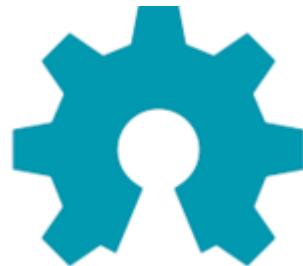
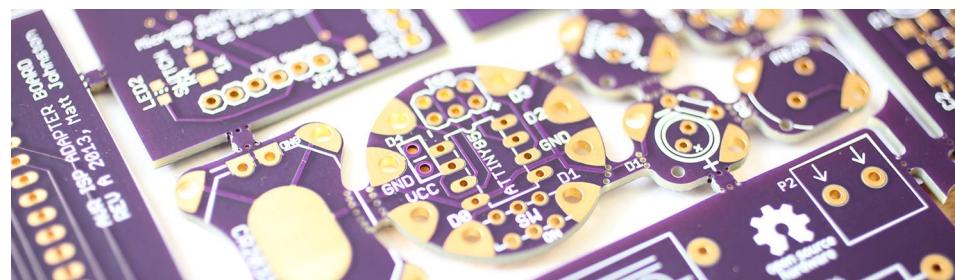


Introduction to Open Source Hardware



Drew Fustini
OSH Park
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

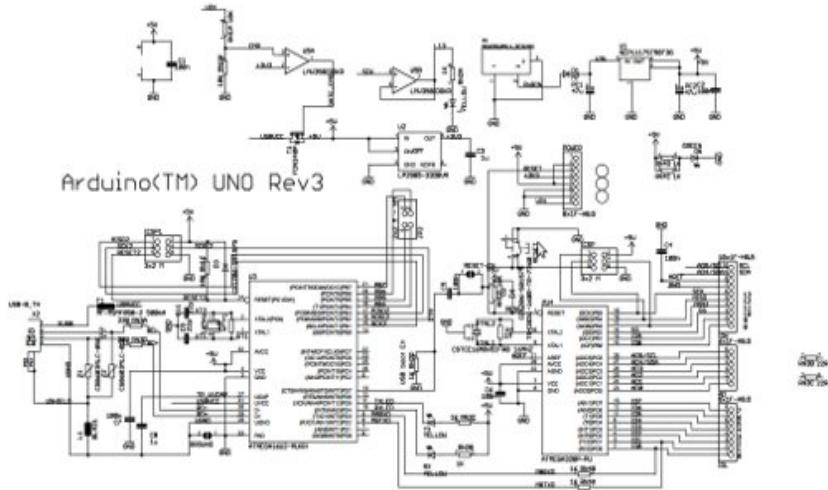


Open Source Hardware

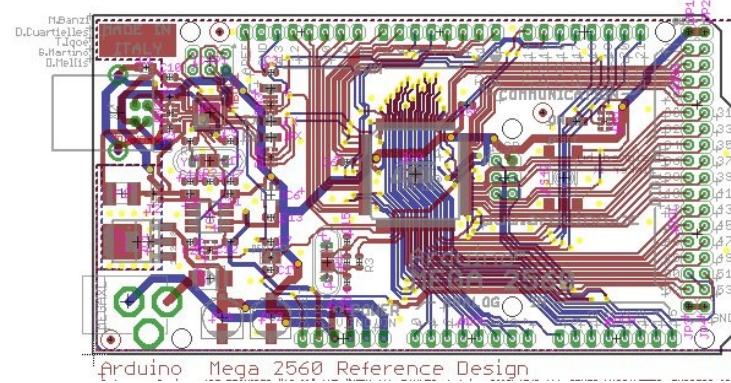


Documentation required for electronics:

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

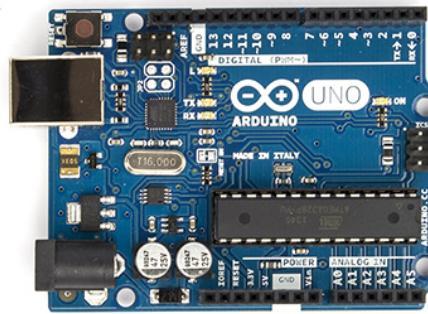


Example: Arduino



The screenshot shows the official Arduino website. At the top left is the Arduino logo (infinity symbol). At the top right is a search bar with the placeholder "Search the Arduino Website". Below the header is a navigation bar with links: Home, Buy, Download, Products, Learning, Forum, Support, Blog, LOG IN, and SIGN UP.

Arduino Uno



- Achieved **critical mass** by **sharing** design files
- [Arduino: The Documentary](#) describes the motivation



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). 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

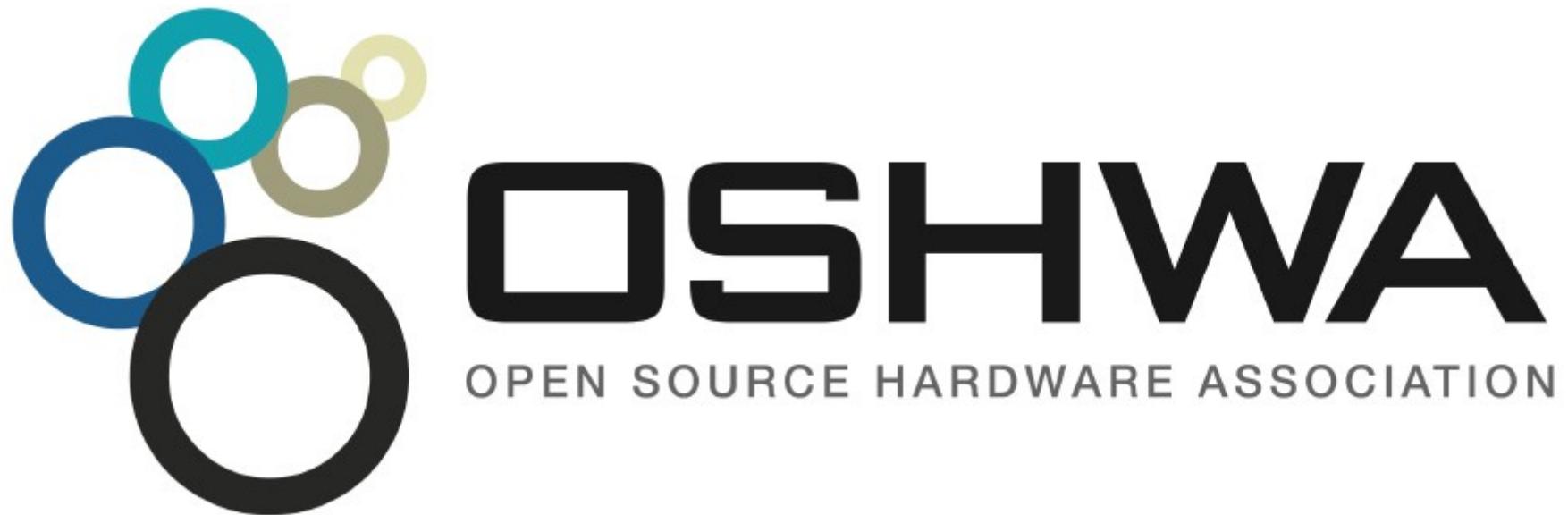


Open Source Hardware

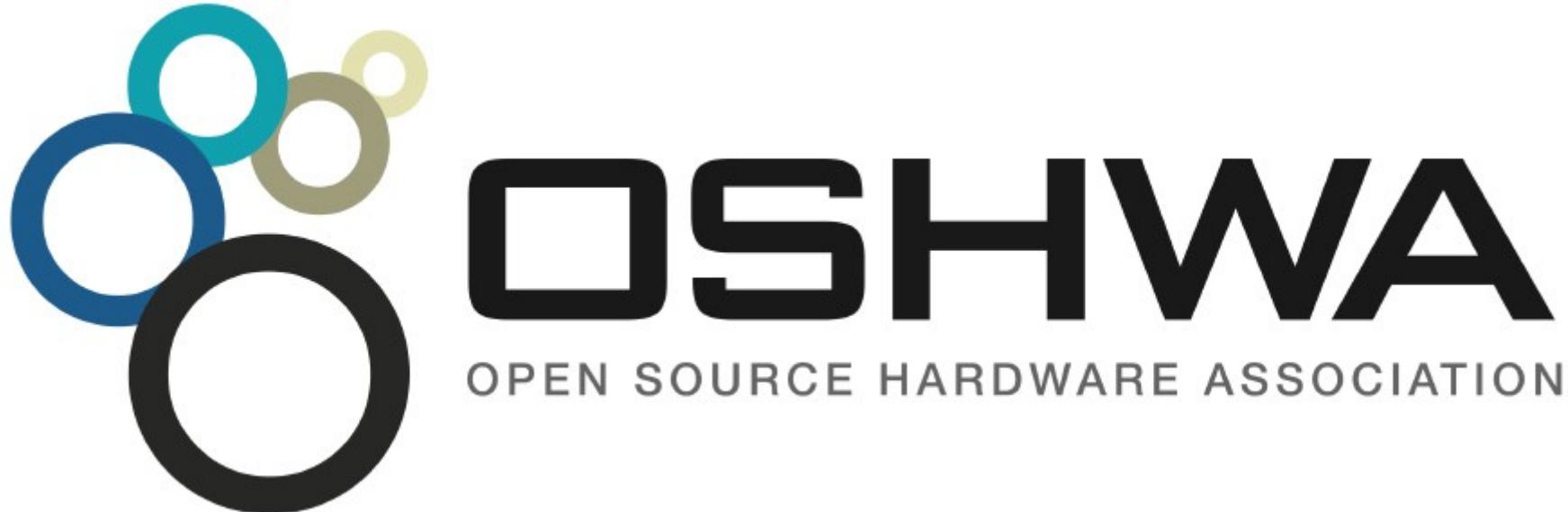


What is the spirit of Open Source?

- 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 Sour... 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

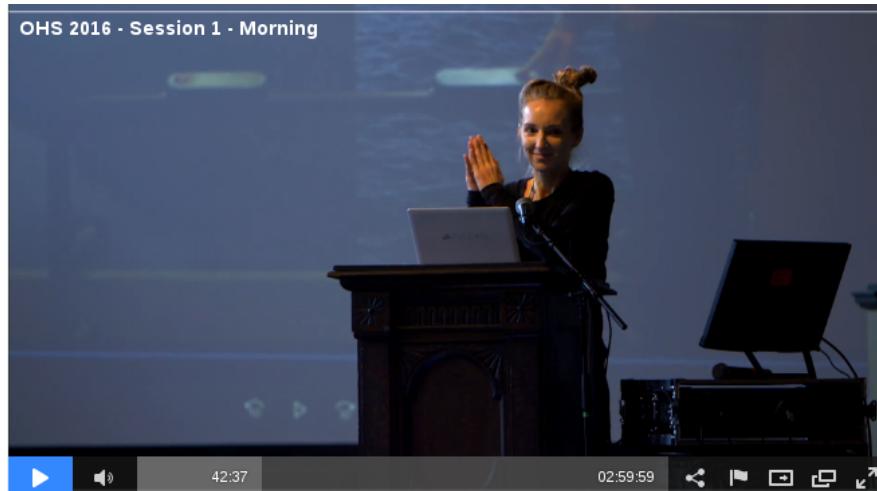


2015 Summit Early Morning Sessions

4 months ago

Open Hardware Summit (OHS)

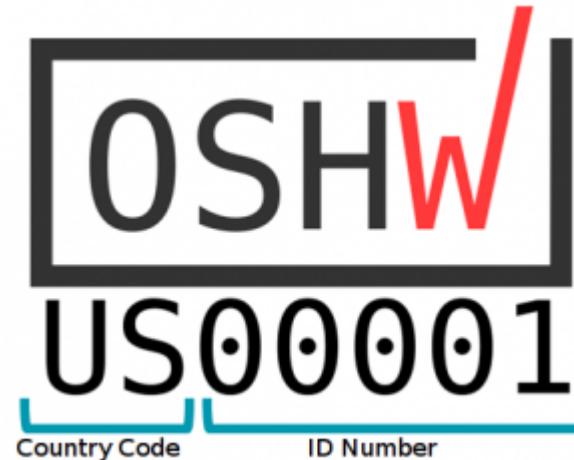
- OHS 2016 morning sessions



- OHS 2016 afternoon sessions

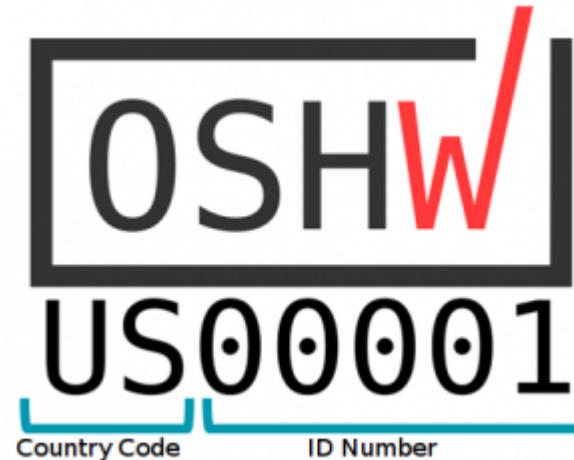


Open Source Hardware Certification Program



- 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

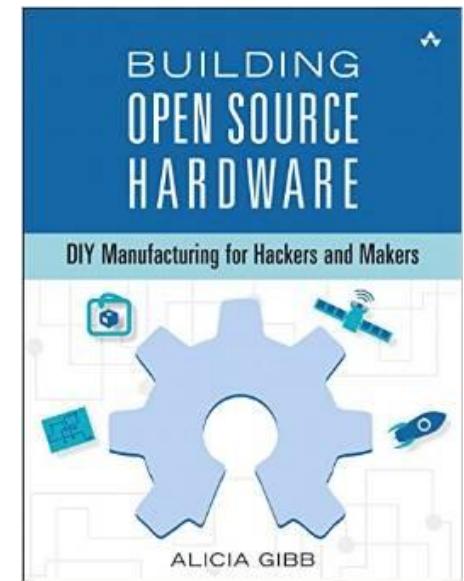


Open Source Hardware



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:
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



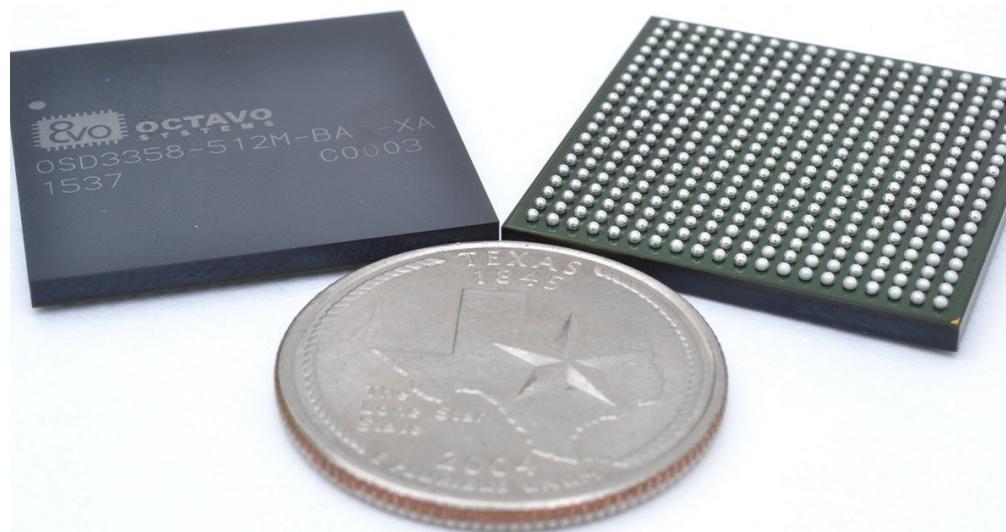
- 1 GHz ARM processor, 512 MB RAM
- 2x 32-bit PRU microcontroller for hard real-time
- 4GB eMMC with Debian GNU/Linux installed
- WiFi 802.11 b/g/n, Bluetooth 4.1 with BLE
- HDMI / USB / 65 GPIO pins / 8 PWM outputs
- 7 analog inputs / 4x UART / 2x I²C / 2x SPI



BeagleBone Black Wireless



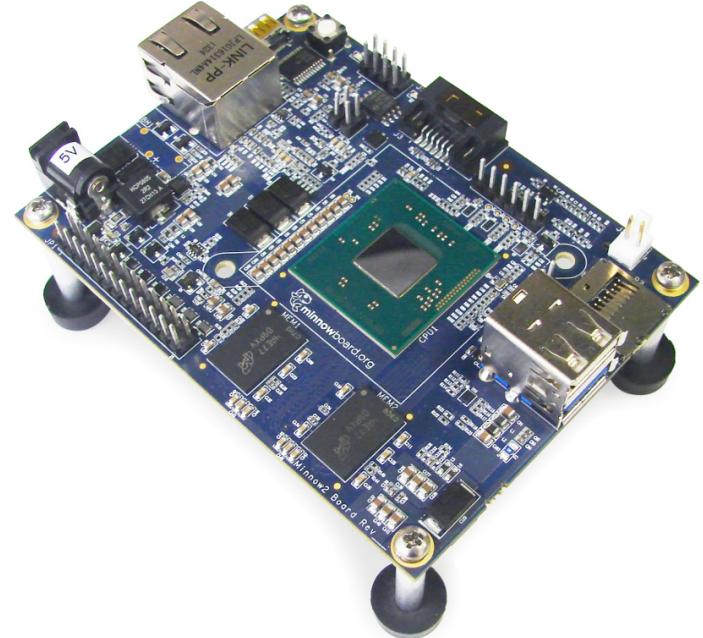
- CadSoft EAGLE design files hosted on GitHub
- Bill of Materials: every part available in qty 1
- Octavo System-in-Package (SiP) large pitch BGA simplifies PCB layout and assembly





MinnowBoard

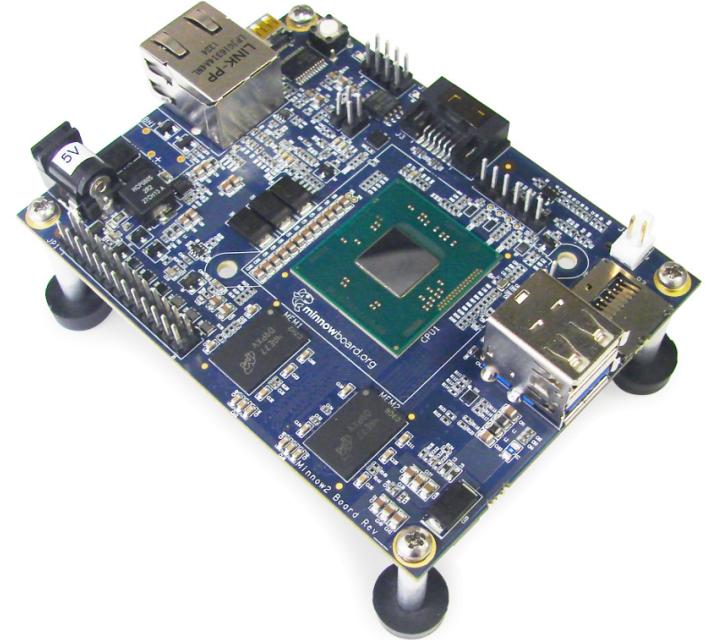
- 64-bit Intel Atom “*Bay Trail*”
- MinnowBoard Turbot
 - \$135: E3826 (dual-core, 1.46 GHz)
- USB 3.0, SATA, PCIe, Gigabit Ethernet, HDMI
- Integrated Intel HD Graphics
 - Open Source Mainline Linux drivers!





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**





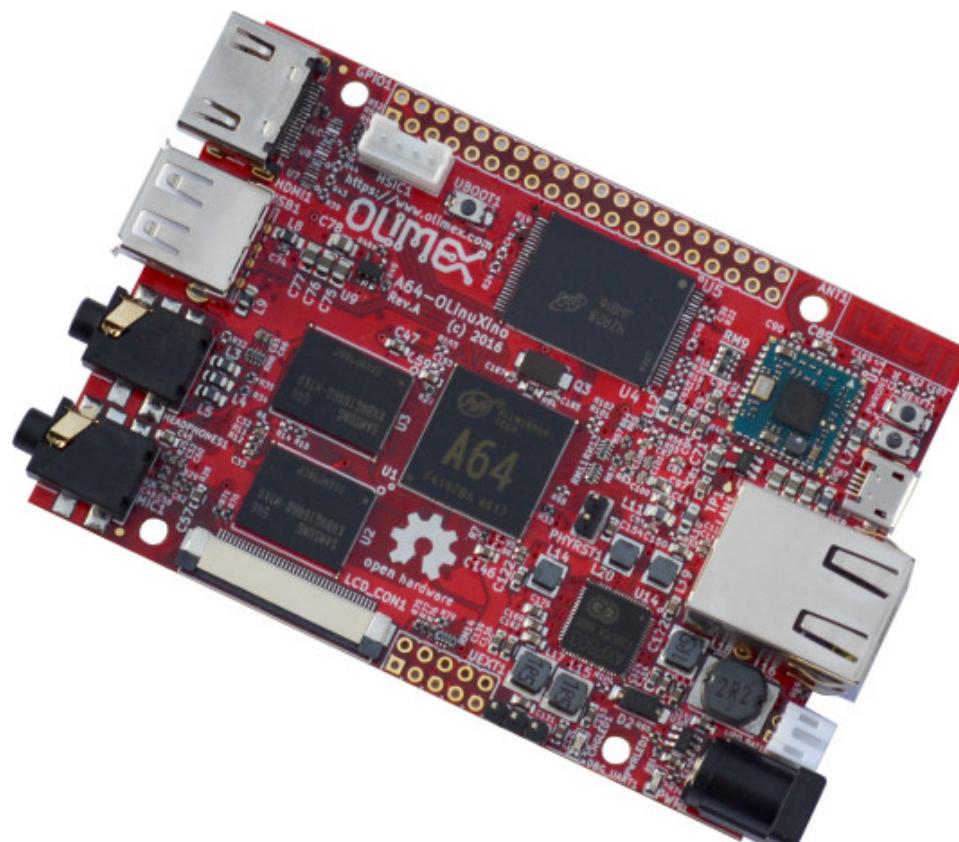
OLinuXino



- 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

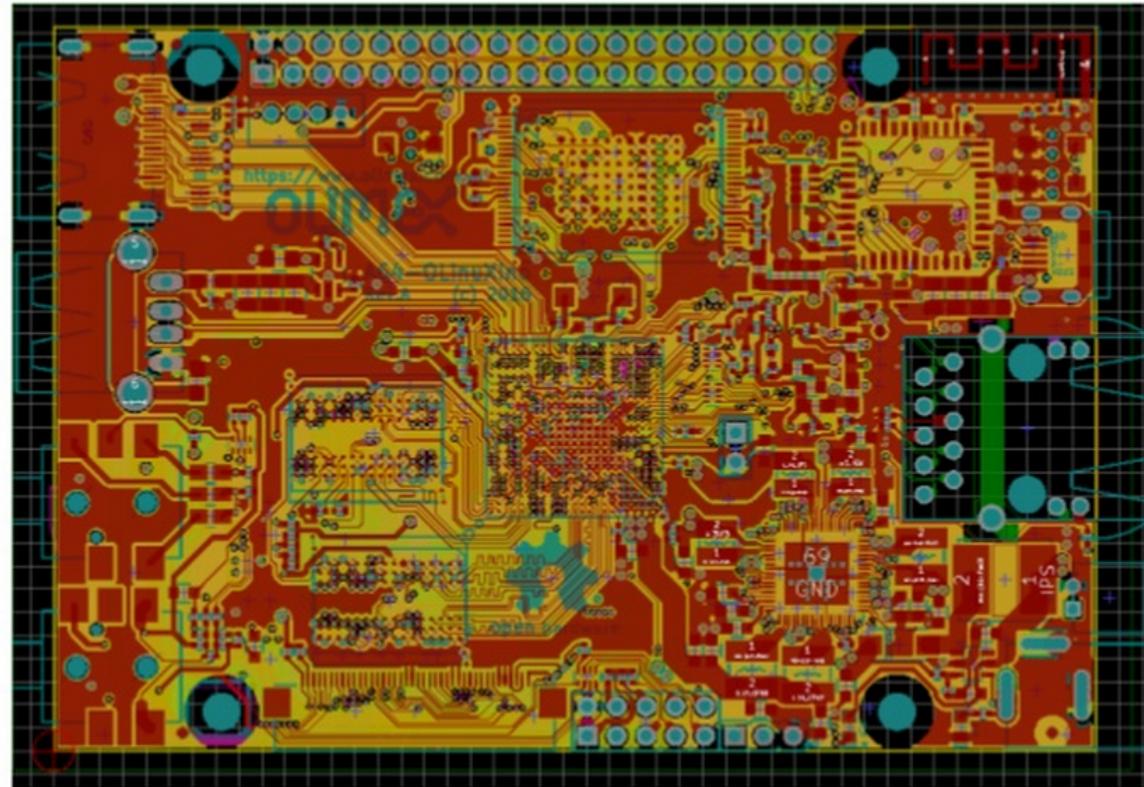
- Allwinner A64: Quad Core **64-bit ARM**
- Designed with Open Source **KiCad**
- 1GB RAM, 4GB eMMC, WiFi+BLE4.0





Using FOSS tools for OSHW project

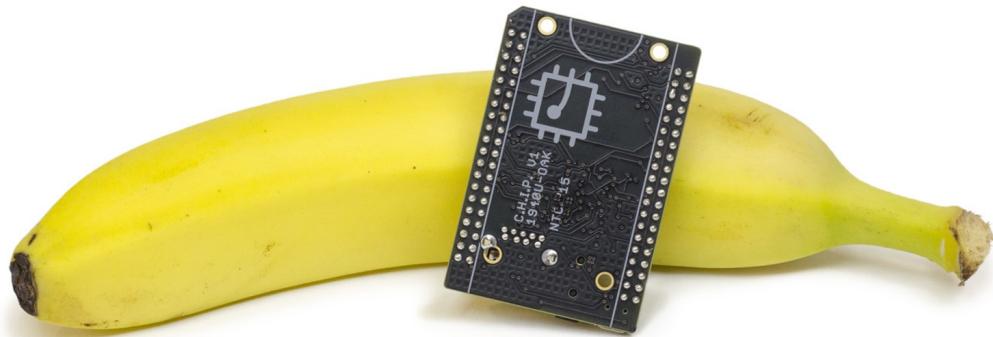
Designing with KiCAD of 64-bit ARM board



Tsvetan Usunov, OLIMEX Ltd

FOSDEM 2016

CHIP



The World's First \$9 Computer

- getchip.com
- Next Thing Co. in Oakland
- Kickstarter in 2015:
 - 39,560 backers
 - \$2,071,927 pledged





1GHz
processor



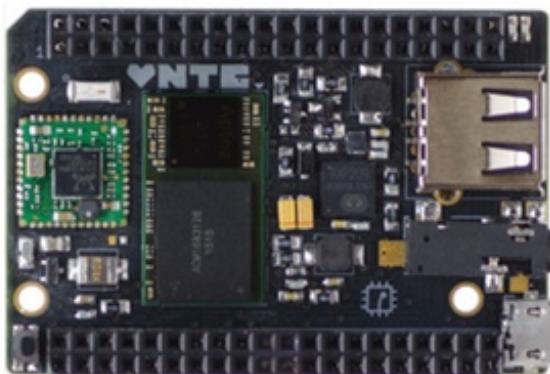
ram



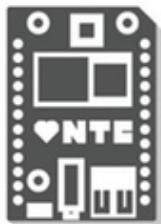
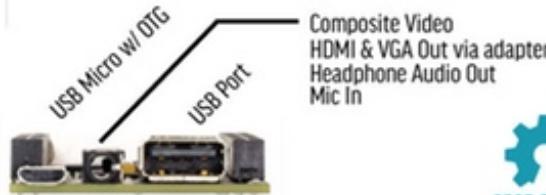
storage

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

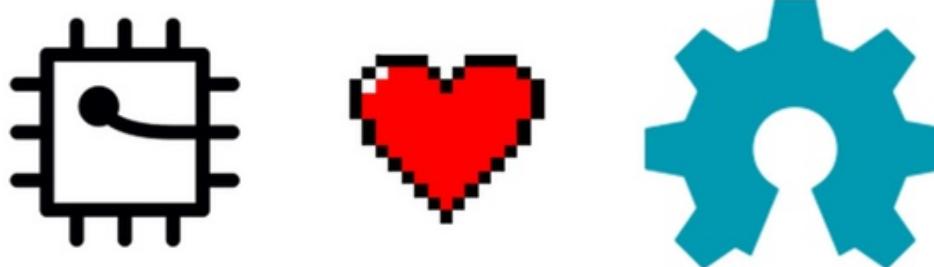


*Battery Power
& Charging
Built In!*



*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

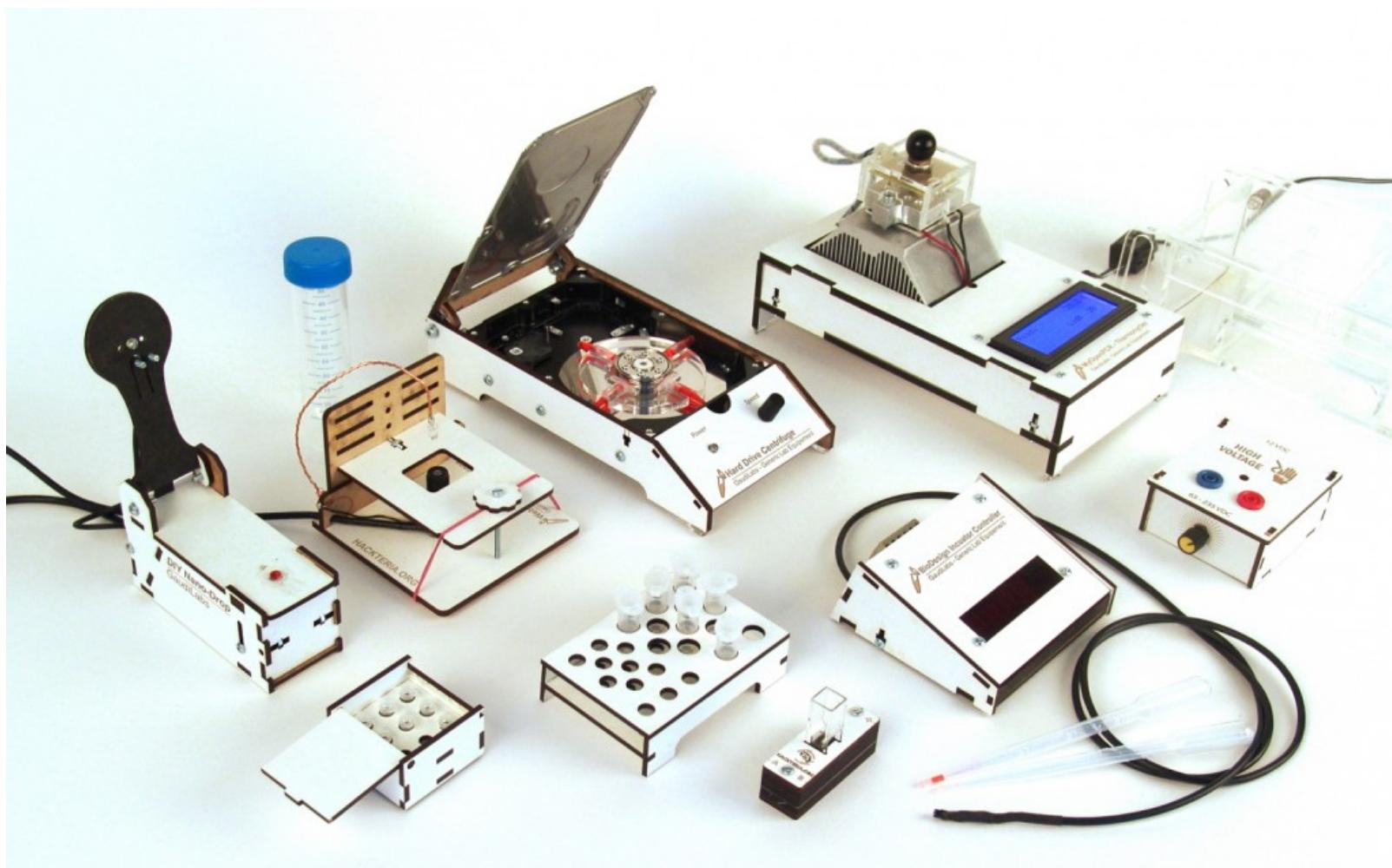
Public Lab

- “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 open source biology art network

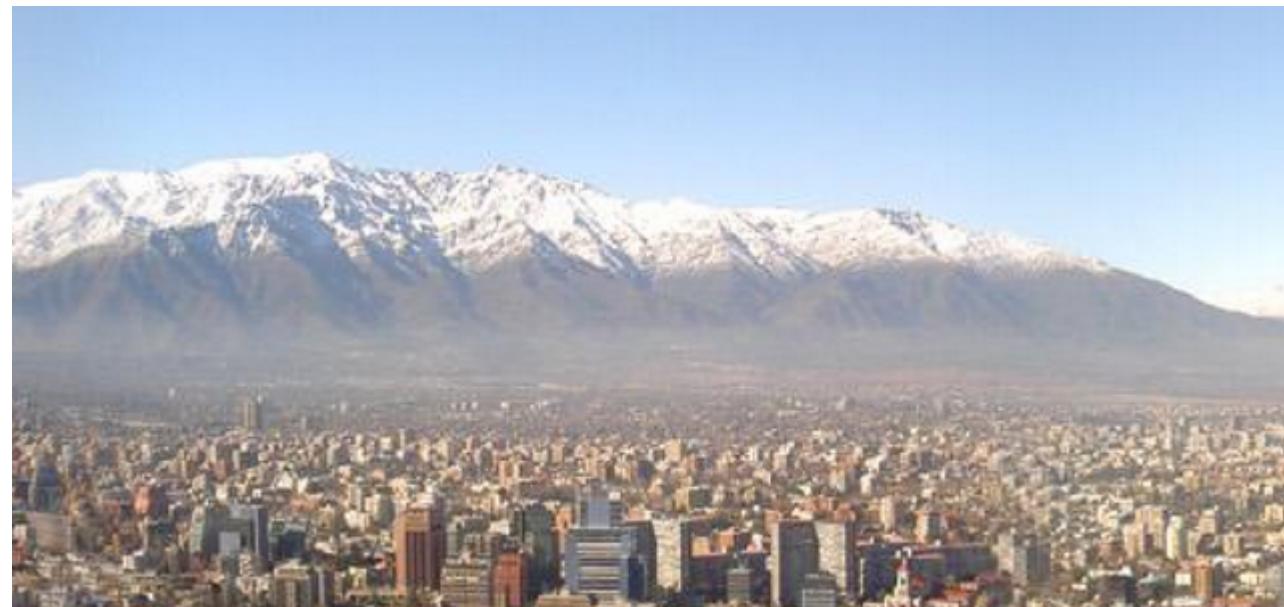


Generic Lab Equipment

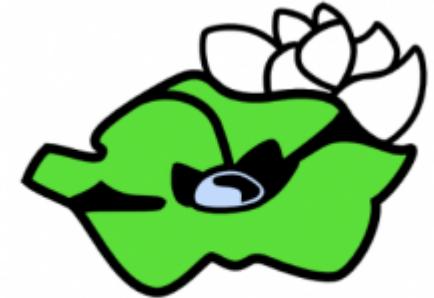
- WebCam Microscope
- Hard Drive Centrifuge
- Incubator Controller
- Gel Box and High Voltage Supply
- Turbidity Meter Kit
- DIY Microvolume Spectrometer
- My Open PCR
- Tube Racks

GOSH 2017

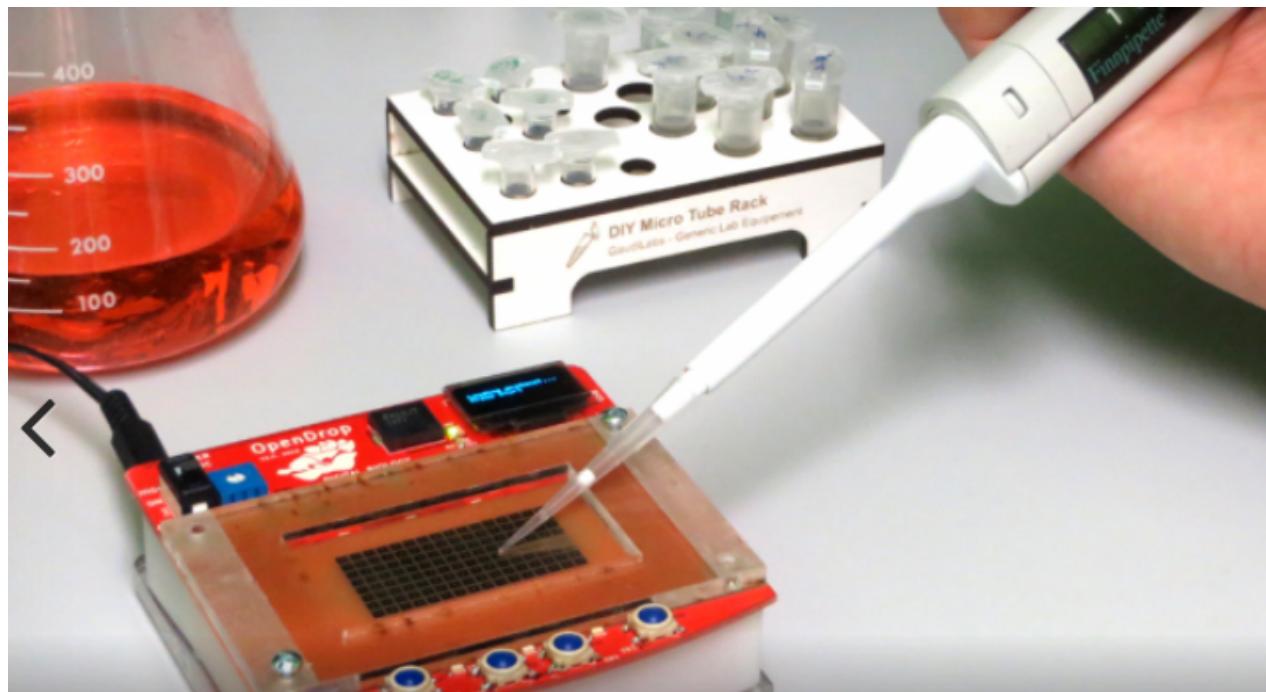
- Gathering for Open Science Hardware
- Santiago, Chile. March 22-25, 2017.
- “growing number of people around world are developing and using Open Science Hardware, and we want to help build self-organising community to drive change in open science”



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



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.”



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



Many thanks to all our supporters including:
Meredith L. Patterson Phillip Stevens
Eri Gentry Jason Bobe Martin Haebeli
Raj Singh Betsy Novotny Jamie Monberg
Ramez Naam Nathan Herring Patrick J Auld
Samir Dobric A. Kestin Guzeldere Andre Hugo
Tricia Salmero Ben Coccilero Kristin Lindquist
Keith Collins Bruce W. Adams Artem
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Ben Stanfield Gendorl Chris Quackenbush
Steve Willis Kevin Burns Brian E Caplin
Amarpreet Cheema Xia Hong Maria Johnston
Mac Cowell Dawei Lin Pete Weber
jasonslater.co.uk Ellen Jorgenson The Ponoko Team

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”



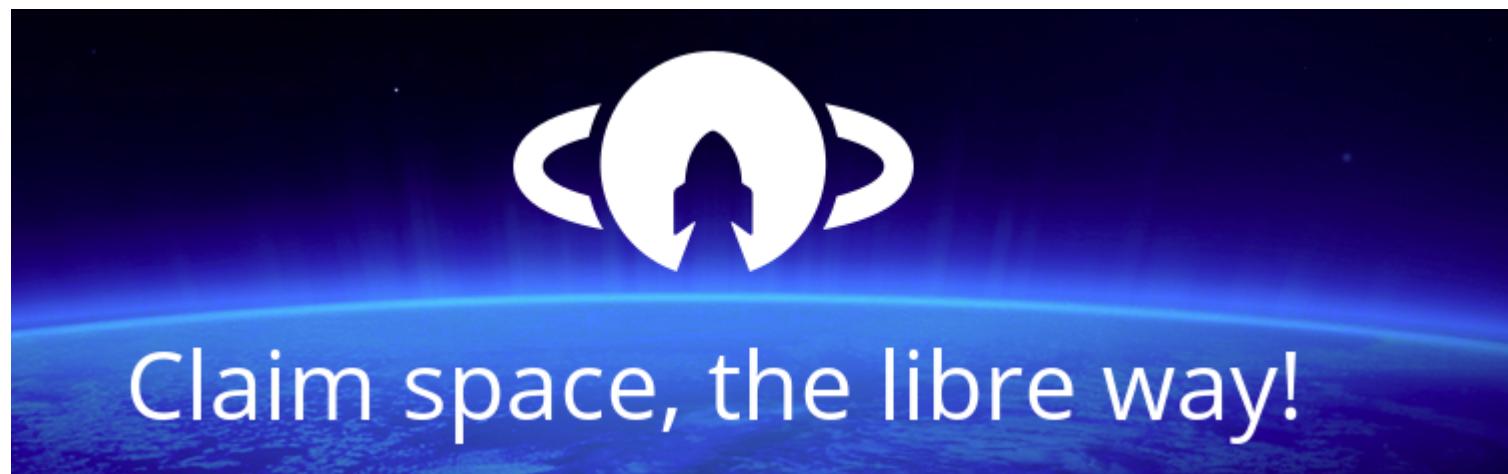
MOST research group

- 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?



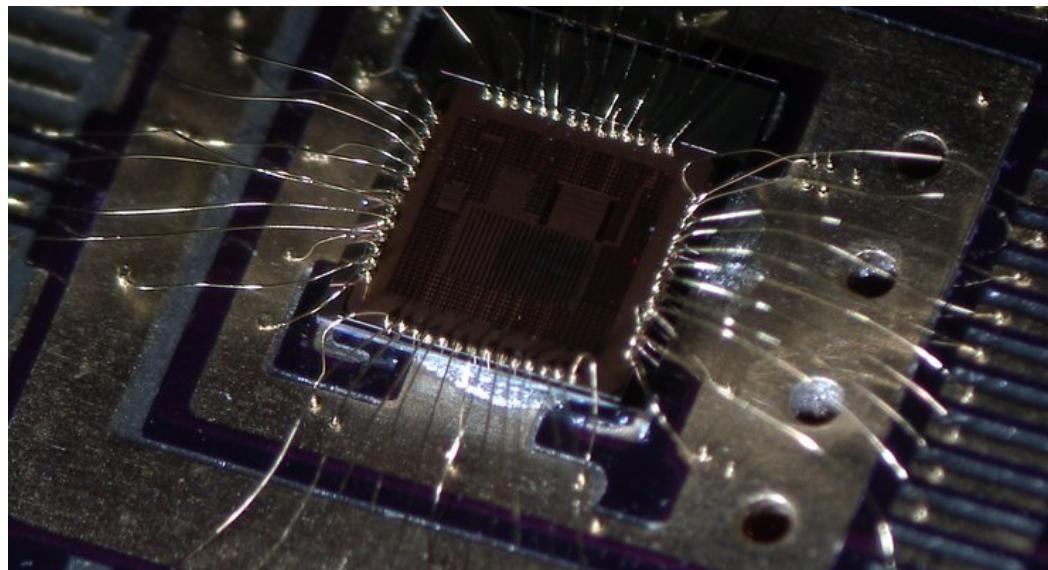
- **RISC-V: Free & Open RISC Instruction Set Arch**
 - “new instruction set architecture (ISA) that was originally designed to support computer architecture research and education and is now set to become a standard open architecture for industry”
 - Video:
[Instruction Sets Want To Be Free: A Case for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

What about silicon?

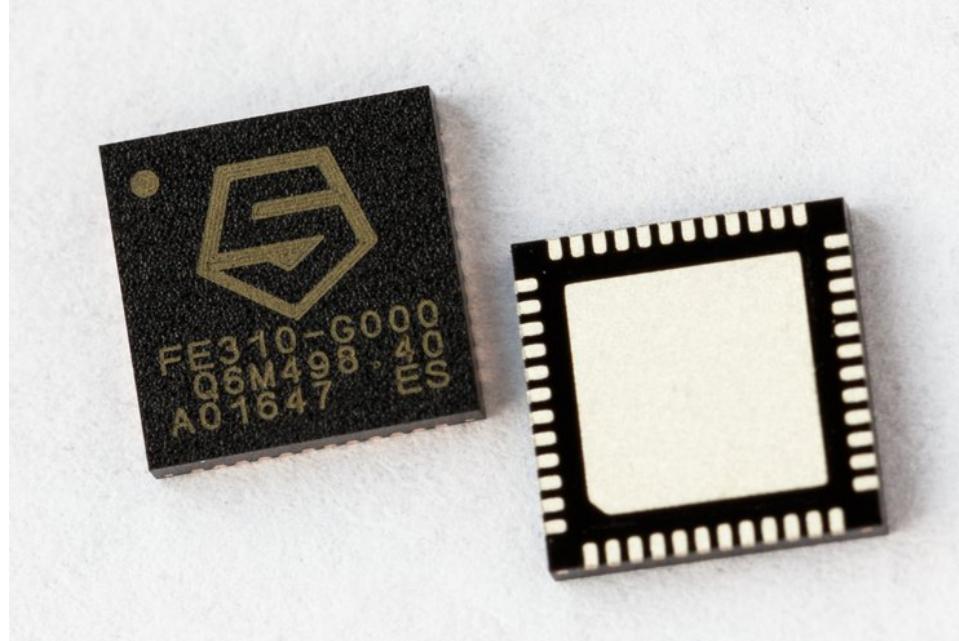


- OnChip Open-V

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



What about silicon?

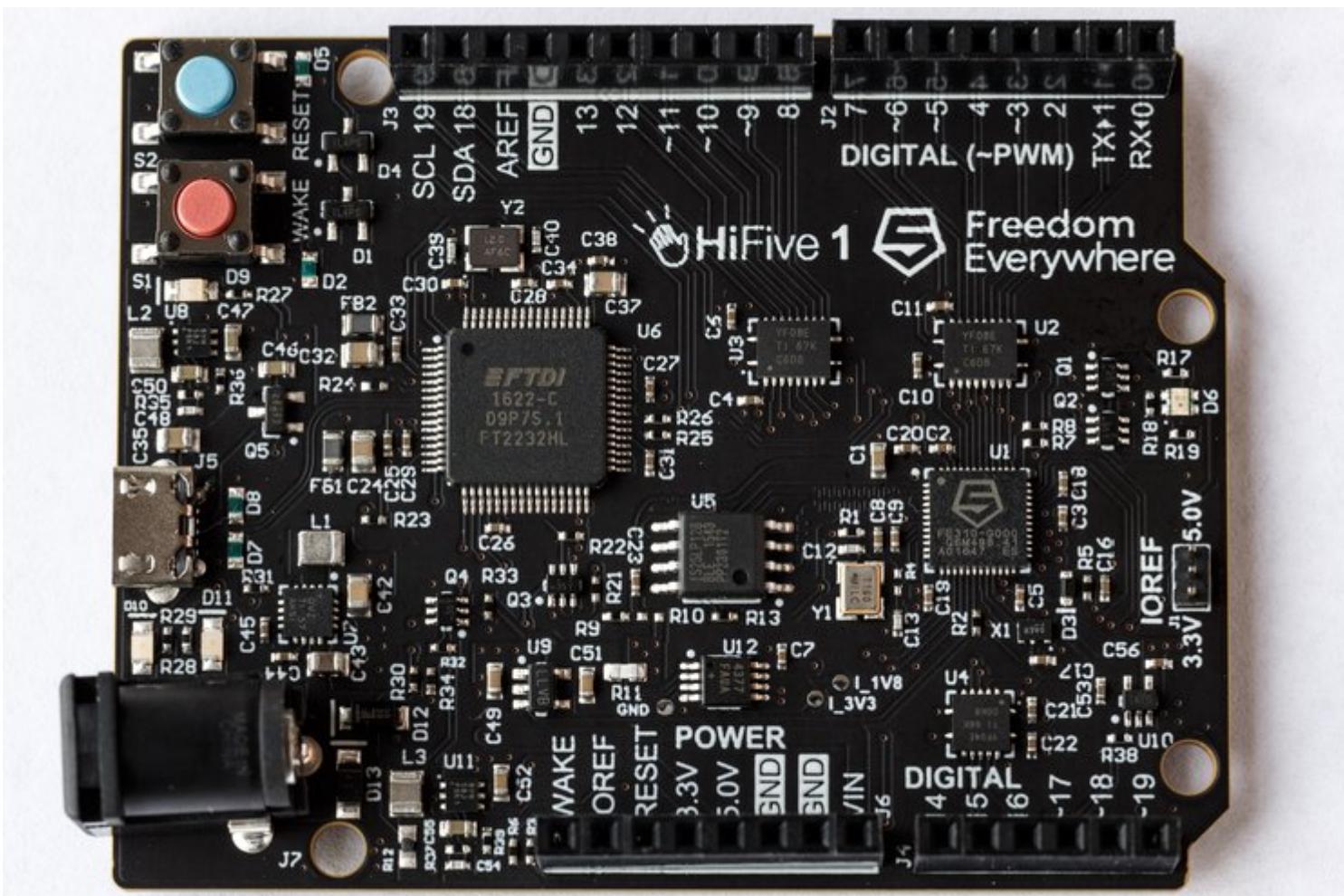


- [SiFive](#)

“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



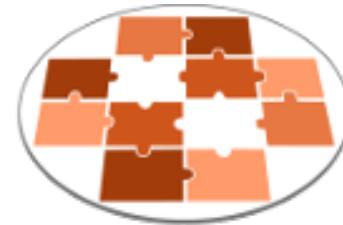
What about silicon?



- 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.”

Section:
BONUS SLIDES

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**



Lulzbot 3-D Printers

100% Open Source
Hardware & Software



- FSF Respects Your Freedom certified

Thanks

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

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- SMS: +1-773-710-7131
- twitter: [@OSHPark / @pdp7](https://twitter.com/@OSHPark)
- [OSH Park Blog](https://oshpark.com/blog)