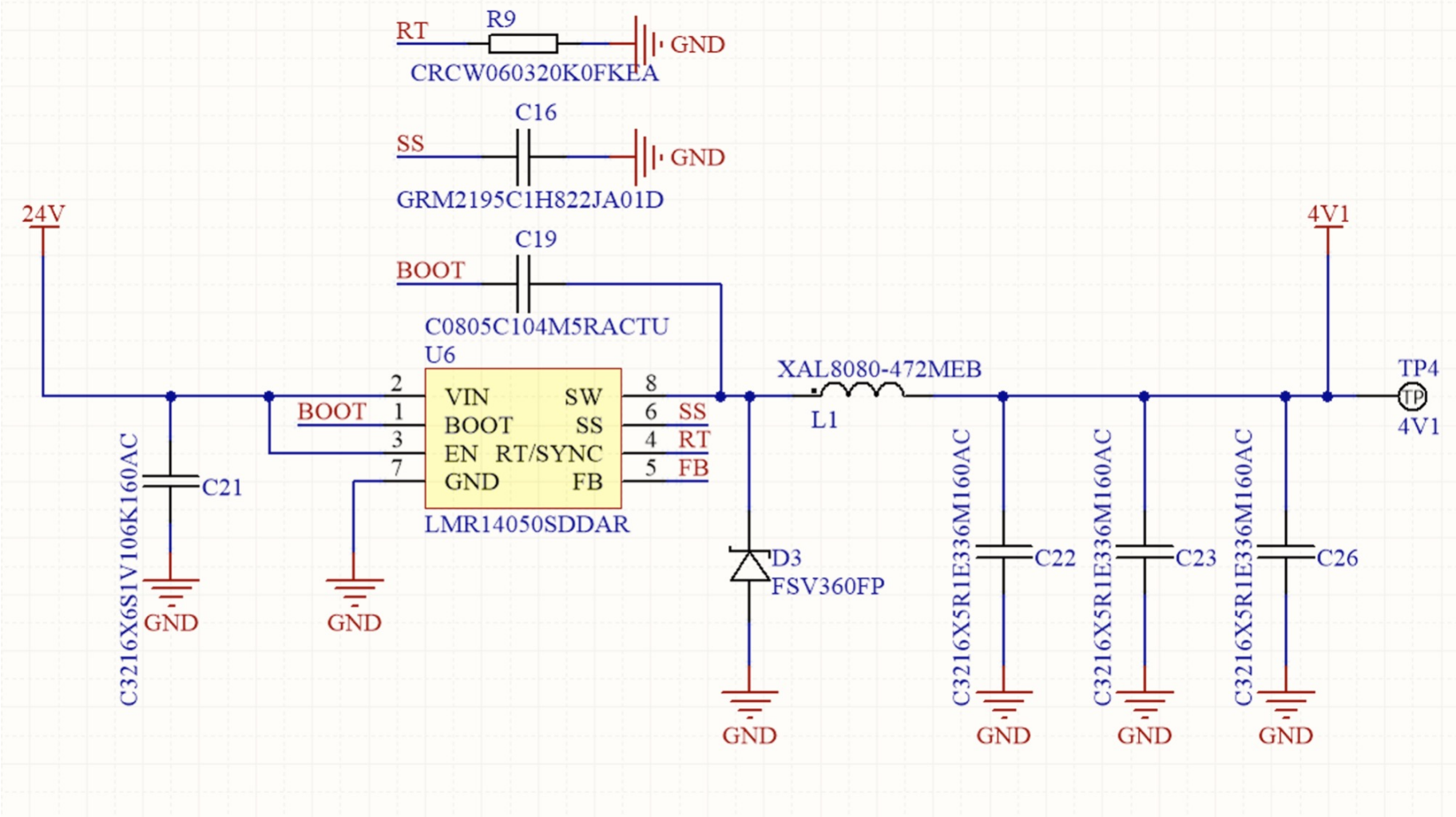
Figure 6. Over-The-Top Current Sense

Research, Experiment & SCH



1. Design

Research, Experiment & SCH

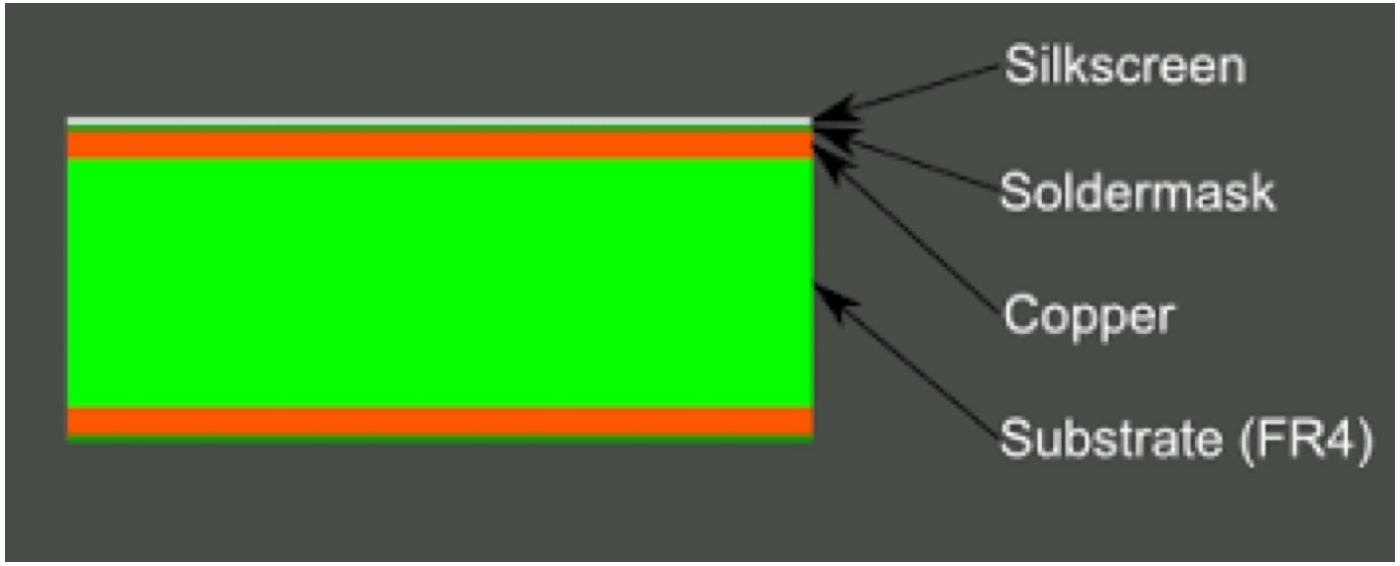


Communications

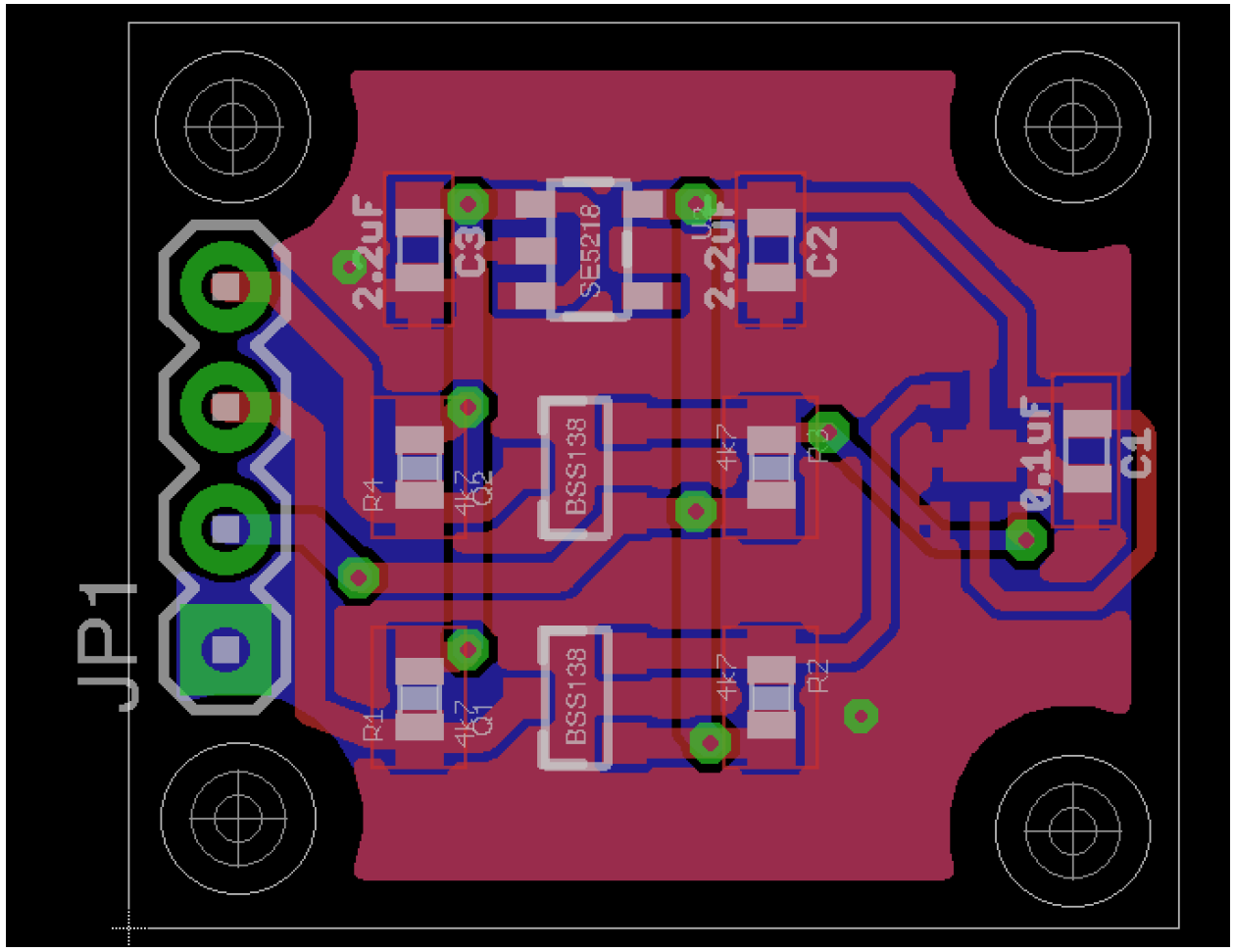
- For an IoT device, there's always some form of communication onboard
- More often it's wireless than wired
  - WiFi
  - LoRa
  - NB-IoT (LTE Cat M1)
  - Bluetooth (BLE)
  - RF
  - 5G
  - Ethernet
  - RS-485 / RS-232
  - Industrial standards (4-20mA…)

PCB

- After the schematics is verified by another engineer(s), it's time to design the PCB
- Done in specialised CAD tools as well
- A lot of things that need to be taken into consideration: mechanical design, high-power traces, noise, high frequency signals, length matching…



PCB


JP1
2.2uF
C3
SE5218
2.2uF
C2
0.1uF
C1
BSS138
BSS138
4k7
4k7
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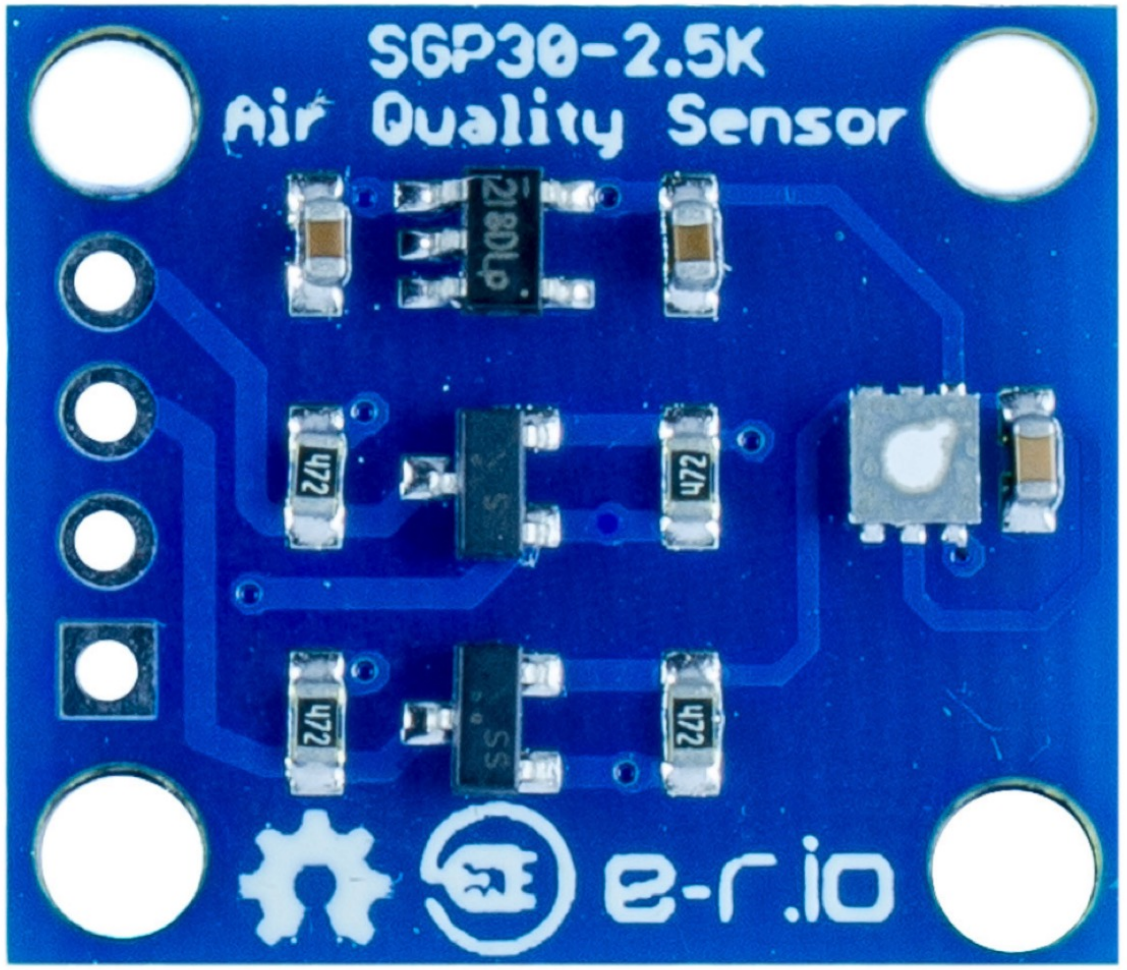
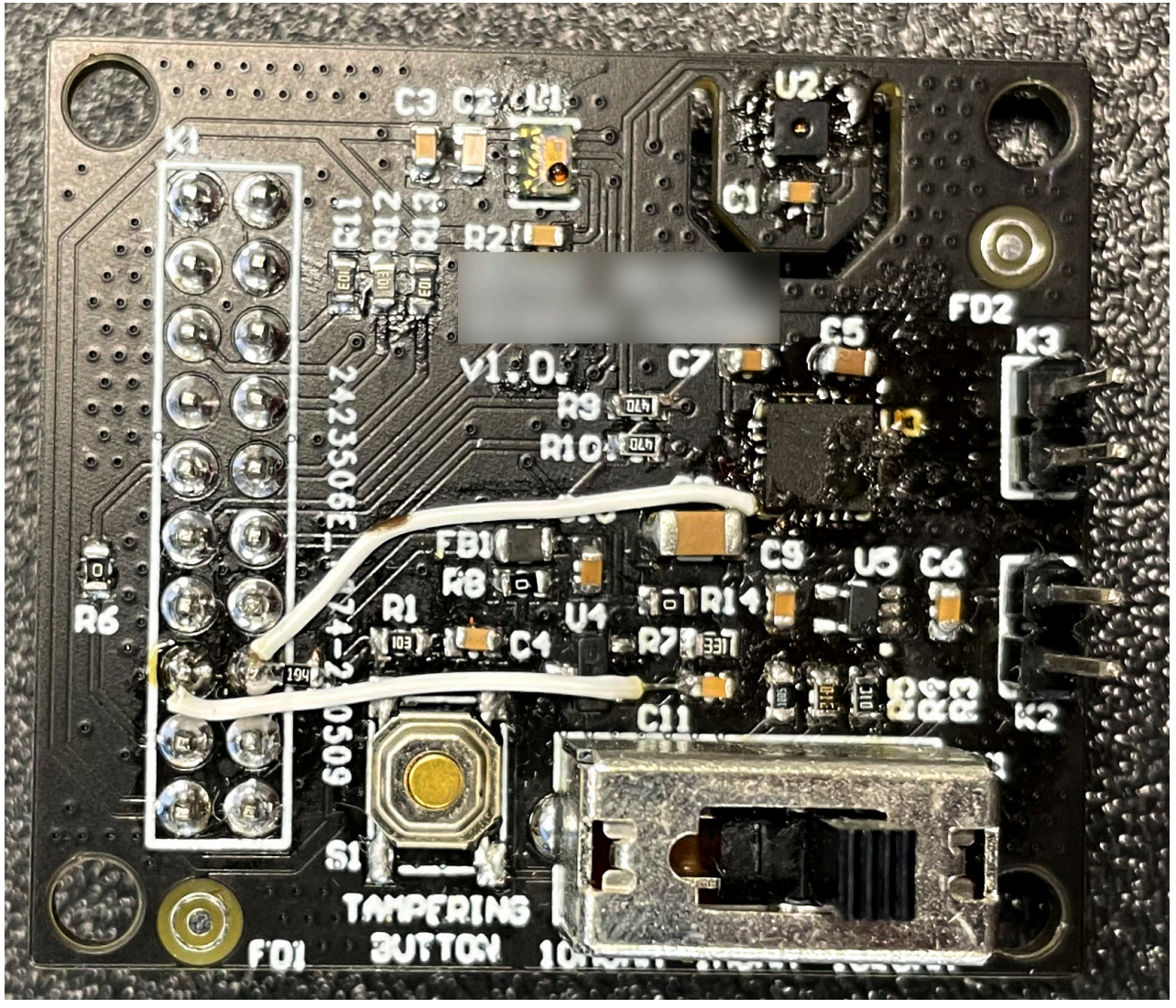
4k7
R4
R1
R2
Q2
Q1


SGP30-2.5K
Air Quality Sensor
e-r.io

Prototyping

- PCB is manufactured, and components are soldered onto the PCB. That way, we get a prototype
- The prototype is tested in detail
- Prototyping is iterative process, there are often errors which need to be found and fixed
- After errors are found, we are back on start: change the schematics, update the board, prototype new board, test again – until everything works as it is supposed to

Prototyping



Embedded software development

- After PCB is developed, it goes to the embedded software developer
- An embedded software (firmware) is written for the device
- First, a driver for each part of the device is created. It ensures proper communication with that part, alongside all needed security measures
- Afterwards, the logic for the board is created. This is the core of the product as it gives instructions what device should do
- It’s usually done in low-level languages, like C++, and it oftentimes access the data using registers
- Recently, high-level languages for embedded are appearing, such as micropython
- git should be used for version control

Infrastructure

- Every IoT device communicated with an other system
- That’s a server with API for access, database for storage… (but there are more modern approaches to this as well)
- Web app or mobile app or any other subsystem can connect to this centralised system to get data IoT device has sent
- OTA (Over The Air) Updates – ability to reflash the device when it is at the customers location – **Crucial**!

Infrastructure

i just wanted a glass of water...

Certification

- Cumbersome process mandatory to sell the product in the market
- For EU, CE is mandatory before placing the product on market. It consist of:
  - RoHS – hazardous Substances
  - EMC – electromagnetic compability
  - LVD – specific for each device, Low Voltage Device
  - RED – Wireless devices (WiFi)
  - others
- For USA and devices with wireless capabilities - FCC

2. Deploy

- The board won’t go into production until (at least) drivers are finished, since some errors can be found in software development phase
- Gerber files are used for production

https://medium.com/supplyframe-hardware/tipping-points-in-electronics-assembly-2969f3d54775

What happens at the factory?

- PCB is manufactured and components are soldered on it

What happens at the factory?

- Programming & testing (bed of nails)

https://sine.ni.com/cms/images/casestudies/cpeb.jpg?size

What happens at the factory?

- Assembly into enclosure
- Packaging
- And finally: shipping to customers and distributors

Finishing the deploy

- There are different kind of deployments:
  - Proof of concept
  - Pilot runs
  - Commercial runs
- Different stakeholders are involved to make sure everything will work as expected

3. Manage

- The longest phase of every IoT device
- Once an IoT device is “out there”, customers expect that it works every second of its lifetime
- That means monitoring and maintaining the infrastructure, fixing the bugs via OTA update, adding new features via OTA…
- Customers usually activates the device first time it’s turned on (knowingly or unknowingly)
- The IoT device management system takes care of the device during its lifetime. For example, Amazon and Microsoft (Azure) offer these kind of systems, as well as many small, specialised companies

4. Decommission

- Once IoT device comes to EOL (End Of Life), it’s being decommissioned
- It usually means user stops using it
- Transfer to a new device should be made as simple as possible, while keeping the data (Apple as an example)
- The data on server is usually retained for a period of time (months or years, depending on nature of the data)

Q&A

Soldered

Studentski posao i praska u Soldered?

posao@soldered.com

Soldered

Get in touch

Any questions?
Want to make OSH product together?
Have an advice for me, or need advice?
...and anything else, contact me!

And, of course, this presentation is open-source. Find it in my GitHub repo:
https://github.com/davidzovko/Presentations

David Zovko

Founder

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P: +385 97 616 3556