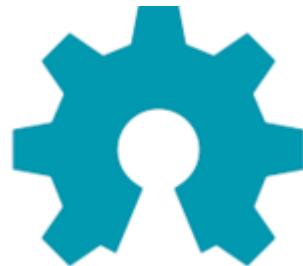
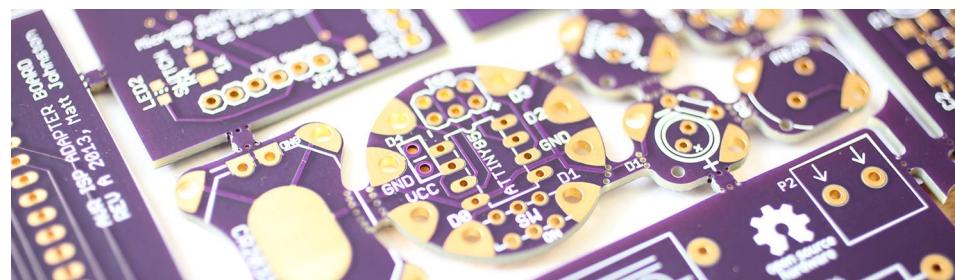


# Introduction to Open Source Hardware



**Drew Fustini**  
**OSH Park**  
[drew@oshpark.com](mailto:drew@oshpark.com)  
[@oshpark / @pdp7](https://twitter.com/@oshpark)





# Open Source Hardware



Design is made  
**publicly available**  
so that anyone can  
**study,**  
**modify,**  
**distribute,**  
**make**  
**or sell**  
designs or  
hardware based on that design

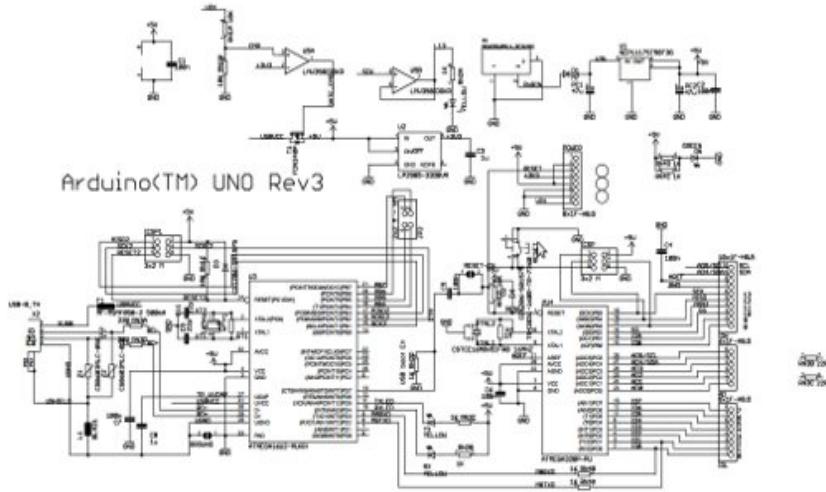


# Open Source Hardware

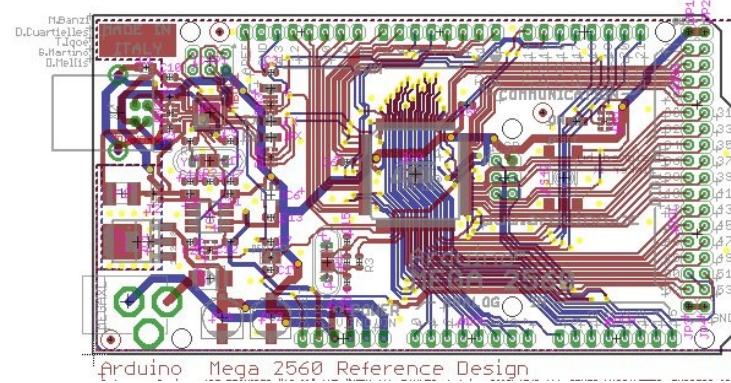


Documentation required for electronics:

## Schematics



## Board Layout



Editable source files for CAD software (*KiCad*, *EAGLE*, *Altium*, etc)

## Bill of Materials (BOM)

*Best practice:* all components available in **low quantity distribution**



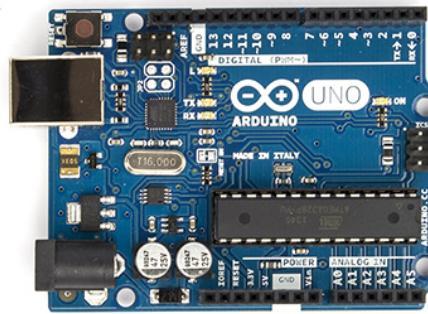
# Open Source Hardware



## Example: Arduino

The screenshot shows the official Arduino website. The top navigation bar includes links for Home, Buy, Download, Products, Learning, Forum, Support, and Blog, along with LOG IN and SIGN UP buttons. The main content area features the Arduino logo and a search bar.

### Arduino Uno



- Achieved **critical mass** by **sharing** design files
- Arduino: The Documentary describes the



# Open Source Hardware



## Example: Arduino

- EAGLE design files for Arduino Uno

The screenshot shows a web browser displaying the Arduino website at <https://www.arduino.cc/en/Main/ArduinoBoardUno>. The page features a navigation bar with links for Buy, Software, Products, Learning, Forum, Support, and Blog. On the left, there's a sidebar with links for Overview, Get Inspired, Related Items, Technical Specs, and Documentation (which is highlighted in light blue). The main content area is titled "Documentation" and contains text about the Arduino Uno being open-source hardware and provides links to download EAGLE files and schematics.

### Documentation

Overview

Get Inspired

Related Items

Technical Specs

Documentation



EAGLE FILES  
IN .ZIP



SCHEMATICS  
IN .PDF





# Open Source Hardware



Publish documentation with an  
Open Source license:

- Creative Commons Share-Alike: **CC-BY-SA**
  - Non-Commercial (NC) clause is NOT acceptable
- Copyleft: **GPLv2, GPLv3**
- Permissive: **Apache, BSD, MIT**
- OSHW inspired: **CERN OHL, TAPR, SolderPad**



# CERN Open Hardware Licence

- Originally written for **CERN** designs hosted in the **Open Hardware Repository**
- Can be used by **any designer** wishing to **share design** information using a **license compliant** with the **OSHW definition criteria**.
- **CERN OHL version 1.2**  
Contains the license itself and a guide to its usage



# CERN Open Hardware Licence

**Myriam Ayass**, legal adviser at CERN and author of the CERN OHL:

- **OHL** is to hardware what **GPL** is to software
- Similar principles to Free or Open Source software
- Anyone should be able to:  
**see the source\***, **study it**, **modify it** and **share it**

*\*the design documentation in case of hardware*



# CERN Open Hardware Licence



- Video interview with [Javier Serrano](#)
- physicist and electronics engineer at CERN
- co-author of the **CERN Open Hardware License**
- creator of the **Open Hardware Repository**



# Open Source Hardware



**Licenses, Copyright and Patents  
can get confusing!**

## Review of Popular OSHW Licenses

Video of Ari Douglas at OHS 2014

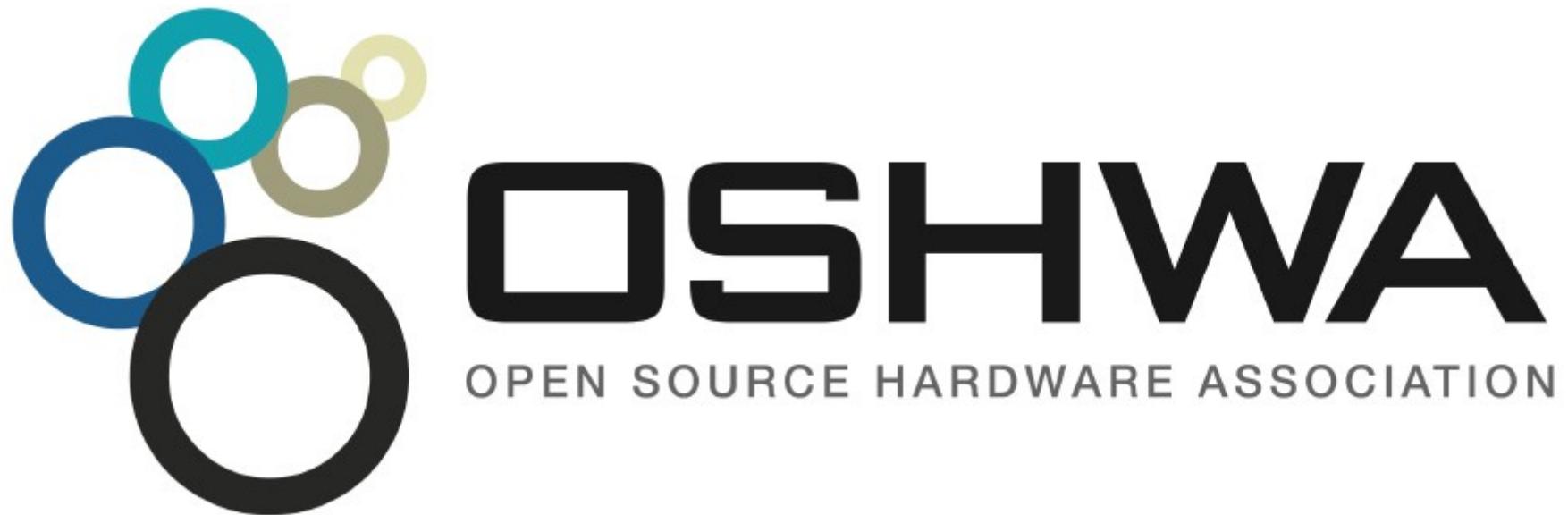


# Open Source Hardware

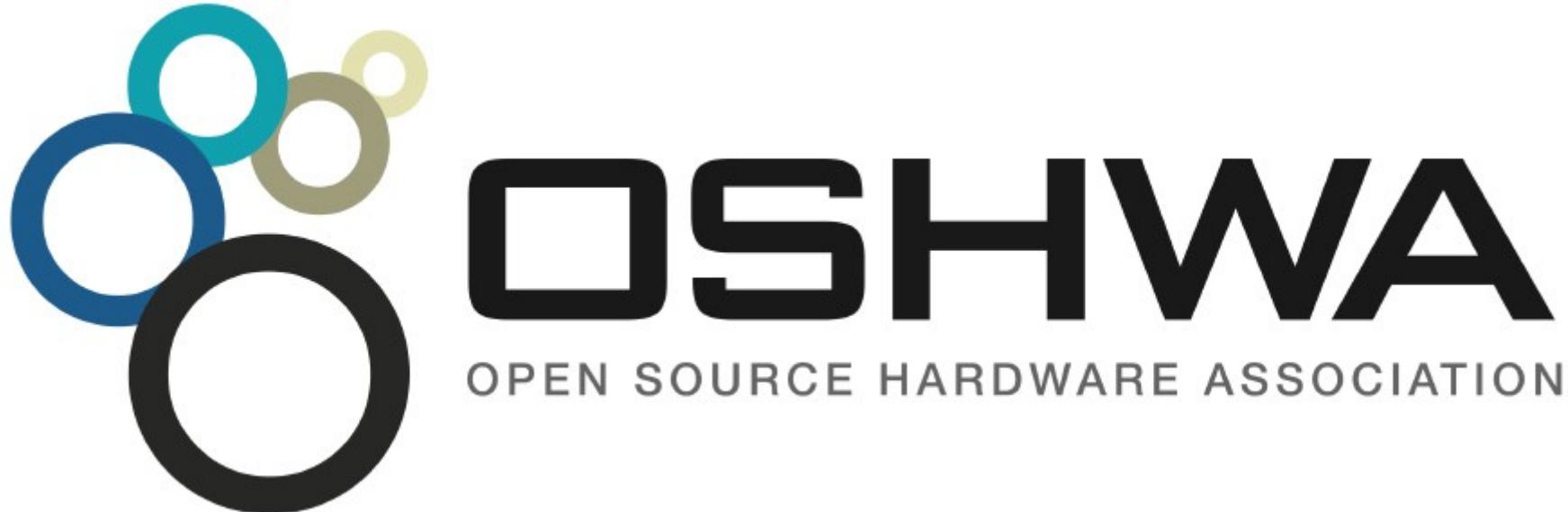


## What is the spirit of Open Source?

- Publish everything that will:  
**enable collaborative development**
- The goal is NOT to just check a box on a marketing flyer or add keywords to a Kickstarter campaign



- US-based 501(c)3 non-profit organization
- Hosts the Open Source Hardware definition
- The Open Source Hardware Association (OSHWA) “aims to be the voice of the open hardware community, ensuring that technological knowledge is accessible to everyone, and encouraging the collaborative development of technology”



- [Best Practices](#)
- [Quick Reference Guide](#)
- [May and Must attributes \(PDF\)](#)

# Open Hardware Summit (OHS)

- OHS 2017: Denver, Colorado, October 5th



- *7 prior summits:*
  - **2010, 2011:** New York Hall of Science
  - **2012:** Eyebeam (*NYC*)
  - **2013:** MIT (*Boston area*)
  - **2014:** Roma, Italia!
  - **2015:** Philadelphia
  - **2016:** Portland, Oregon

# Open Hardware Summit (OHS)

- OHS 2017: Denver, Colorado, October 5th



- Speaker Submissions are open!
- Ada Lovelace Fellowship aims to increase diversity by offering a \$500 travel stipend each for 10 people

# Open Hardware Summit (OHS)

## 2014 videos:

OSHWA's Videos on Vimeo – Iceweasel

Slides | Linu... LinuxCon + ... Donate » Lib... Premier Farn... Linux/includ... Open Sourc... Inbox - Outlook... fustini oshw... OSHW | oli... fustini "oshw... About OSHWA's... +

https://vimeo.com/user14106369/videos/sort:date/format:detail "oshw spirit"

vimeo Join Log in Create Watch On Demand Search videos, people, and more Upload

### OSHWA's Videos

47 Videos 0 Appearances 47 Total

Sort: Date / Alphabetical / Plays / Likes / Comments / Duration

 **Closing Remarks by Simone Cicero and Gabriella Levine** 11:48  
from OSHWA Added 10 months ago | ▶ 30 ❤ 0 💬 0  
+ More details

 **John Dimatos - The Open Source Advantage on Kickstarter (2014 OHS)** 11:45  
from OSHWA Added 10 months ago | ▶ 55 ❤ 0 💬 0  
Session: Implication of Open Source in Business and Culture 2014 Open Hardware Summit <https://twitter.com/ohsummit> <http://www.2014.oshwa.org/> <http://www.oshwa.org/>  
+ More details

 **Tristan Copley Smith - EcoHacking the Future (2014 OHS)** 15:13  
from OSHWA Added 10 months ago | ▶ 362 ❤ 2 💬 0  
Session: Implication of Open Source in Business and Culture 2014 Open Hardware Summit <https://twitter.com/ohsummit> <http://www.2014.oshwa.org/> <http://www.oshwa.org/>  
+ More details

 **Ari Douglas - Review of Popular OSHW Licenses (2014 OHS)** 13:10

#### BROWSE VIDEOS

Here are all of the videos that **OSHWA** has uploaded to Vimeo. Appearances are videos that OSHWA has been credited in by others.

Follow

#### ALSO CHECK OUT

More stuff from OSHWA

47 Videos 1 Like 2 Collections

OSHWA's Videos

# Open Hardware Summit (OHS)

## 2015 videos:



**2015 Summit Late Afternoon Sessions**

4 months ago



**2015 Summit Early Afternoon Sessions**

4 months ago



The Best Open Hardware Summit  
Ever.

**2015 Summit Late Morning Sessions**

4 months ago

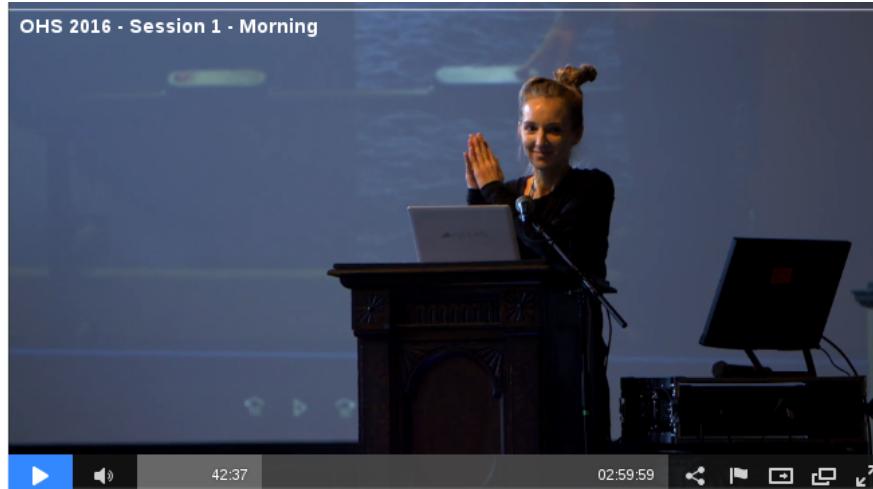


**2015 Summit Early Morning Sessions**

4 months ago

# Open Hardware Summit (OHS)

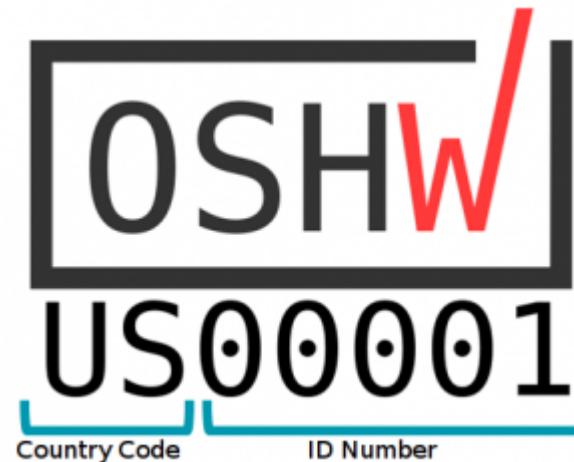
- OHS 2016 morning sessions



- OHS 2016 afternoon sessions

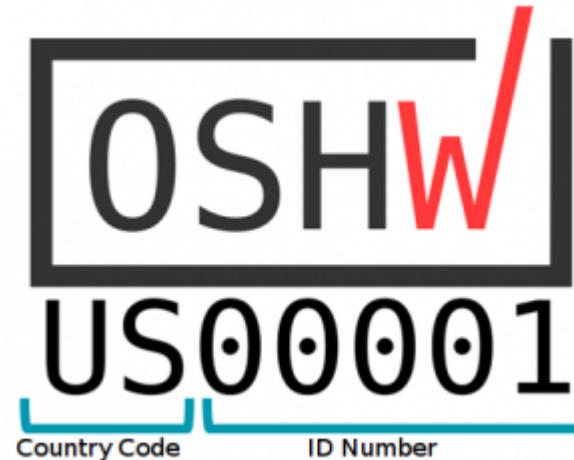


# Open Source Hardware Certification Program



- Announced by OSHWA at Open Hardware Summit in Portland back in October 2016
- Blog post:  
[Announcing the OSHWA Open Source Hardware Certification Program](#)

# Open Source Hardware Certification Program



- Allows hardware that complies with the community definition of Open Source Hardware to display a certified OSHW logo
- Make it easier for users of OSHW to track down documentation and information
- *More information:* [certificate.oshwa.org](http://certificate.oshwa.org)

# Open Hardware Europe Summit 2016



- [Video playlist on YouTube](#)
- [Open Hardware Europe Summit & The DIY 2.0 revolution](#)
  - “The global open hardware community met in Vienna, Austria to give talks about new aspects, new methods and lessons learned for the open hardware movement.”

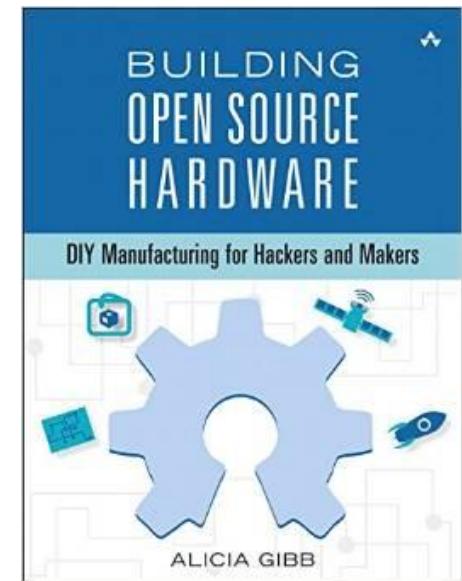


# Open Source Hardware



## Resources

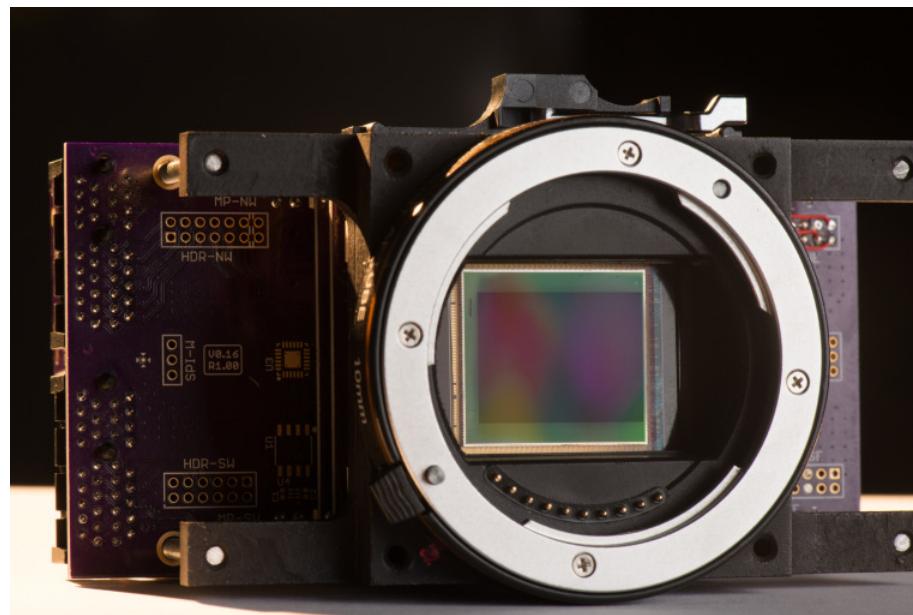
- Join OSHWA
- Subscribe to the mailing list
- Post in the OSHWA Forum
- Follow on Twitter:
  - [@OHSummit](#)
  - [@oshwassociation](#)
- [Building Open Source Hardware](#)  
by Alicia Gibb (*executive director of OSHWA*)



*Section:*  
OSHW PRODUCTS



- “The goal of the global community-driven **apertus° project** is to create a variety of powerful, affordable, free (in terms of liberty), sustainable and open digital cinema tools that we as filmmakers love to use”





- “The AXIOM product line is the result of this ongoing endeavor and after successful crowd funding and receiving an EU Innovation grant is well on track to redefine the industry well beyond the DIY garages and hobbyist labs the project started in”

A X I O M  
Beta



# Lulzbot 3-D Printers

100% Open Source  
Hardware & Software



- FSF Respects Your Freedom certified



# RepRap 3-D Printers



- RepRap project started as an academic initiative to develop a low-cost 3D printer that can print most of its own components
- Giving Manufacturing a New Life  
by Adrian Bowyer
- Prusa i3 M2 RepRap designed and manufactured by Josef Prusa in Czech Republic



# Novena laptop

- Created by **Bunnie & xobs**
  - Chumby! Hacking the X-Box! Amazing reverse engineers
  - *The Exploration and Exploitation of an SD Memory Card*
- **100% Open Source Hardware** laptop
- **Quad-core 1.2GHz Freescale ARM CPU**
- **FPGA!** 4GB RAM, WiFi, 2x Ethernet, SSD



*Section:*  
LINUX on OSHW



- ARM Linux on Open Source Hardware
- Developed by [BeagleBoard.org Foundation](#) and [BeagleBoard.org Community](#)
- Manufacturers: [element14](#), [GHI](#), [Seeed](#)





# BeagleBone Black Wireless



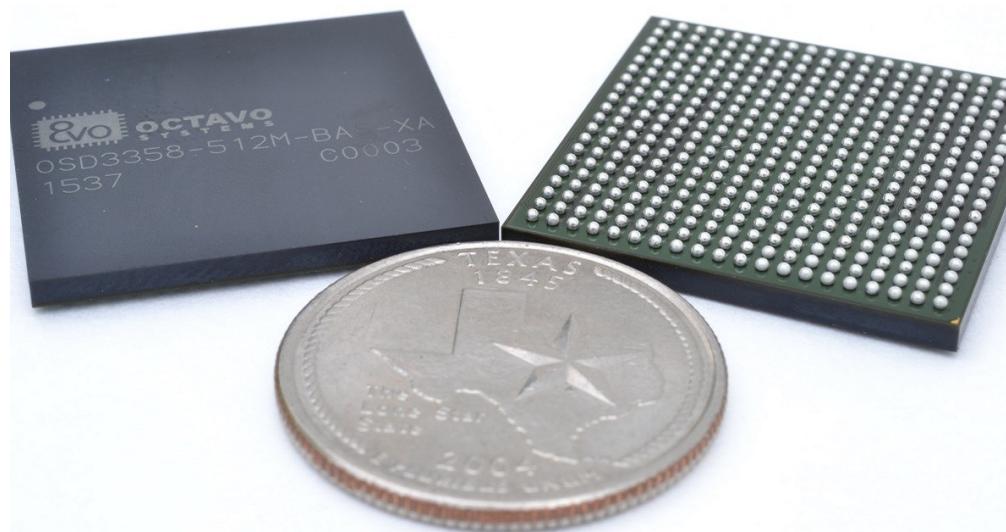
- 1 GHz ARM processor, 512 MB RAM
- 2x 32-bit PRU microcontroller for hard real-time
- 4GB eMMC with Debian GNU/Linux installed
- WiFi 802.11 b/g/n, Bluetooth 4.1 with BLE
- HDMI / USB / 65 GPIO pins / 8 PWM outputs
- 7 analog inputs / 4x UART / 2x I<sup>2</sup>C / 2x SPI



# BeagleBone Black Wireless



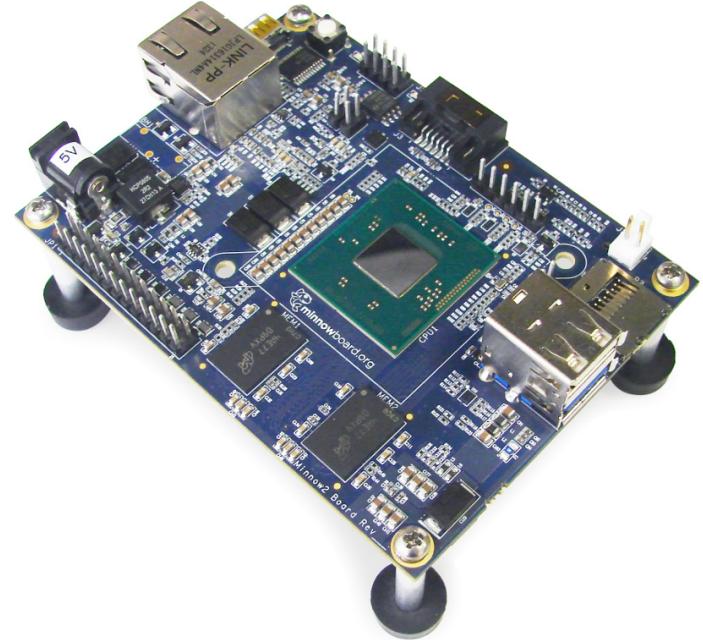
- CadSoft EAGLE design files hosted on GitHub
- Bill of Materials: every part available in qty 1
- Octavo System-in-Package (SiP) large pitch BGA simplifies PCB layout and assembly





# MinnowBoard

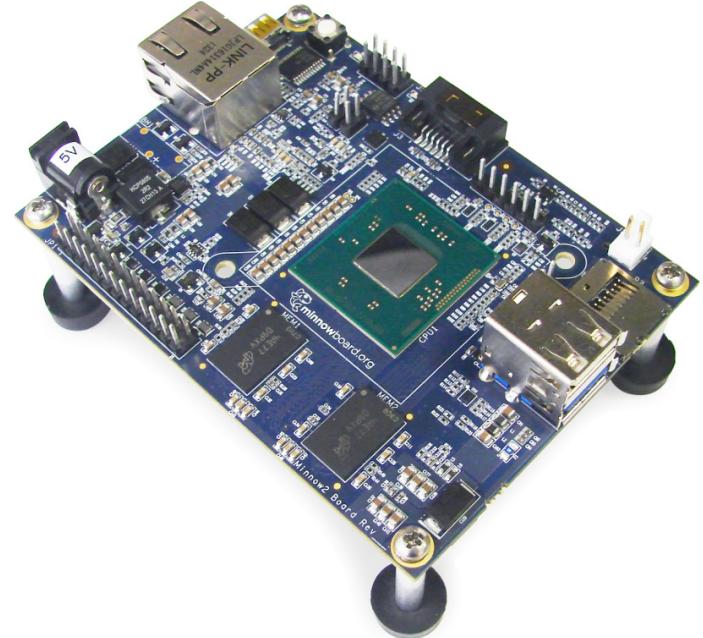
- 64-bit Intel Atom “*Bay Trail*”
- MinnowBoard Turbot
  - \$135: E3826 (dual-core, 1.46 GHz)
- USB 3.0, SATA, PCIe, Gigabit Ethernet, HDMI
- Integrated Intel HD Graphics
  - Open Source Mainline Linux drivers!





# MinnowBoard

- Manufactured by [ADI](#)
- Released under Creative Commons **CC-BY-SA**
- Download:
  - [x] **Schematic** (Orcad DSN & PDF)
  - [x] **Board Layout** (Allegro BRD & Gerbers)
  - [x] **Bill of Materials**





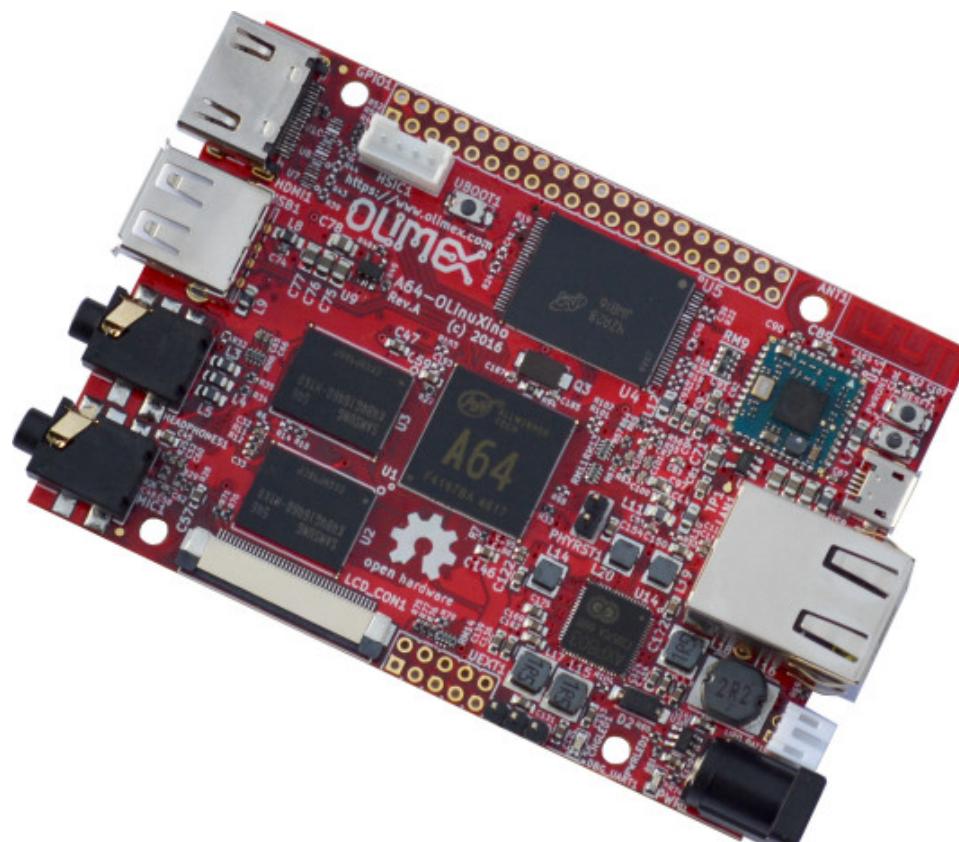
# OLinuXino



- Low cost OSHW Linux computers
- Designed and manufactured by **Olimex** in **Bulgaria**
- [Blog post:](#)  
“Open Source Hardware, why it matters and what is pseudo OSHW”

# A64-OlinuXino

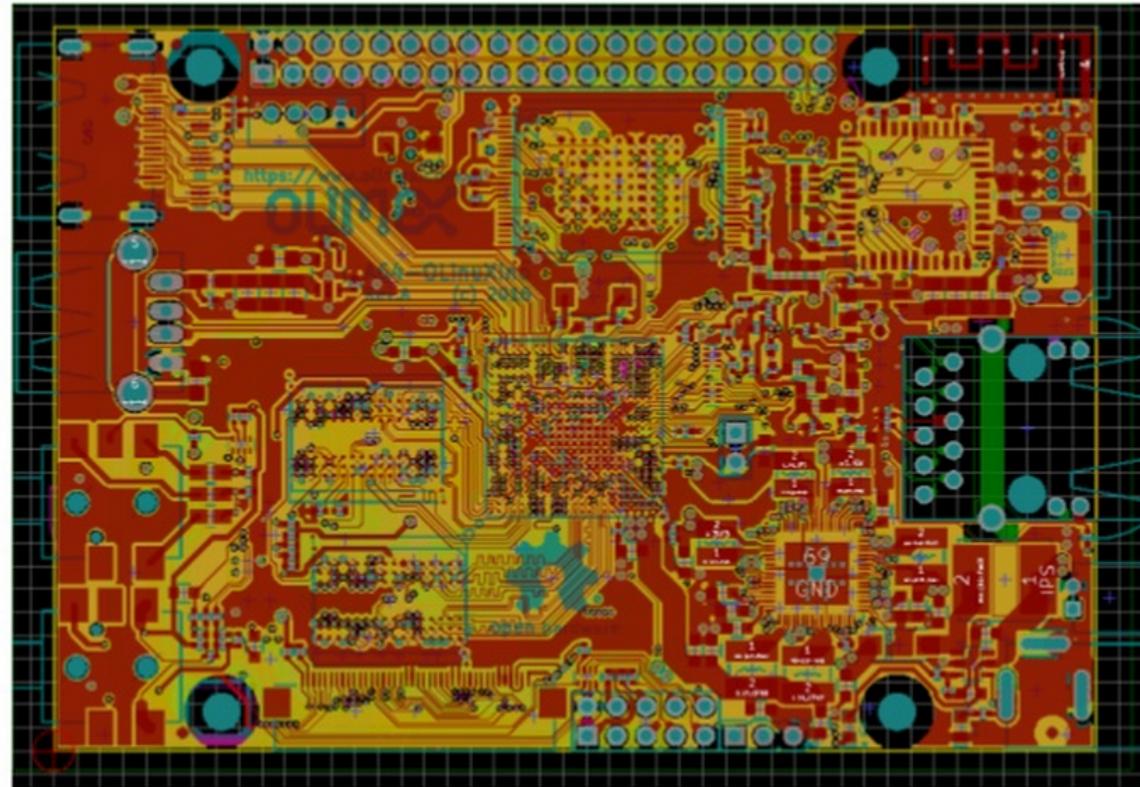
- Allwinner A64: Quad Core **64-bit ARM**
- Designed with Open Source **KiCad**
- 1GB RAM, 4GB eMMC, WiFi+BLE4.0





Using FOSS tools for OSHW project

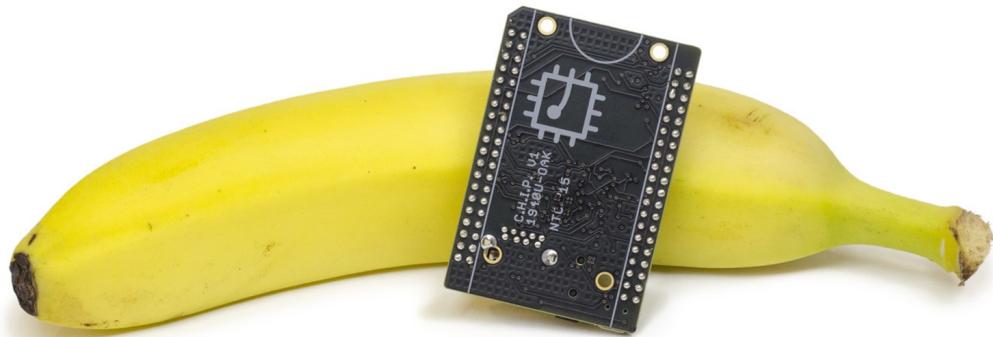
## Designing with KiCAD of 64-bit ARM board



Tsvetan Usunov, OLIMEX Ltd

FOSDEM 2016

# CHIP



*The World's First \$9 Computer*

- [getchip.com](http://getchip.com)
- Next Thing Co. in Oakland
- Kickstarter in 2015:
  - 39,560 backers
  - \$2,071,927 pledged





**1GHz**  
processor



ram



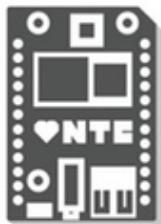
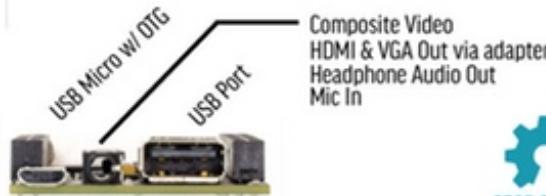
storage

60mm/2.3"

40mm/1.5"



1GHZ Allwinner A13 Compatible SoC  
Mali400 GPU w/ OpenGL ES 2.0 & OpenVG 1.1  
512MB DDR3 Ram  
4GB NAND Flash Storage



C.H.I.P. is built with Making in Mind

Realtek 2-in-1 Bluetooth 4.0 + WIFI B/G/N  
I2C + SPI + UART + 8 x GPIO  
Camera Sensor Support (MIPI-CSI)  
Native LCD Support 4.3-8"  
Battery Power & Charging



Fast Boot Debian Based Linux OS  
Over The Air Updates  
OpenGL ES 2.0  
OpenVG 1.1



**WIFI** & **Bluetooth**  
802.11B/G/N  
4.0

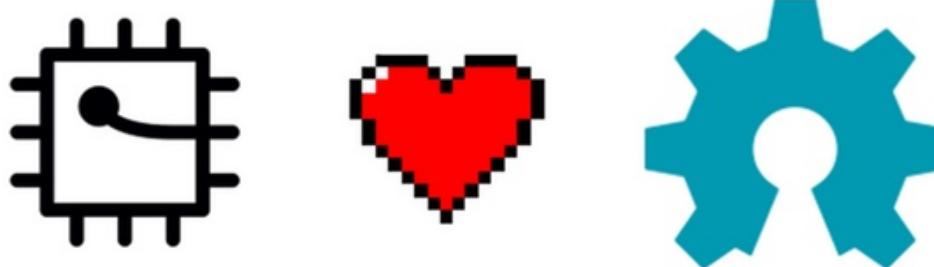


*Battery Power  
& Charging  
Built In!*



*Run C.H.I.P. for  
Hours with a  
Single Cell LiPo.*

# C.H.I.P. is OSHW



- **GitHub:** [NextThingCo/CHIP-Hardware](#)
  - Schematics
  - PCB Layout
  - Bill of Materials (*BoM*)
- **License:**
  - Creative Commons Attribution-ShareAlike (CC-BY-SA)

# *Section:* OSHW in Science

*Suggestions from the OSHWA mailing list*

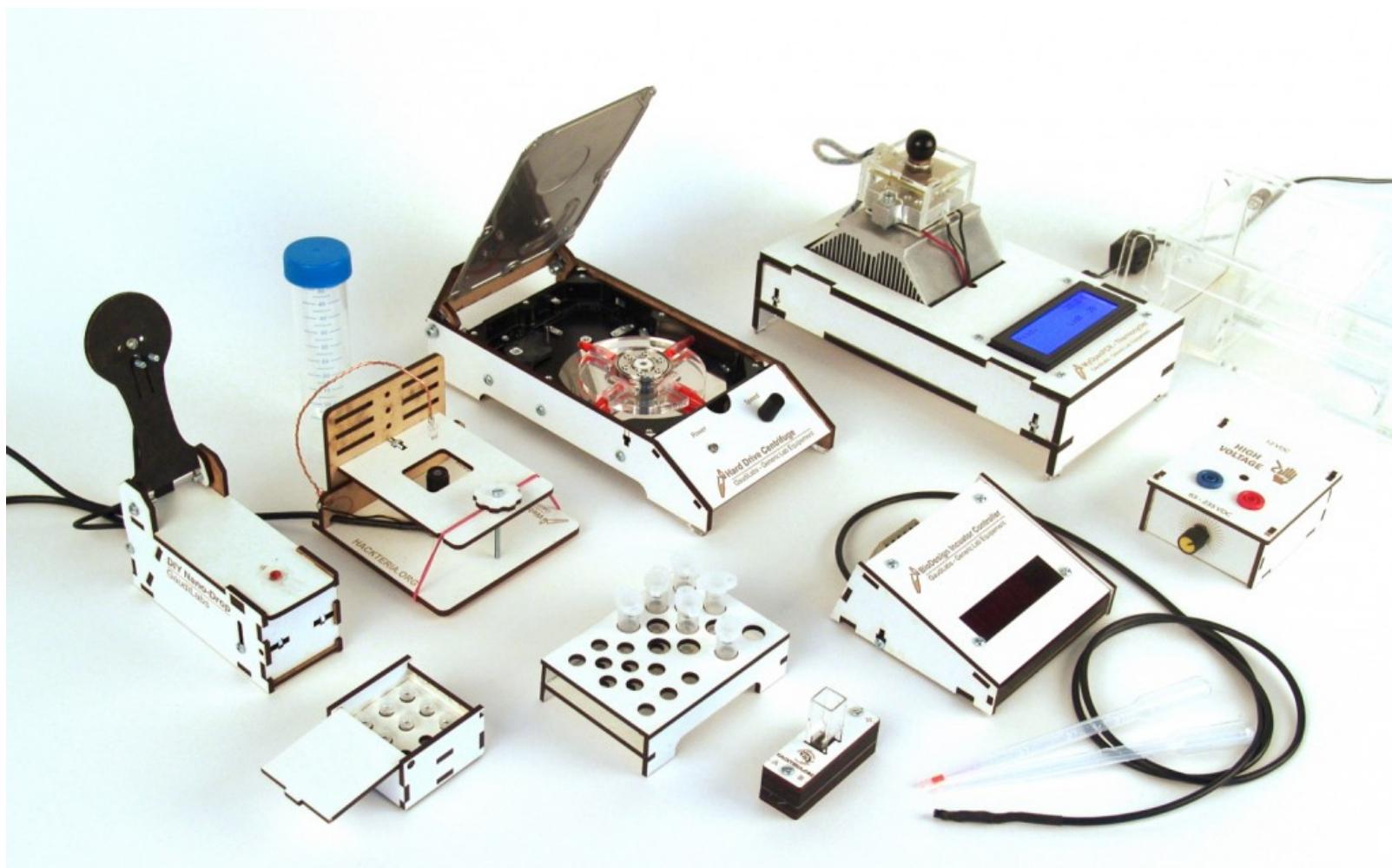
# Public Lab

- “Using inexpensive DIY techniques, we seek to change how people see the world in environmental, social, and political terms.”
- Office in Portland!
- Riffle: Open Source Water Monitoring
- Desktop Spectrometry
- Balloon Mapping Kit



# Generic Lab Equipment

- GaudiLabs in Lucern, Switzerland
  - part of the [hackteria.org](http://hackteria.org) open source biology art network

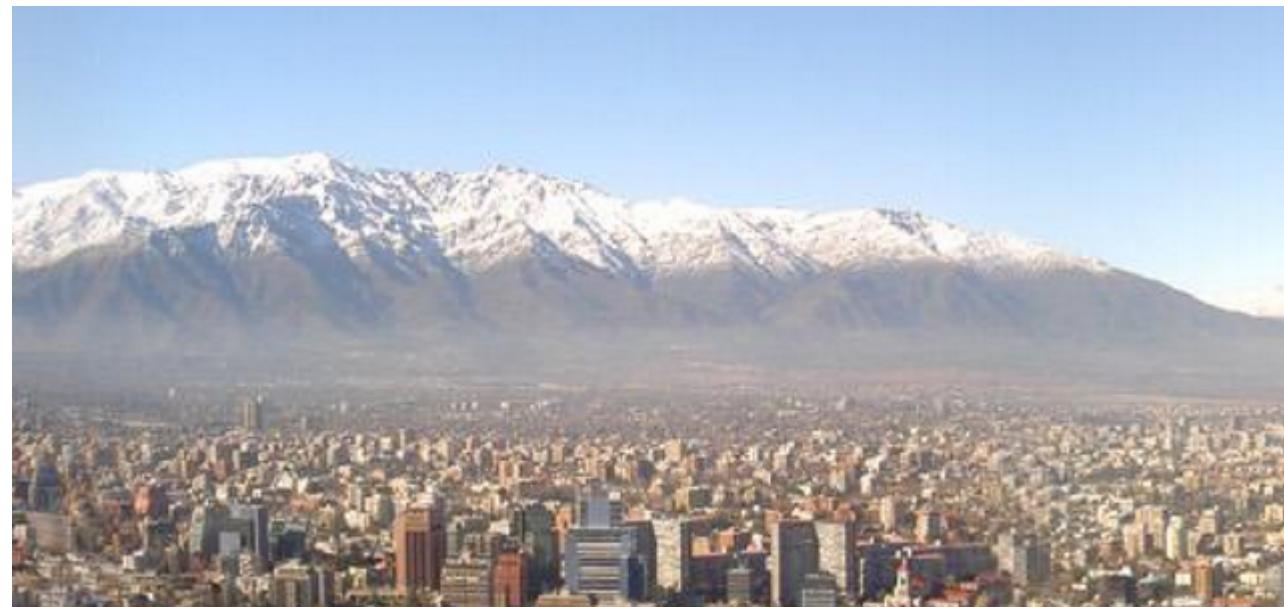


# Generic Lab Equipment

- WebCam Microscope
- Hard Drive Centrifuge
- Incubator Controller
- Gel Box and High Voltage Supply
- Turbidity Meter Kit
- DIY Microvolume Spectrometer
- My Open PCR
- Tube Racks

# GOSH 2017

- Gathering for Open Science Hardware
- Santiago, Chile. March 22-25, 2017.
- “growing number of people around world are developing and using Open Science Hardware, and we want to help build self-organising community to drive change in open science”

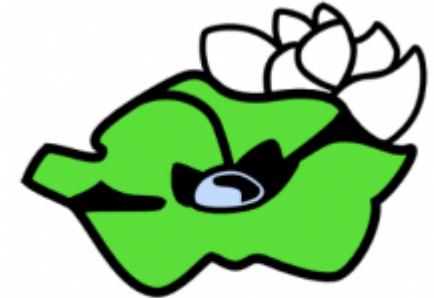


# OpenTrons

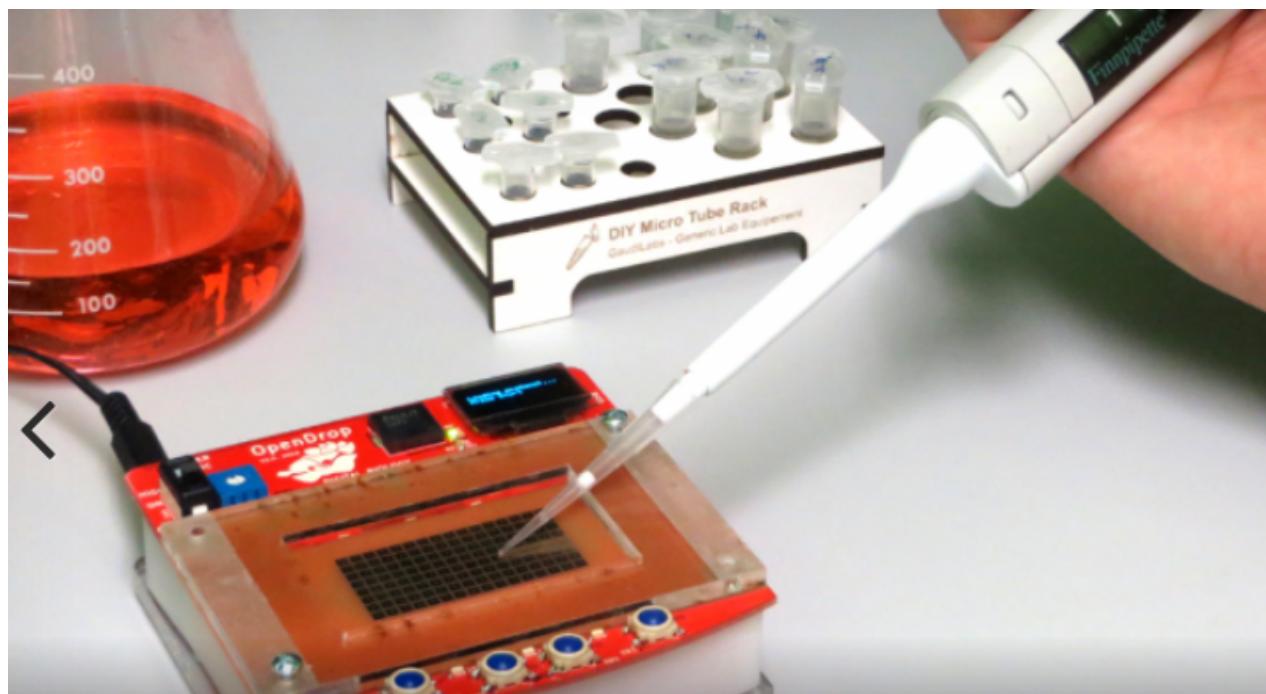
- **Robots for Biologists**
- “We think biologists should have robots to do **pipetting** for them.”
- “They should be able to spend their time designing experiments and analyzing data.”



# OpenDrop



- “Desktop Digital Biology Laboratory” **OpenDrop**
- digital microfluidics platform for research
- part of a bigger ecosystem around digital biology with the aim of making personal lab-automation accessible to more people



# OpenPCR

- PCR is a method of copying DNA molecules.
- OpenPCR is a project to develop open source hardware, software, and protocols to perform PCR and Real-Time PCR reactions
- community dedicated to openness in science and applying the fundamental technologies of PCR to global problems



# Open Source Imaging (MRI)

- Open Source Magnetic Resonance Imaging
- [Opencore NMR](#) is an open-source toolkit for implementing an NMR spectrometer
- [LukasW log](#): “COSI Magnet: Single ring results look fantastic! Less than 2% difference to simulation”



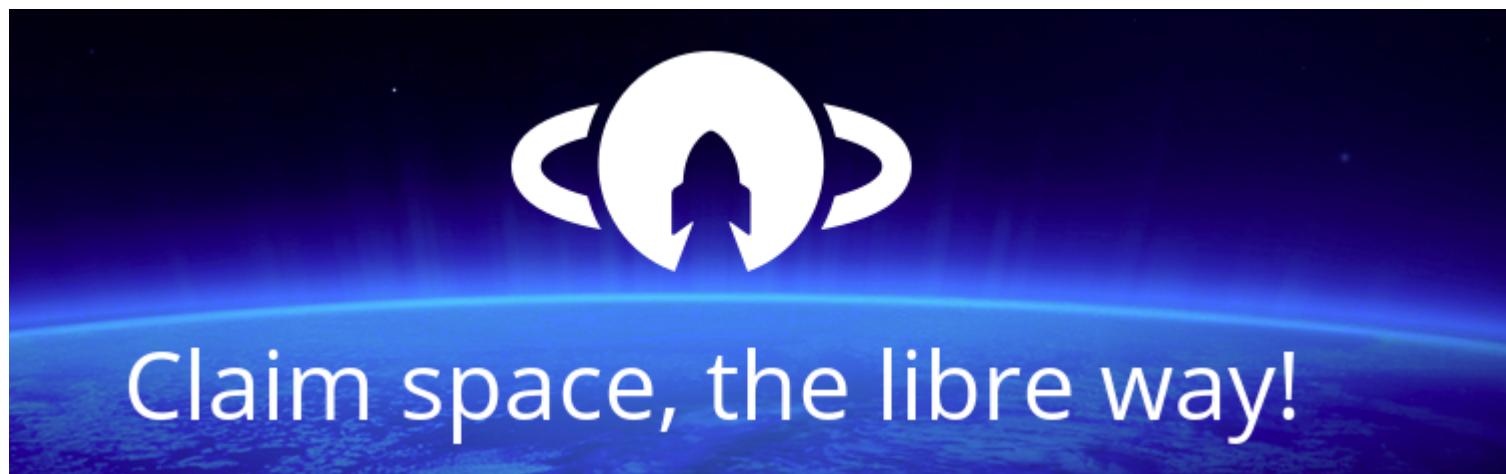
# MOST research group

- Joshua Pearce Research Group at Michigan Tech in Open Sustainability Technology (*MOST*) focuses on open and applied sustainability
- Exploring the way solar photovoltaic technology can sustainably power our society



# Libre Space Foundation

- Non-profit for Open Source HW & SW in Space
- UPSat: first open hardware satellite bound to be launched to the International Space Station in late December
- SatNOGS: open source hardware satellite ground-station network



*Section:*  
Open Source Silicon

# *What about silicon?*



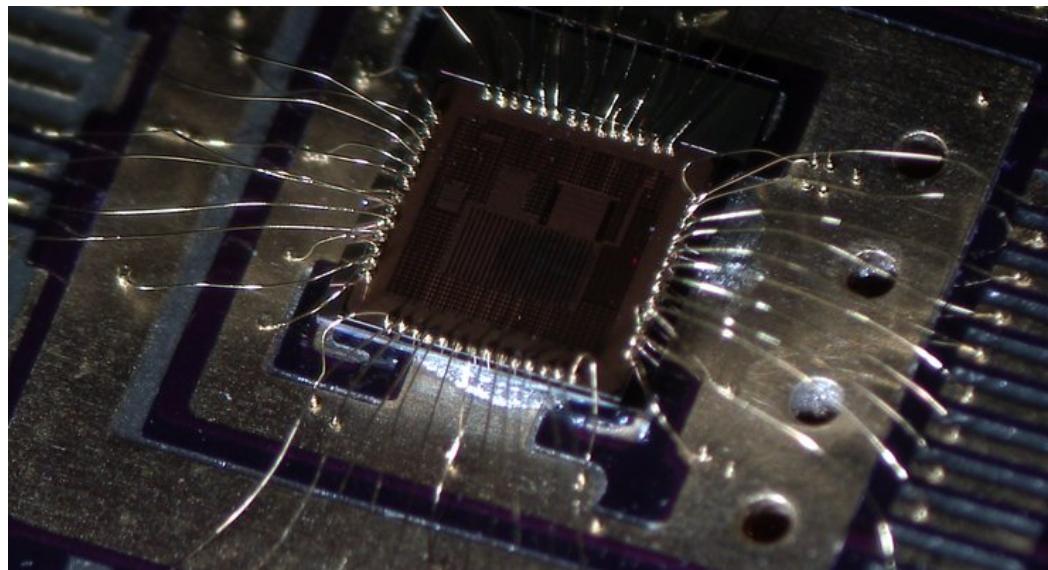
- **RISC-V: Free & Open RISC Instruction Set Arch**
  - “new instruction set architecture (ISA) that was originally designed to support computer architecture research and education and is now set to become a standard open architecture for industry”
  - Video:  
[Instruction Sets Want To Be Free: A Case for RISC-V](#)

# *What about silicon?*

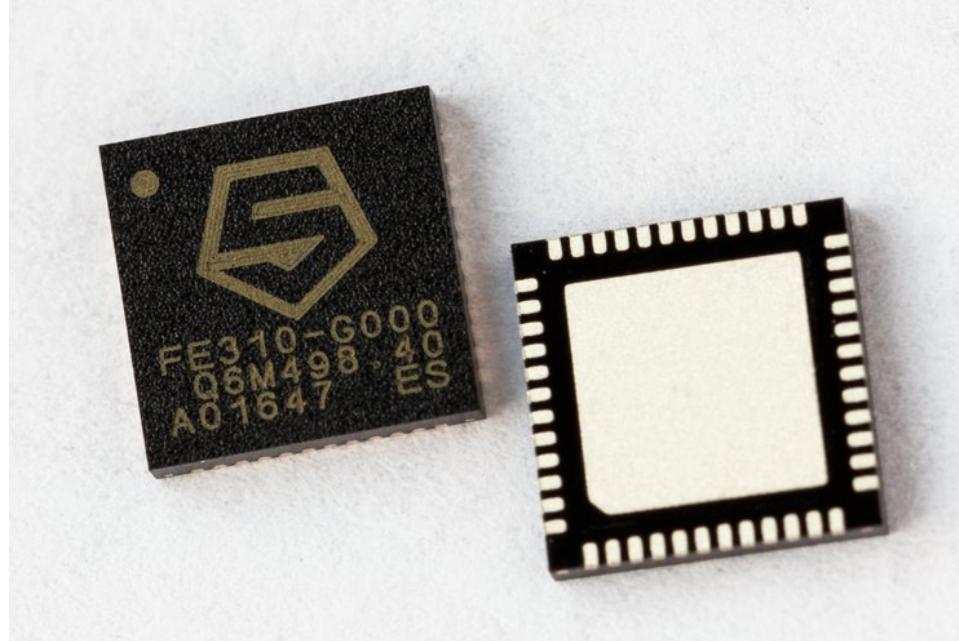


- OnChip Open-V

“completely free (as in freedom) and open source 32-bit microcontroller based on the RISC-V architecture”



# *What about silicon?*

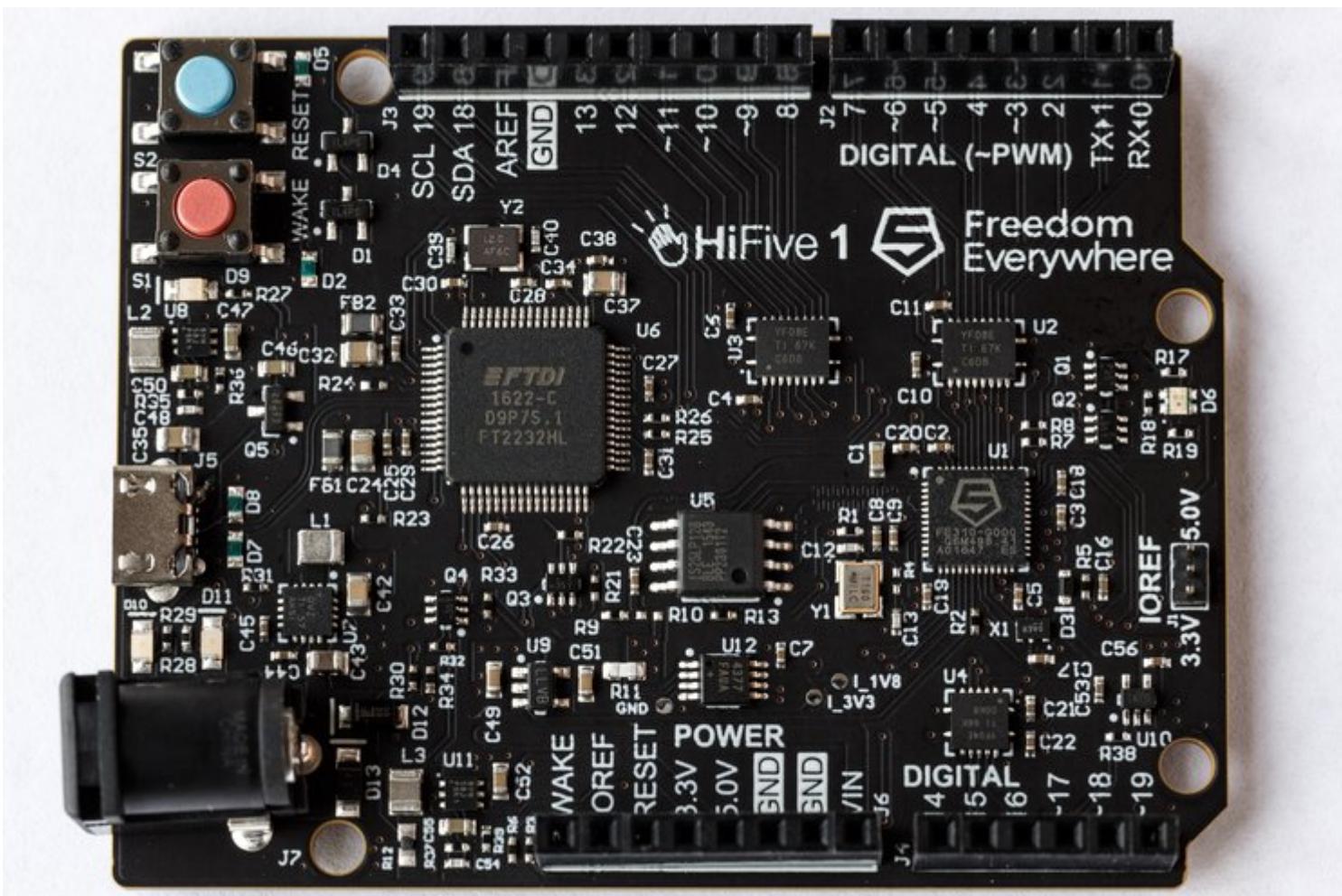


- [SiFive](#)

“founded by the creators of the free and open RISC-V architecture as a reaction to the end of conventional transistor scaling and escalating chip design costs”

# *What about silicon?*

- [HiFive1](#): Arduino-Compatible RISC-V Dev Kit



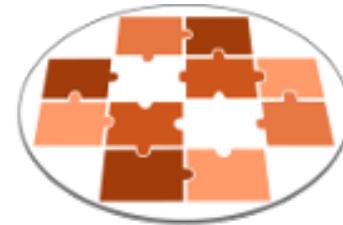
# *What about silicon?*



- LowRISC

“creating a fully open-sourced, Linux-capable, RISC-V-based SoC, that can be used either directly or as the basis for a custom design. We aim to complete our SoC design this year”

# *What about silicon?*



**FOSSi**  
Foundation

- **FOSSi Foundation**

- The Free and Open Source Silicon Foundation
- “non-profit foundation with the mission to promote and assist free and open digital hardware designs and their related ecosystems. FOSSi Foundation operates as an open, inclusive, vendor-independent group.”

# Thanks

- Suggestions from the [OSHWA mailing list](#):
  - Abram Connelly
  - Andrew Plumb
  - Andrew Quitmeyer
  - Eleftherios Kosmas
  - Marcin Jakubowski

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- twitter: [@OSHPark / @pdp7](https://twitter.com/@OSHPark)
- [OSH Park Blog](https://oshpark.com/blog)