

Slides: <https://github.com/pdp7/talks/blob/master/oshw-garage-2019.pdf>

Open Source Hardware and Open Source Chip Design



Drew Fustini
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- Open Source Hardware designer at OSH Park
 - PCB manufacturing service in the USA known for purple soldermask!
 - drew@oshpark.com / Twitter: [@oshpark](https://twitter.com/@oshpark)
- Volunteer Member of Board of Directors of BeagleBoard.org Foundation
 - drew@beagleboard.org
- Volunteer Member of the Board of Directors of the Open Source Hardware Association (OSHWA)
 - serving as Vice President
 - drew@pdp7.com



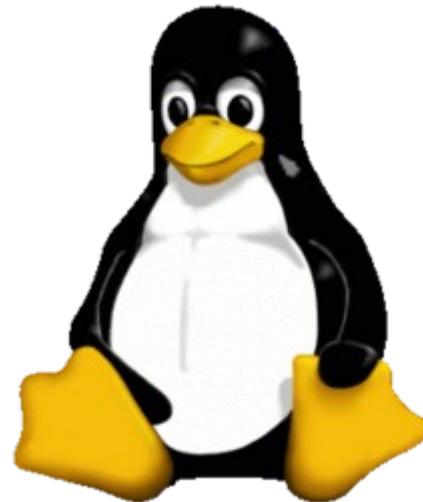
What is Open Source?



- Examples of popular Open Source projects



Apache



LibreOffice[®]



Firefox[®]



What is Open Source?

- The term "**open source**" refers to something people can **modify and share** because its design is **publicly accessible**
- **Open Source software** is software with source code that anyone can: **inspect, modify, and enhance**



What is Free Software?



A program is free software if the users have
four essential freedoms:

- 1) run the program as you wish, for any purpose
- 2) study how the program works, and change it so it does your computing as you wish
- 3) redistribute copies so you can help your neighbor
- 4) distribute copies of your modified versions



Open Source Hardware



- **FLOSS** is a term to describe software that is Free, Libre, or Open Source Software
- In the context of hardware projects, I consider these terms equivalent:
 - Free Hardware
 - Libre Hardware
 - Open Hardware
 - Open Source Hardware

Slides: <https://github.com/pdp7/talks/blob/master/oshw-garage-2019.pdf>



Statement of Principles:

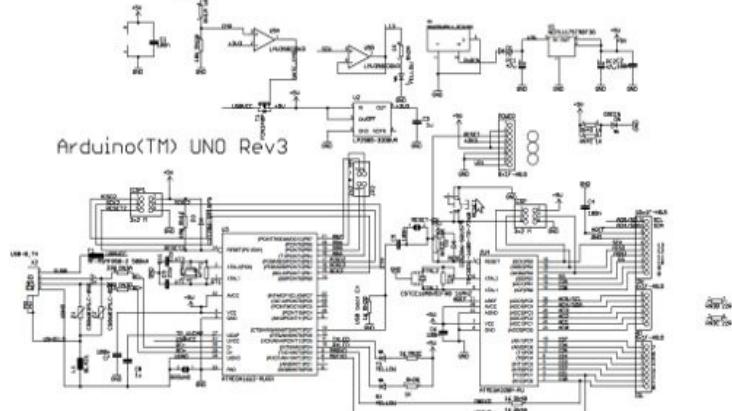
Hardware whose **design** is made **publicly available** so that anyone can **study**, **modify**, **distribute**, **make**, and **sell** the design or hardware based on that design

Slides: <https://github.com/pdp7/talks/blob/master/oshw-garage-2019.pdf>

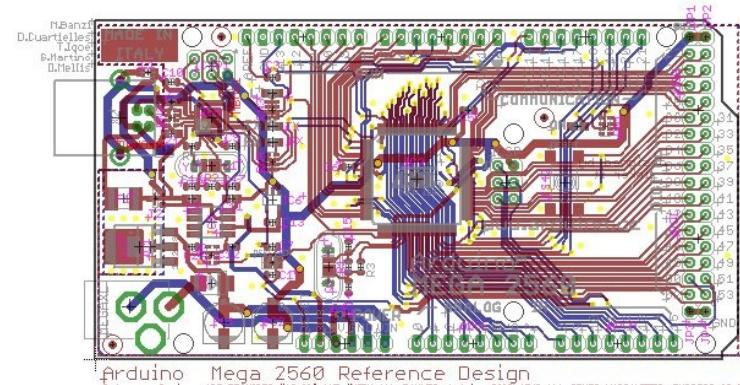
Open Source Hardware

Documentation required for electronics:

Schematics



Board Layout



Editable source files for CAD software such as KiCad or EAGLE

Bill of Materials (BoM)

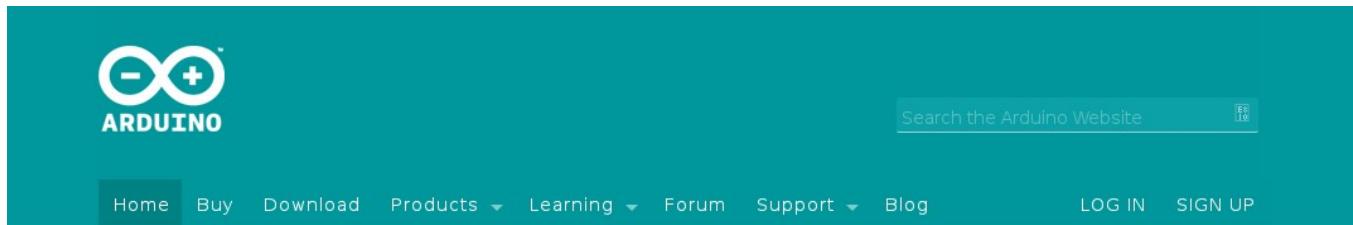
Best practice: all components available from distributors in **low quantity**



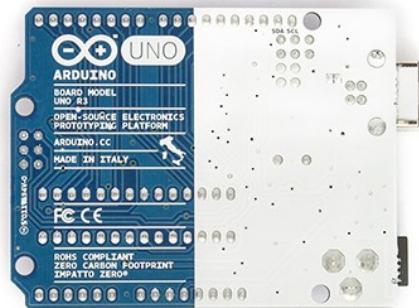
Open Source Hardware



Example: **Arduino** achieved critical mass by sharing their hardware designs and source code



Arduino Uno



Arduino: The Documentary describes the team's motivation



Open Source Hardware



✓ Example: [Arduino Uno](#) schematic and PCB layout design files for EAGLE CAD can be downloaded from [Arduino.cc](#)

The screenshot shows a web browser window with the Arduino website. The URL in the address bar is <https://www.arduino.cc/en/Main/ArduinoBoardUno>. The page title is "Arduino - ArduinoBoa...". The main navigation menu includes "Buy", "Software", "Products", "Learning", "Forum", "Support", and "Blog". On the left, there's a sidebar with links: "Overview", "Get Inspired", "Related Items", "Technical Specs", and "Documentation" (which is highlighted). The main content area has a large orange heading "Documentation". Below it, there's a section titled "OSH: Schematics, Reference Design, Board size" with the text: "Arduino / Genuino Uno is open-source hardware! You can build your own board using the following files:". Two download buttons are shown at the bottom: a yellow one for "EAGLE FILES IN .ZIP" and a brown one for "SCHEMATICS IN .PDF".

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



- 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

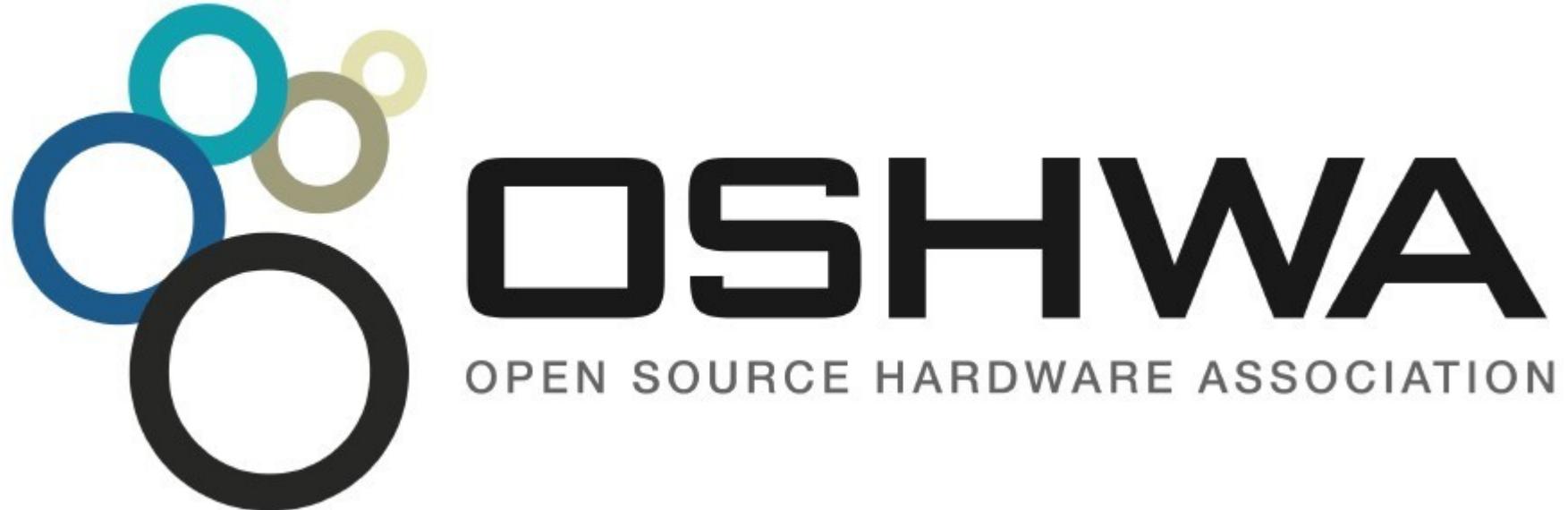


Open Source Hardware

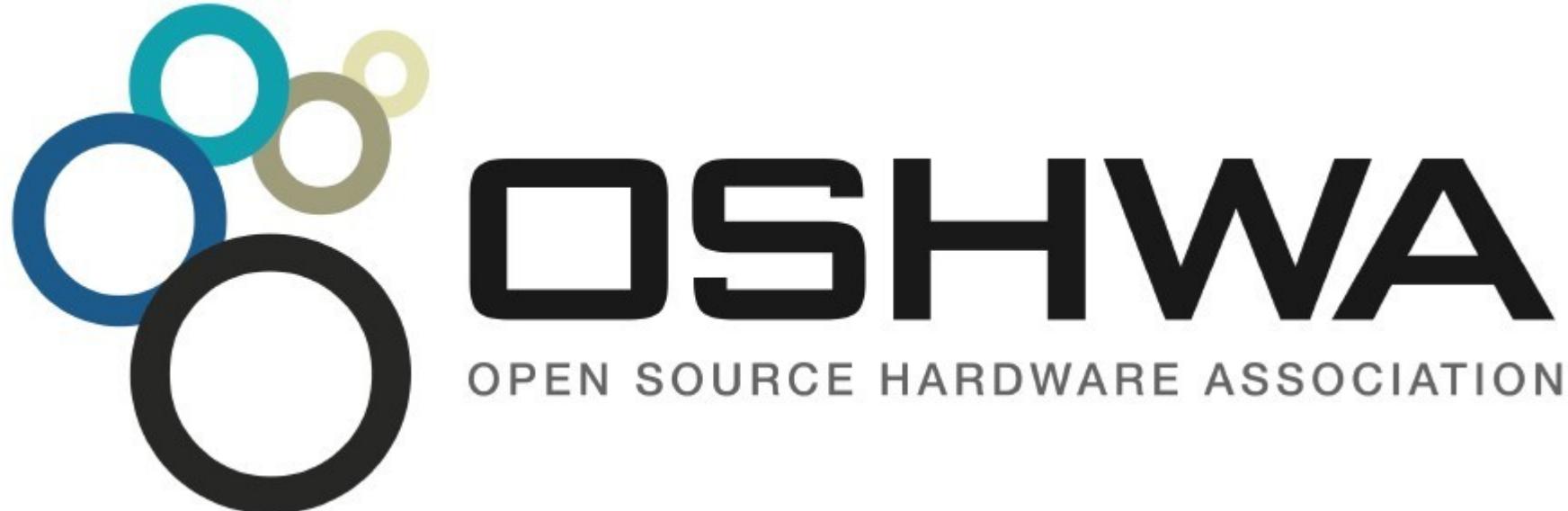


What is the spirit of Open Source?

- Publish everything that will:
enable collaborative development
- Goal is NOT to check a box on a marketing brochure or add keywords to a crowdfunding campaign



- US-based 501(c)3 non-profit organization
- Hosts the **Open Source Hardware definition**
- “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”



- OSHW Best Practices
- Quick Reference Guide
- OSHW "May and Must" (PDF)
- OSHW Checklist (PDF)

Open Hardware Summit (OHS)

- OHS 2020: March 13 in NYC (USA)
 - <http://2020.oshwa.org/>
- *8 prior summits:*
 - **2010, 2011:** New York Hall of Science
 - **2012:** Eyebeam (*NYC*)
 - **2013:** MIT (*Boston area*)
 - **2014:** Roma, Italia!
 - **2015:** Philadelphia, USA
 - **2016:** Portland, Oregon, USA
 - **2017:** Denver, USA
 - **2018:** MIT (Cambridge, MA, USA)

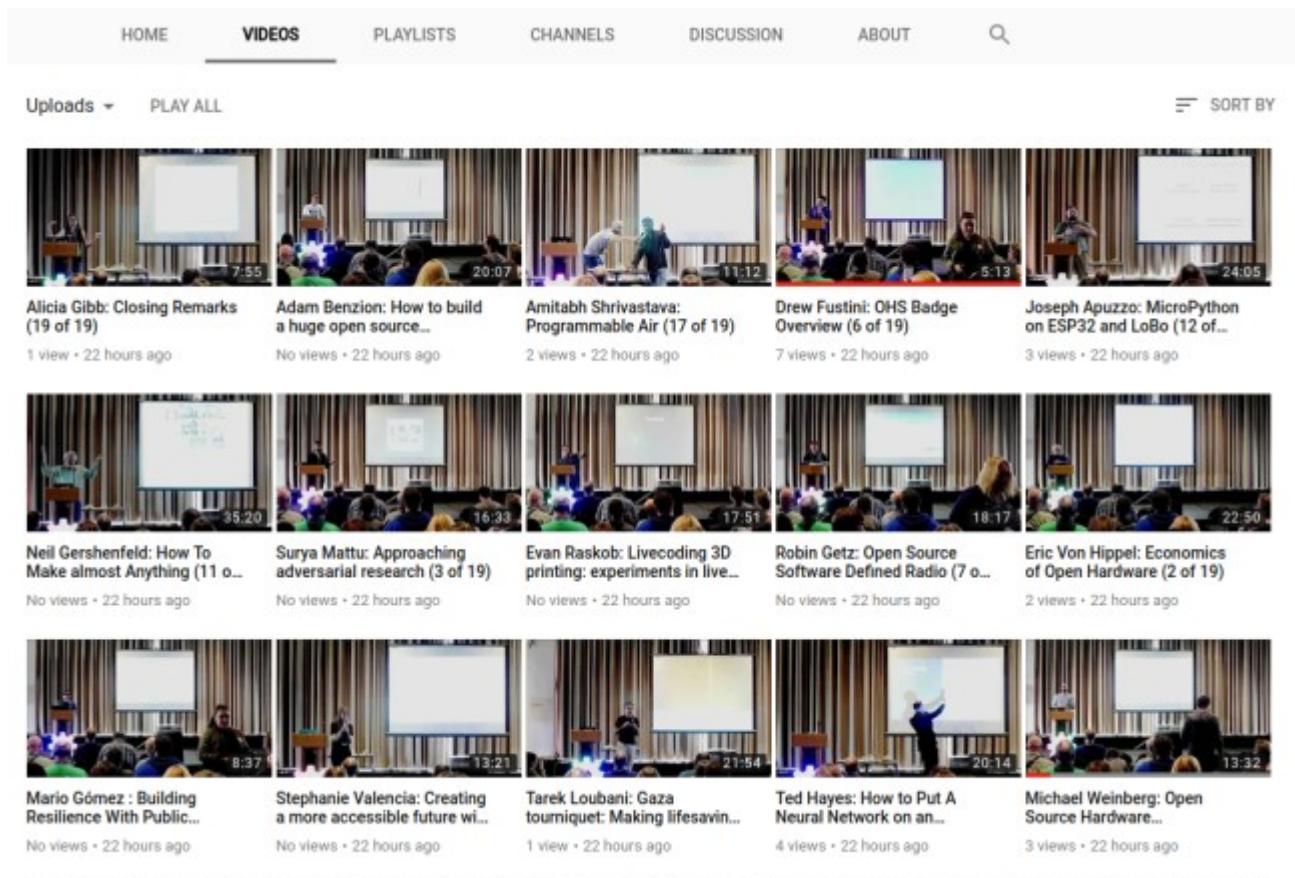
October is Open Hardware Month!



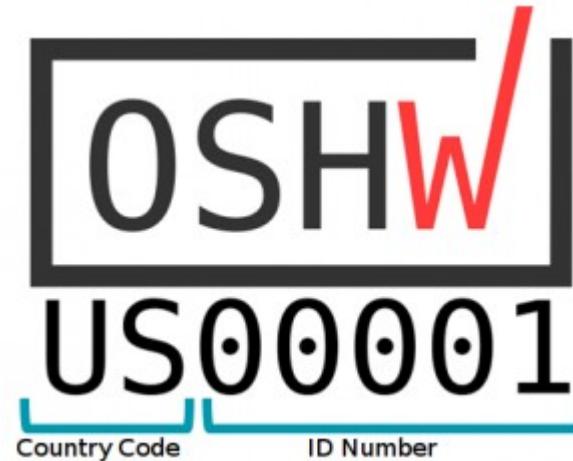
- People all over the world celebrated with meet-ups, talks and workshops
- Kicked off with events at RAIT in Vienna (Austria) and SparkFun in Colorado (USA), followed by gatherings in Poland, Panama, Thailand, Japan, Ghana and more!
- 40 events in 14 different countries across 5 continents

Open Hardware Summit (OHS)

- The Open Hardware Summit 2018 talks are available as individual videos on YouTube



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](#)



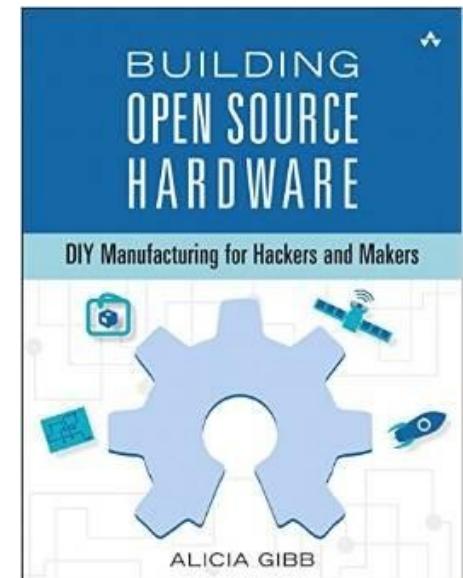
Open Source Hardware



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*)



Slides: <https://github.com/pdp7/talks/blob/master/oshw-garage-2019.pdf>



Section:
LINUX on OSHW
(my two favorite things!)

Novena laptop

- Created by Bunnie Huang & Sean Cross (xobs)
 - Chumby, “Hacking the Xbox”, [amazing reverse engineers](#)
- 100% Open Source Hardware laptop
- Quad-core 1.2GHz ARM, 4GB RAM, SSD, WiFi
- Xilinx FPGA for custom hardware design
- Software Defined Radio (SDR) module



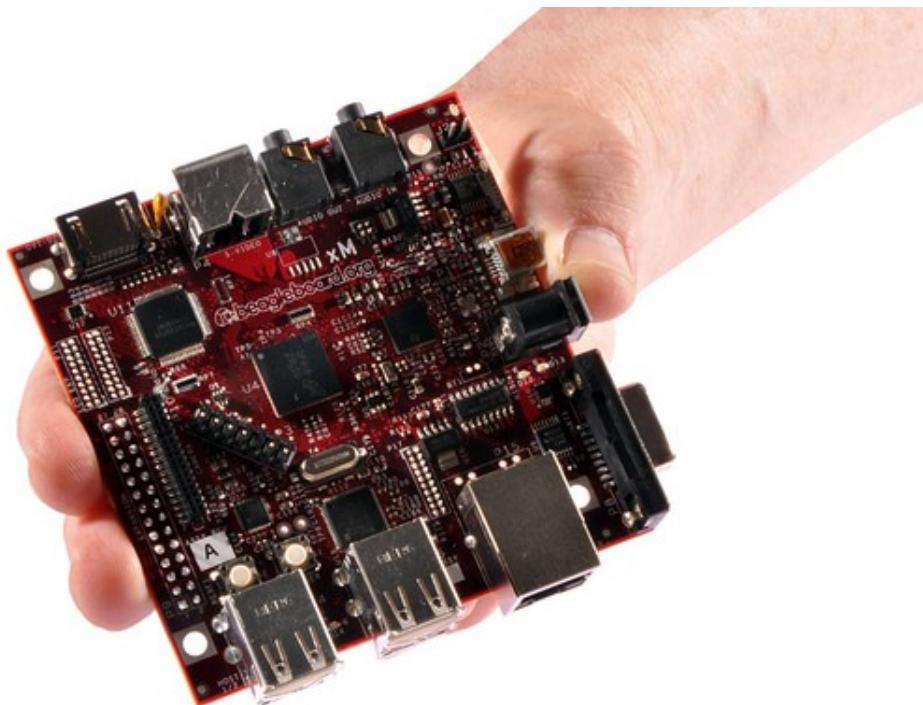


- Open Source Hardware computing for Makers, Educators & Professionals
- Developed by [BeagleBoard.org Foundation](#) and [BeagleBoard.org Community](#)
- Manufacturers: [element14](#), [GHI](#), [Seeed](#)



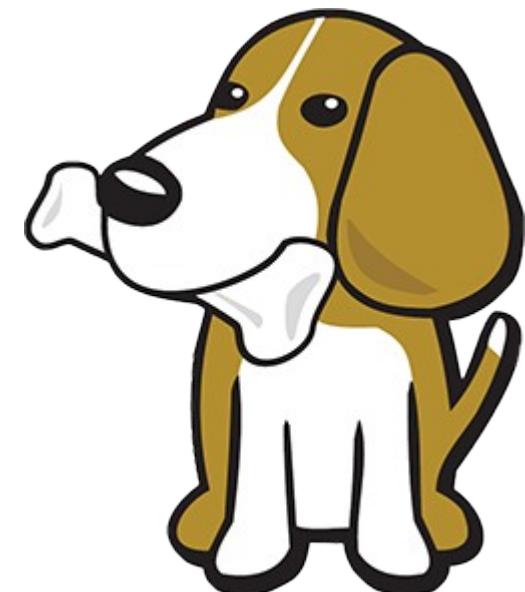


BeagleBoard.org released the first
BeagleBoard, an affordable, open
hardware ARM computer in **2008**





Maker focused, Altoids tin sized
BeagleBone introduced in **2011**





More affordable, more powerful
BeagleBone Black in 2013

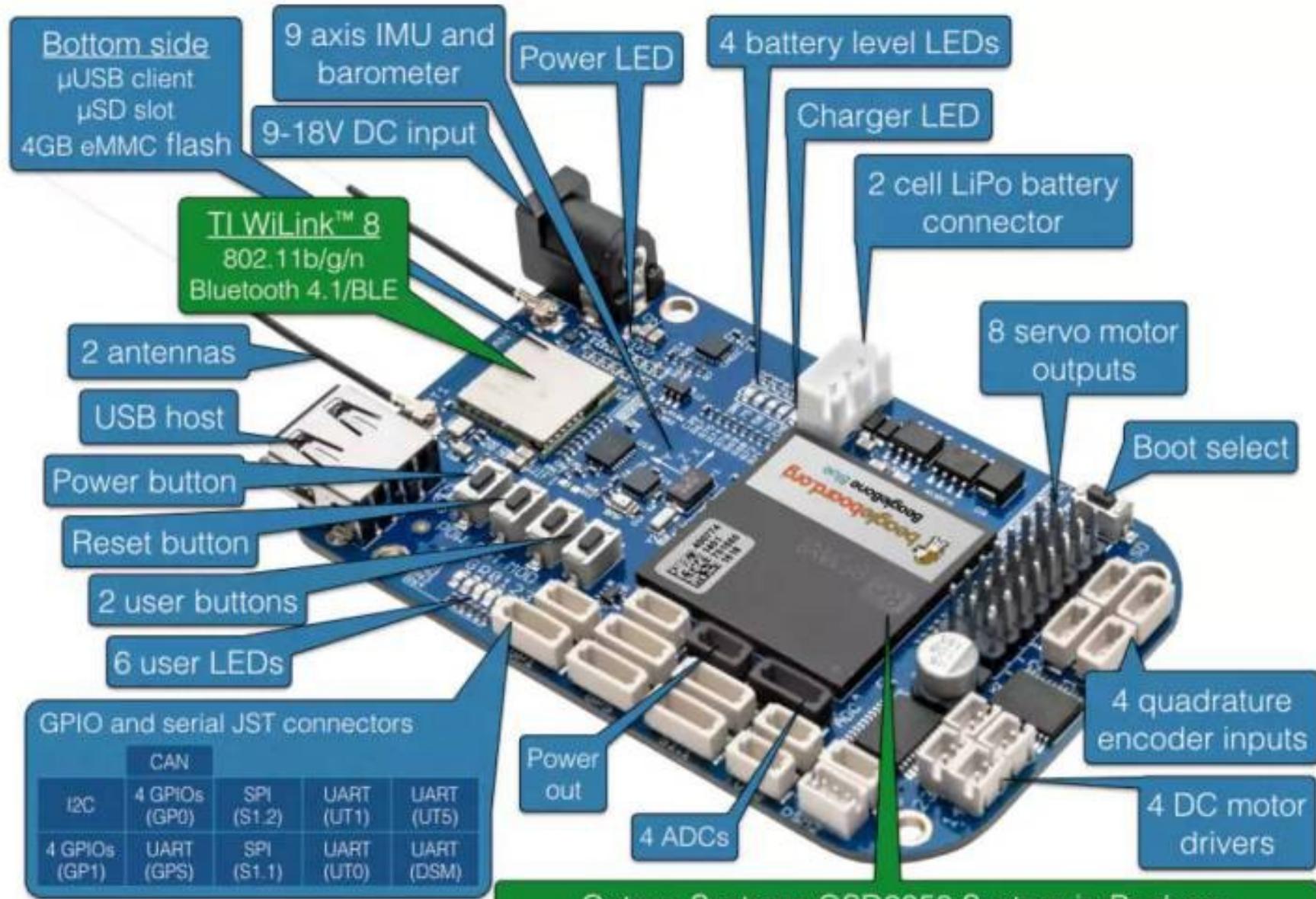




Open Source Hardware BeagleBone derivatives

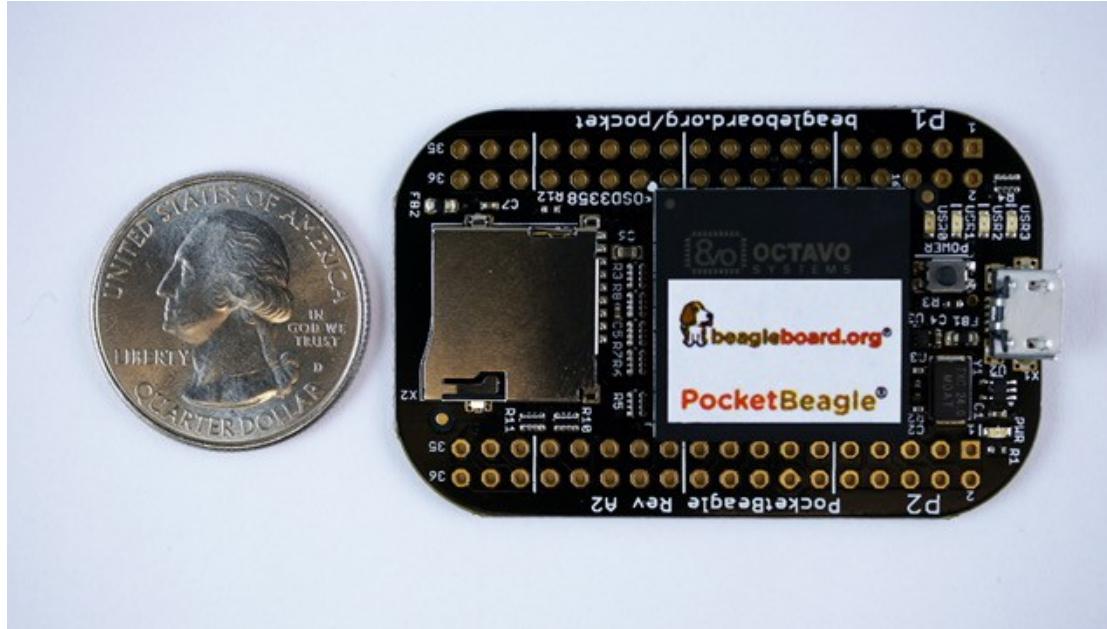
	Capes	HDMI	Flash	Special
BeagleBoard.org BeagleBone	Y	N	N	JTAG
BeagleBoard.org BeagleBone Black	Y	Y	Y	-
Arrow BeagleBone Black Industrial	Y	Y	Y	Industrial
Element14 BeagleBone Black Industrial	Y	Y	Y	Industrial
SeeedStudio BeagleBone Green	Y	N	Y	Grove
SanCloud BeagleBone Enhanced	Y	Y	Y	1GB, 1Gbit, wireless
BeagleBoard.org BeagleBone Blue	N	N	Y	Robotics
BeagleBoard.org BeagleBoard-X15	N	Y	N	Big jump in CPUs and I/O

BeagleBone Blue: complete Linux robotics controller. 4 layer PCB designed in EAGLE.



1-GHz TI ARM® Cortex®-A8, 512-MB DDR3, power management

BeagleBoard.org PocketBeagle



- Michael Welling designed the “*PocketBone*” using the Octavo SiP and shared on Hackaday.io
- In response to online demand, BeagleBoard.org worked with GHI in Michigan to design and manufacture a new product: the PocketBeagle

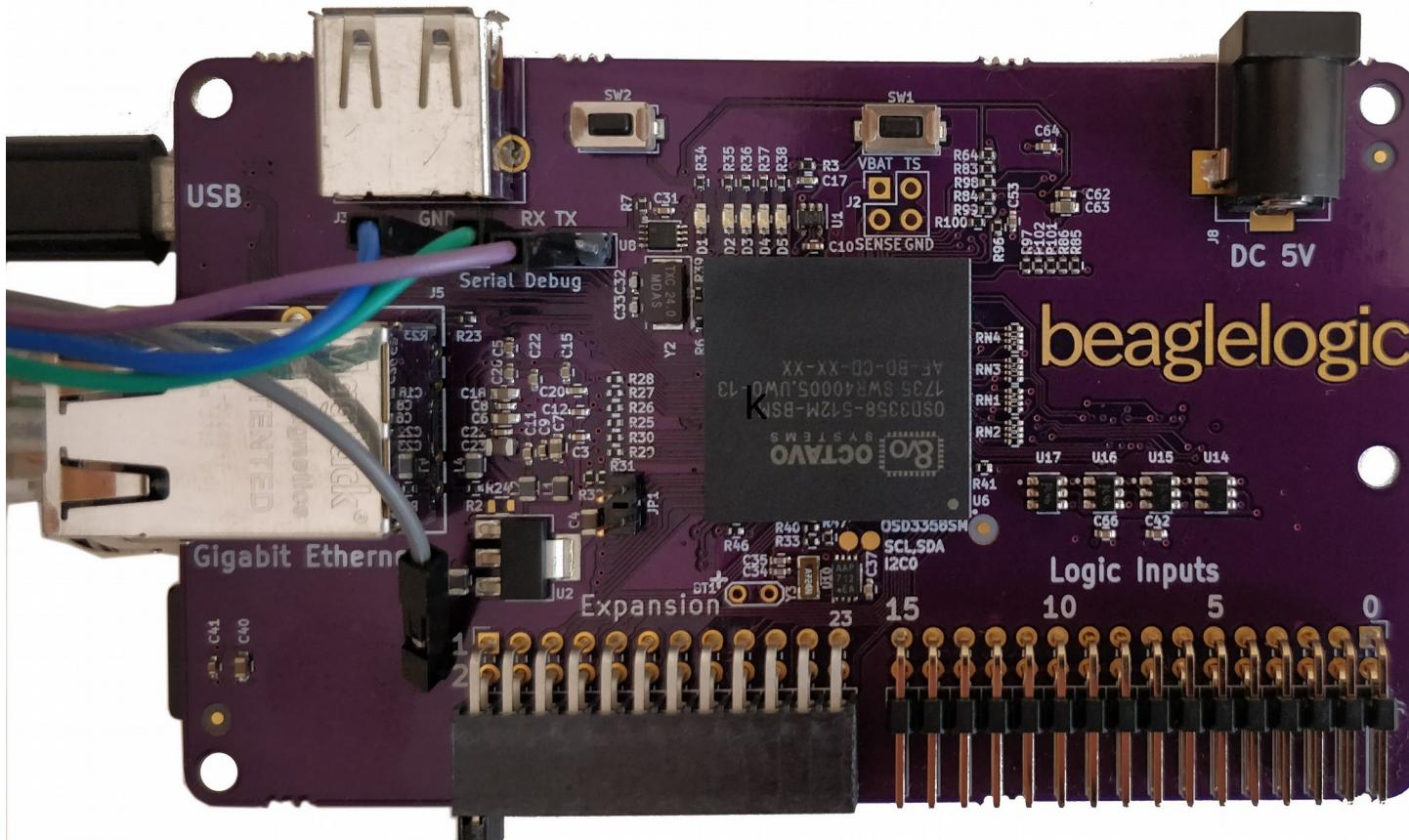
BeagleBoard.org PocketBeagle

- PocketBeagle design makes it feasible for individuals to create their own derivatives
- 4 layer PCB published for EAGLE and KiCad
- Low cost assembly is possible with solder paste stencil and toaster oven



BeagleLogic

- Kumar Abhishek created a derivative board intended to be used a logic analyzer
 - Finalist in the Best Product round of the Hackaday Prize



BeagleBone AI: The Fast Track for Embedded Machine Learning



2 46 pin expansion headers compatible with many BeagleBone® Black cape add-on boards

USB super-speed (5Gbps) Type-C host/client (multiport capable) with power input (5V@3A)

1GB RAM
(2nd IC on bottom side)

USB high-speed (480Mbps)
Type-A host

micro-HDMI
(bottom side)

micro-SD
(bottom side)

16GB on-board eMMC
flash storage

serial port

Gigabit Ethernet

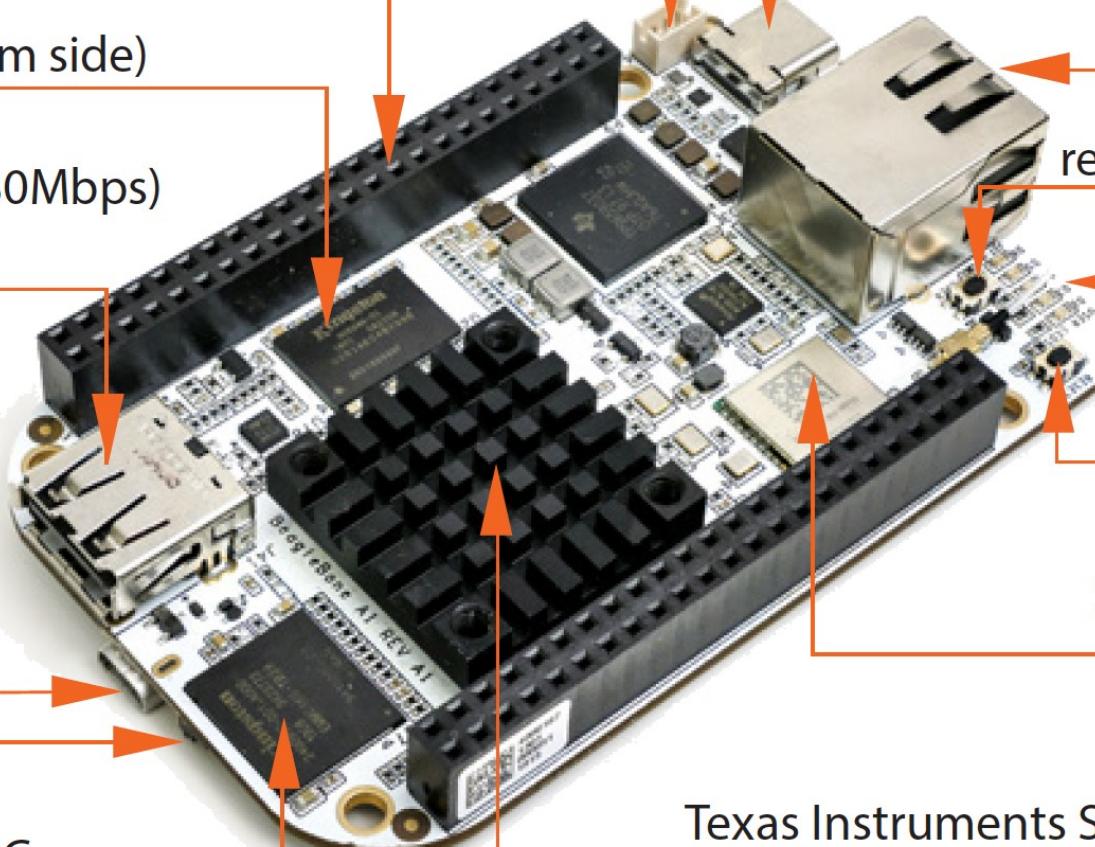
reset button

5 user LEDs

power button

2/5GHz 802.11ac WiFi and Bluetooth

Texas Instruments Sitara AM5729 multicore 1.5GHz ARM processor with AI, I/O, graphics and video accelerators



BeagleBone AI

“TI C66x digital-signal-processor (DSP) cores and embedded-vision-engine (EVE) cores supported through an optimized TIDL machine learning OpenCL API with pre-installed tools. Focused on everyday automation in industrial, commercial and home applications.”

Feature highlights:

- 1GB RAM and 16GB on-board eMMC flash with high-speed interface
- USB type-C for power and superspeed dual-role controller; and USB type-A host
- Gigabit Ethernet, 2.4/5GHz WiFi, and Bluetooth
- microHDMI
- Zero-download out-of-box software experience

BeagleBone AI design files

README.md

BeagleBoard.org BeagleBone AI

Fast track to Embedded Artificial Intelligence

BeagleBone AI is built on the proven BeagleBoard.org® open source Linux platform for small SBCs and more powerful industrial computers. Based on the Texas Instruments® Sitara™ processor, it provides the power of the Sitara™ processor and the performance of the BeagleBoard.org® SoC in a compact package. It features the powerful SoC with the ease of BeagleBone® Black header and BeagleBoard.org® compatibility. It is designed to explore how artificial intelligence (AI) can be used in everyday applications. The BeagleBone AI includes a neural network engine (NNE) and embedded-vision-engine (EVE) cores supported through the BeagleBoard.org® software stack and installed tools. Focused on everyday automation in industrial, medical, and consumer applications.

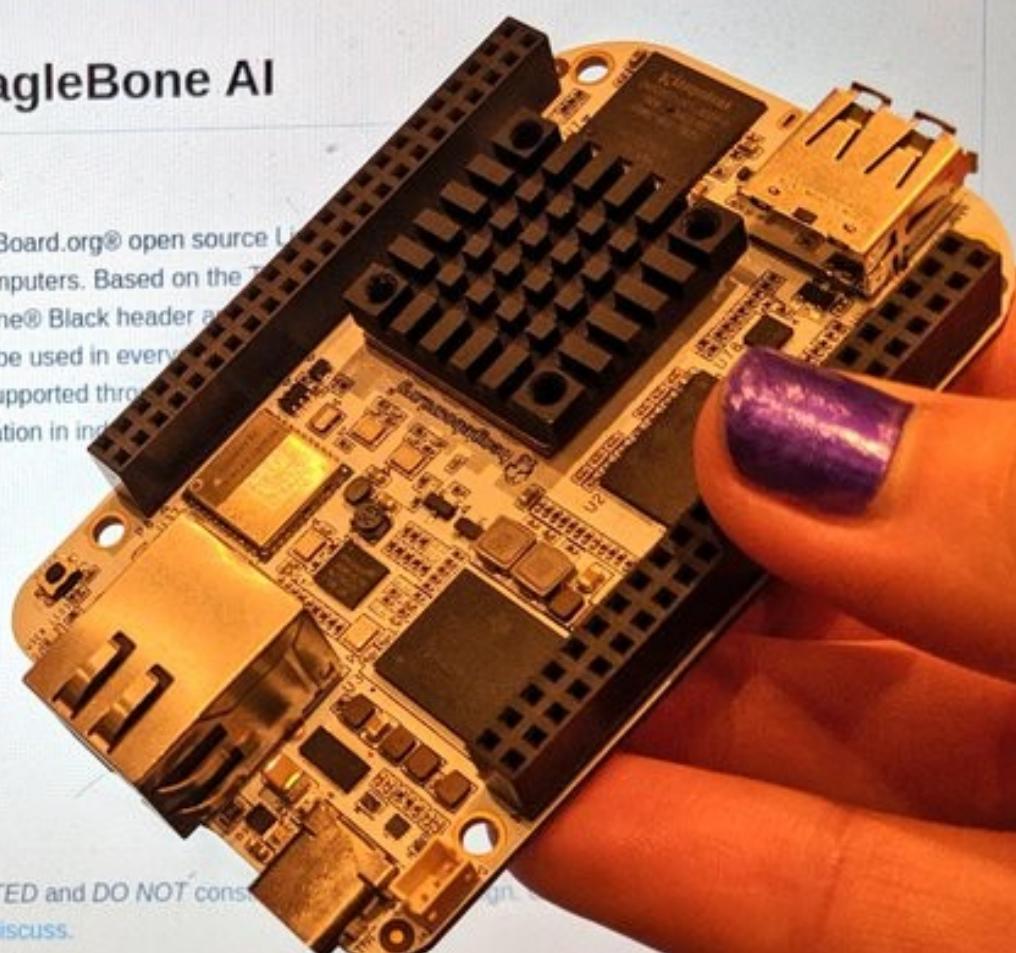
OSHW
US000169

Terms

These design materials are **NOT SUPPORTED** and **DO NOT** constitute a license under any intellectual property rights of OSHW or others. Support is allowed via resources at BeagleBoard.org/discuss.

THERE IS NO WARRANTY FOR THE DESIGN MATERIALS, TO THE EXTENT PERMITTED BY APPLICABLE LAW. EXCEPT WHEN OTHERWISE STATED IN WRITING THE COPYRIGHT HOLDERS AND/OR OTHER PARTIES PROVIDE THE DESIGN MATERIALS "AS IS" WITHOUT WARRANTY OF ANY KIND, EITHER EXPRESSED OR IMPLIED.

CSV





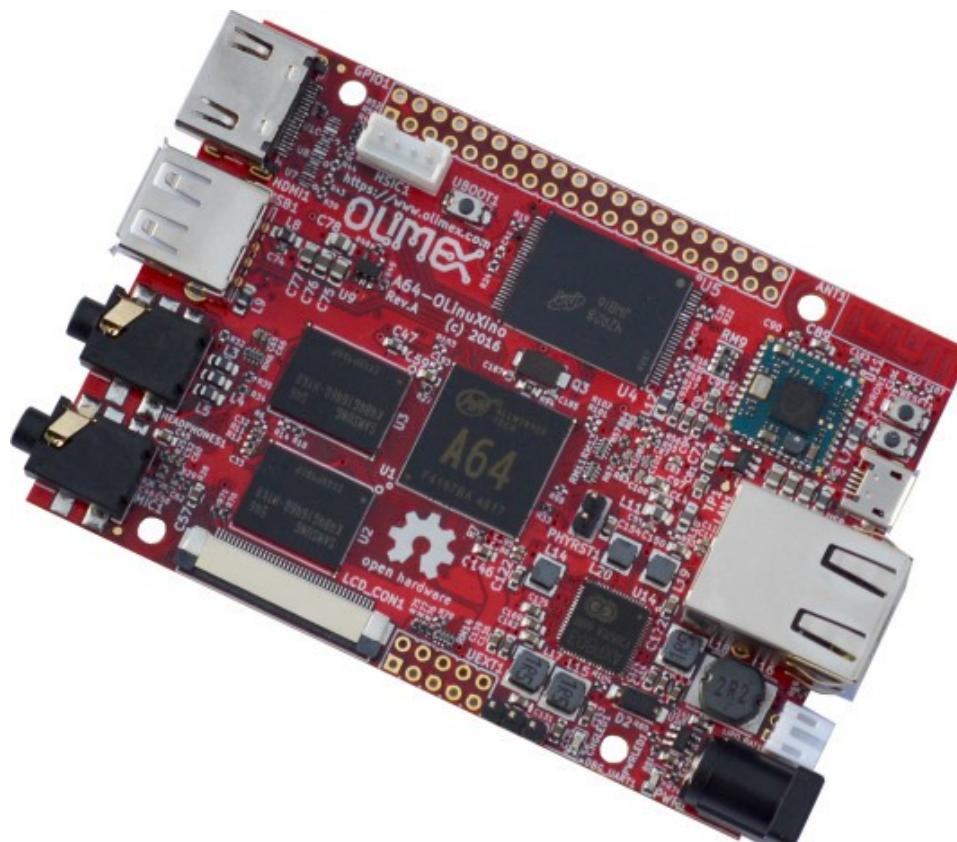
OLinuXino



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

A64-OlinuXino

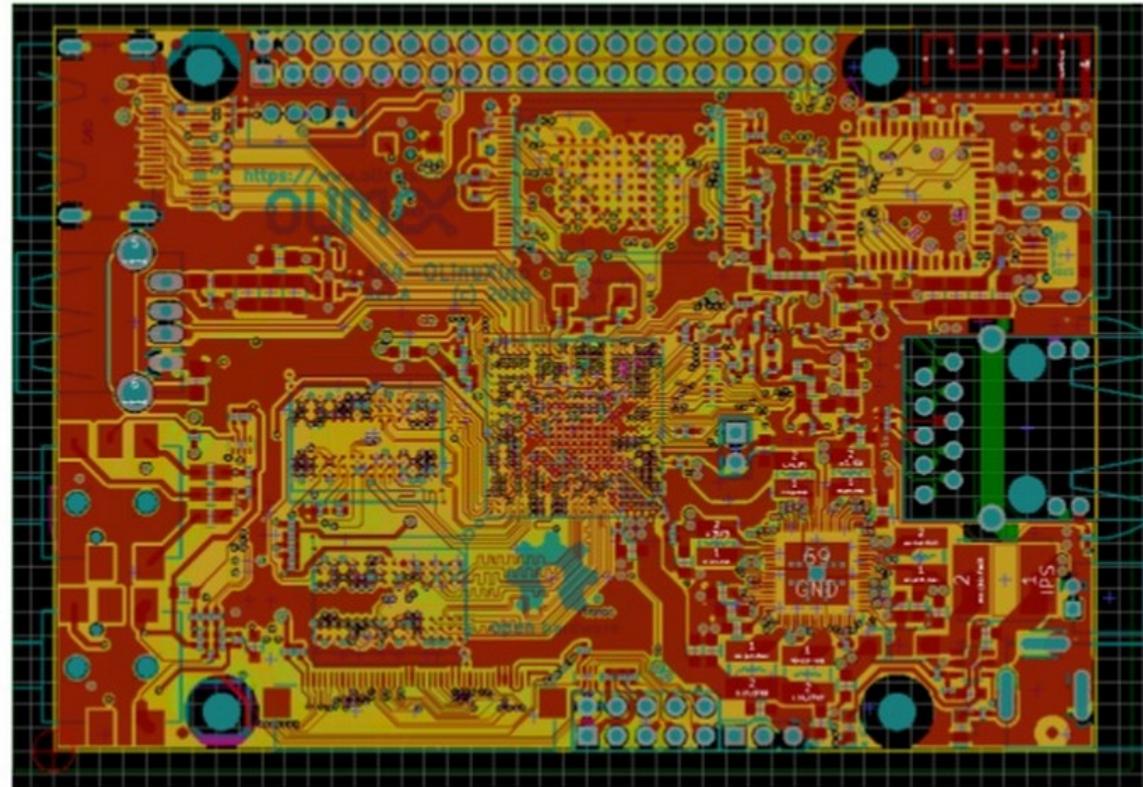
- Allwinner A64: Quad Core **64-bit ARM**
- Designed with Open Source **KiCad**
- 1GB RAM, 4GB eMMC, WiFi+BLE4.0





Using FOSS tools for OSHW project

Designing with KiCAD of 64-bit ARM board



Tsvetan Usunov, OLIMEX Ltd

FOSDEM 2016

[Slides](#) / [Video](#)

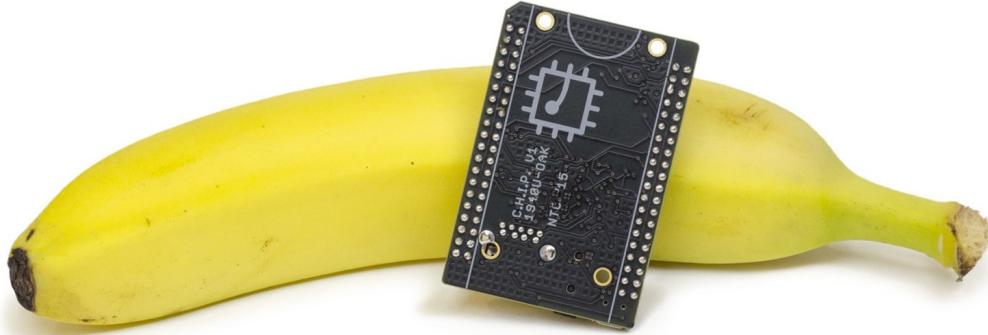


- **KiCad** is an Open Source EDA suite including Schematic Capture and PCB Layout
- Cross platform: **Windows**, **Mac OS** and **Linux**
- **CERN has contributed** professional CAD features for high-speed digital design
- Learn to design your own PCB in KiCad with: **Getting to Blinky**

- “DIY Open Source Hardware Software Hacker's friendly Modular Laptop”
- Developing an Open Source Laptop talk by Olimex founder Tsvetan Usunov at Hackaday Belgrade
- Design files on GitHub:
“everyone can download & learn, study, edit, modify”



C H I P

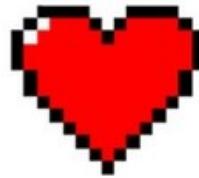
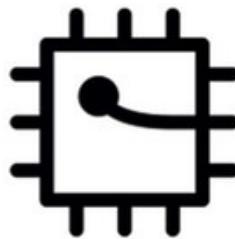


The World's First \$9 Computer

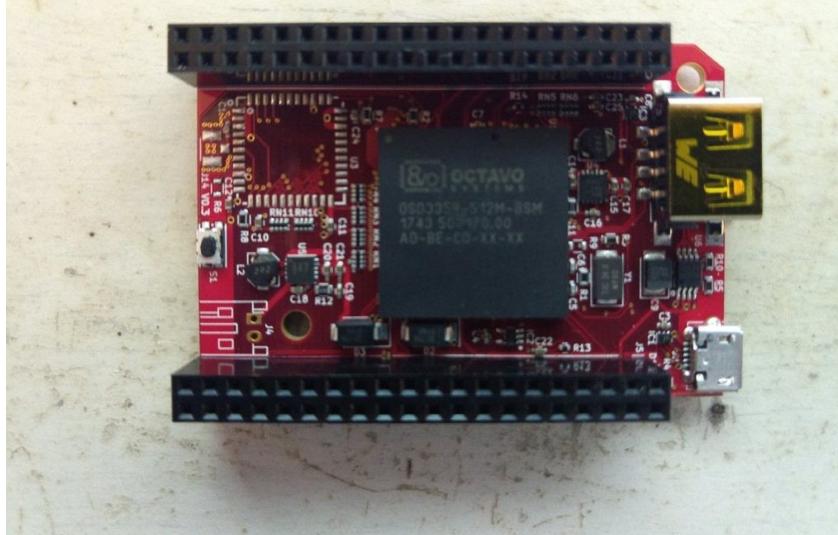
- getchip.com
- Next Thing Co. in Oakland
- Kickstarter in 2015
- Company ended in 2018



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)



- Nebula One created by Groguard to be compat
- PocketChip with Nebula One running DOOM!

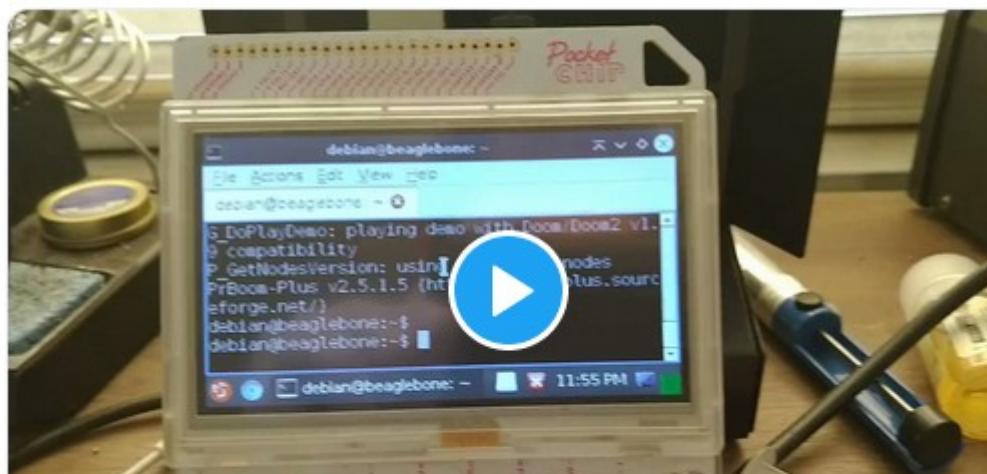


Groguard
@groguard

Follow ▾

Doom running on the NebulaOne board in the
PocketCHIP. Wifi and LCD are working! Just
need get the keyboard sorted next! @pdp7

@Jadon @dcschelt



Giant Board by groguard

- A single-board computer in the Adafruit Feather form factor
- Funded on Crowd Supply

CROWD SUPPLY

BROWSE

LAUNCH

ABOUT US

Search



Giant Board

by Groboards

Open Hardware
Computers & Networking
Development Kits

A single-board computer in the Adafruit Feather form factor

Part of
Microchip Get Launched
2019



\$13,670 raised
of \$12,250 goal

111% Funded!

Order Below

8 updates Aug 08 funded on 162 backers

Last update posted Aug 07, 2019

me@example.com

Subscribe to Updates



Open Source and FPGAs

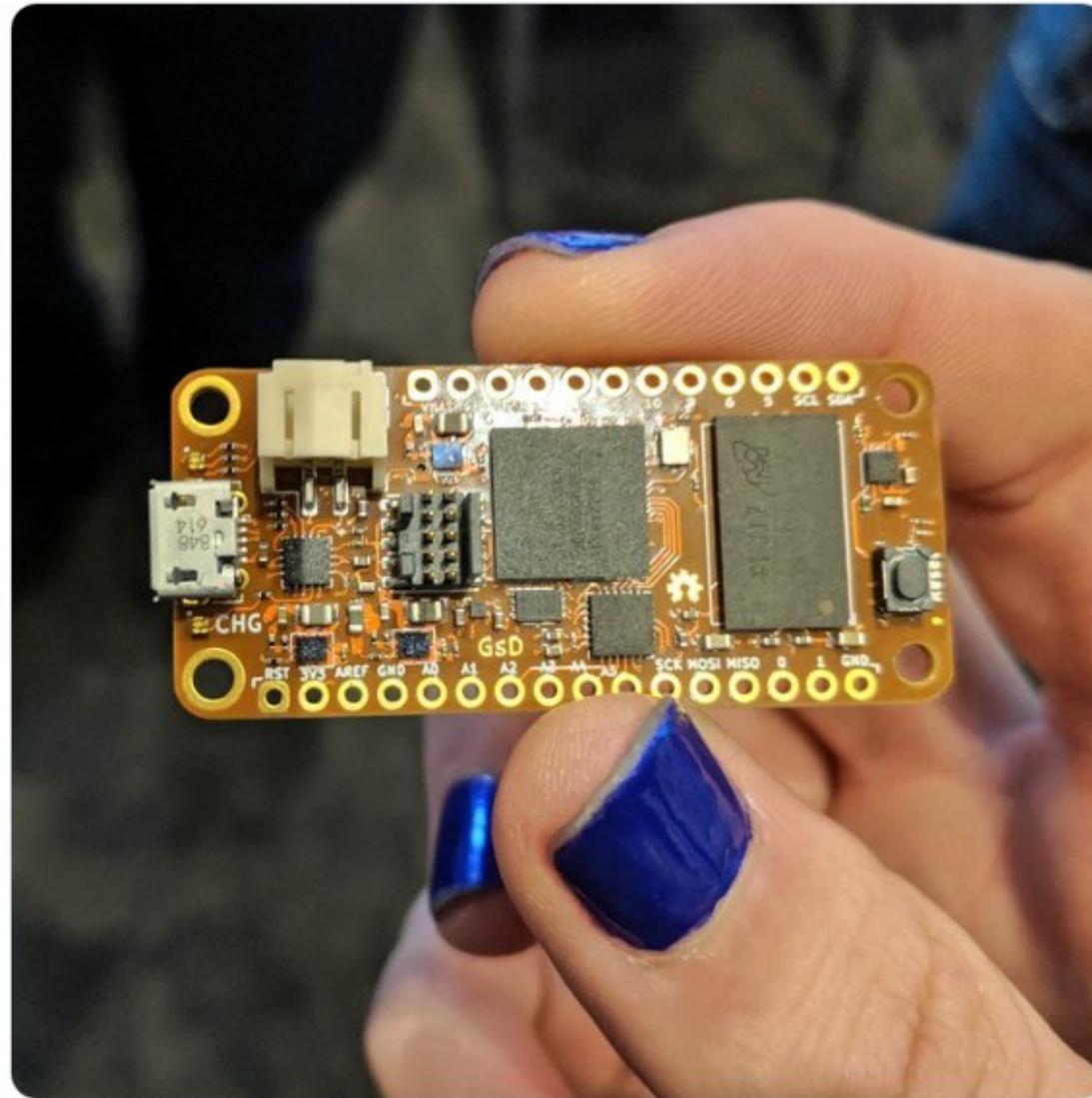
- Open Source toolchains for FPGAs!
 - Project IceStorm for Lattice iCE40
 - Project Trellis for Lattice ECP5
- Open Source Hardware boards with Lattice ECP5 FPGA with open RISC-V “soft” CPU:
 - [Orange Crab by Greg Davill](#)
 - [Radiona.org ULX3S](#)
 - [David Shah's Trellis board \(Ultimate ECP5 Board\)](#)
 - [MyStorm with ECP5 by Alan](#)

← Tweet



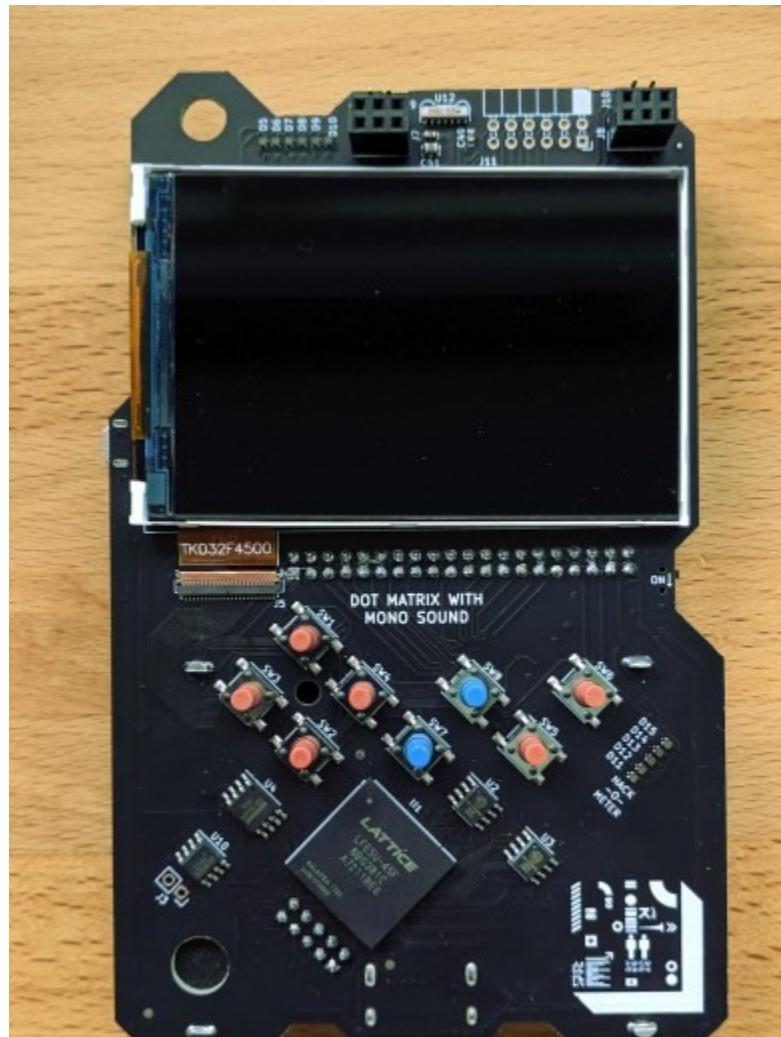
Drew Fustini
@pdp7

Awesome to see the Orange Crab ECP5 FPGA board by
@GregDavill in Lyon thanks to @antonblanchard! 🍔
🦀



Hackaday 2019 Supercon badge

- RISC-V “soft” core on ECP5 FPGA
- Gigantic FPGA In A Game Boy Form Factor



Slides: <https://github.com/pdp7/talks/blob/master/oshw-garage-2019.pdf>



Section:
Open Source and Chip Design

What about open source chips?



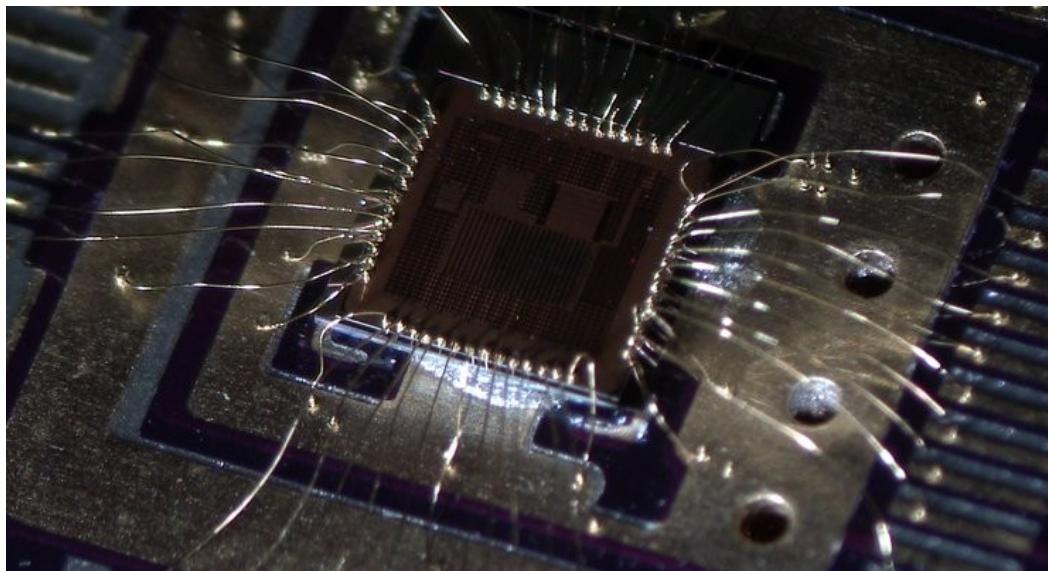
- **RISC-V: Free and Open RISC Instruction Set Arch**
 - “new instruction set architecture (ISA) that was originally designed to support computer architecture research and education and is now set to become a standard open architecture for industry”
 - Video: [Instruction Sets Want To Be Free: A Case for RISC-V](#)
 - Video: [Krste Asanovic presents](#) at RISC-V and Open Source Silicon Event in Munich on March 23, 2017

What about open source chips?



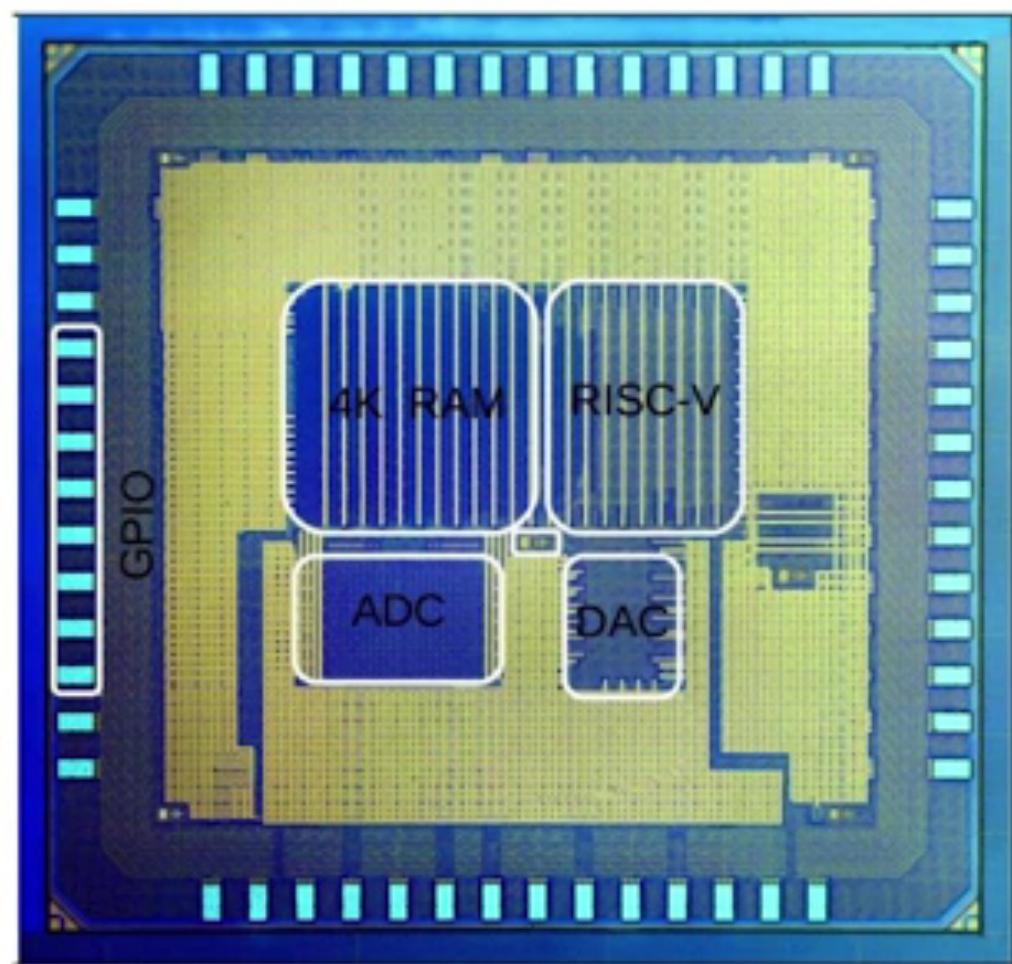
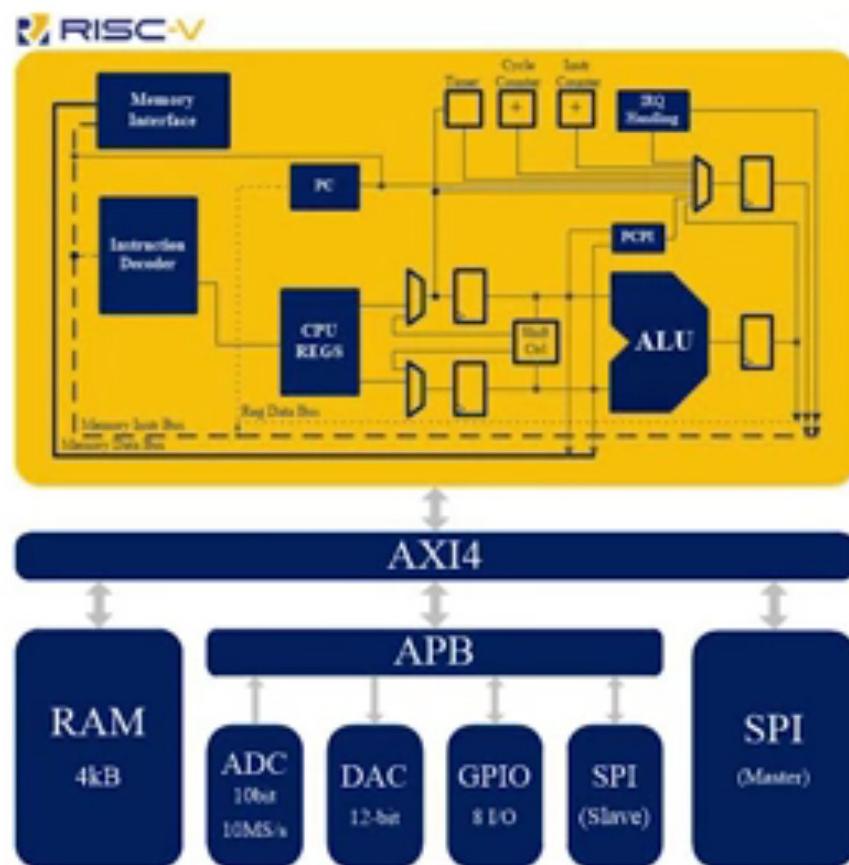
- [OnChip Open-V](#)

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



OnChip Open-V

A 32-bit RISC-V based Microcontroller



OnChip Open-V

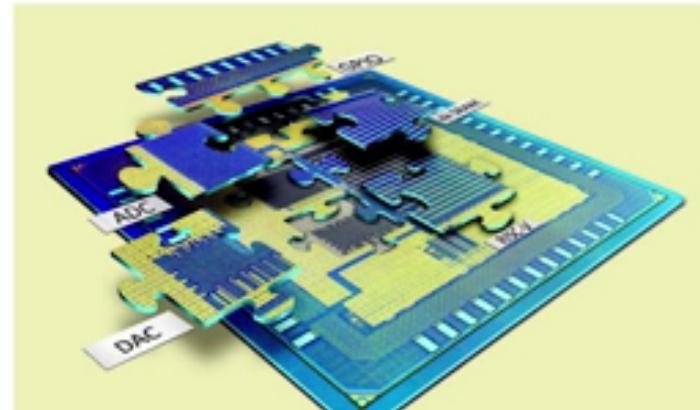


- Crowd Supply update: [A Taste of Chip Design](#)
- Video: [YoPuzzle: mRISC V development platform](#)
- Video: [RISC-V Community needs Peripheral Cores](#)

Good to have an Open ISA. What about Peripheral?



- IP vendors have IP based on previous customer. **Hard to get** a glue-and-play that works for your SoC. → \$\$\$
- There are some std, such as PHYs: USB, LPDDR, PCIe, AMBA
BUT
no for clocking circuitry, biasing, GPIO
For instance a simple Power-on-Reset can hit your pocket, just because!
- Buses IP are out there but expensive.

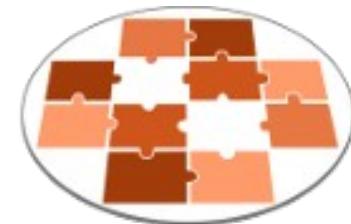


Open Source chip design



- 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”
- Video: [Rob Mullins talking about lowRISC](#)
(RISC-V & Open Source Silicon Event in Munich on March 23, 2017)
- [Laura James](#) from lowRISC is here!

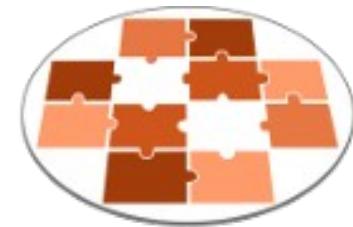
Open Source chip design



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”
 - “FOSSi Foundation operates as an open, inclusive, vendor-independent group.”

Open Source chip design

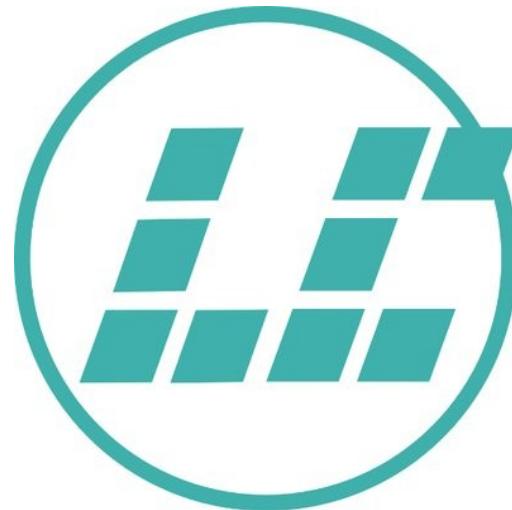


FOSSi
Foundation

- Open Source Silicon Design Ecosystem
 - Talk by FOSSi co-founder Julius Baxter



Open Source chip design



- **LibreCores**
 - Project of the FOSSi Foundation
 - “**gateway to free and open source digital designs** and other components that you can use and **re-use in your digital designs**”
 - “advances the idea of OpenCores.org”

Latch-Up Conf 2019 videos

Portland Oregon



May 4-5 2019

Week of Open Source Hardware

The video player displays a slide with the following content:

History

- March 2011: CERN OHL 1.0
- July 2011: CERN OHL 1.1
- September 2013: CERN OHL 1.2
- 2017: CERN OHL 2, beta 1
- 2019 : CERN OHL 2, beta 2

Below the slide, the video player interface shows:

CERN Open Hardware Licence 2.0
80 views

Like 3 | Dislike 0 | Share | Save | ...

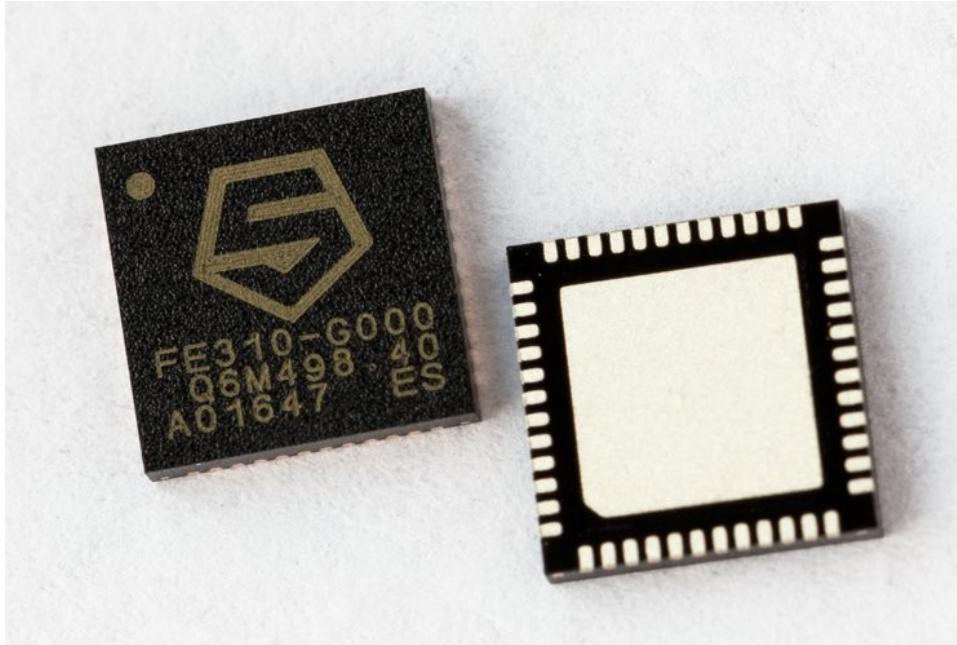


FOSSI Foundation

Published on Jun 20, 2019

SUBSCRIBE 654

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”

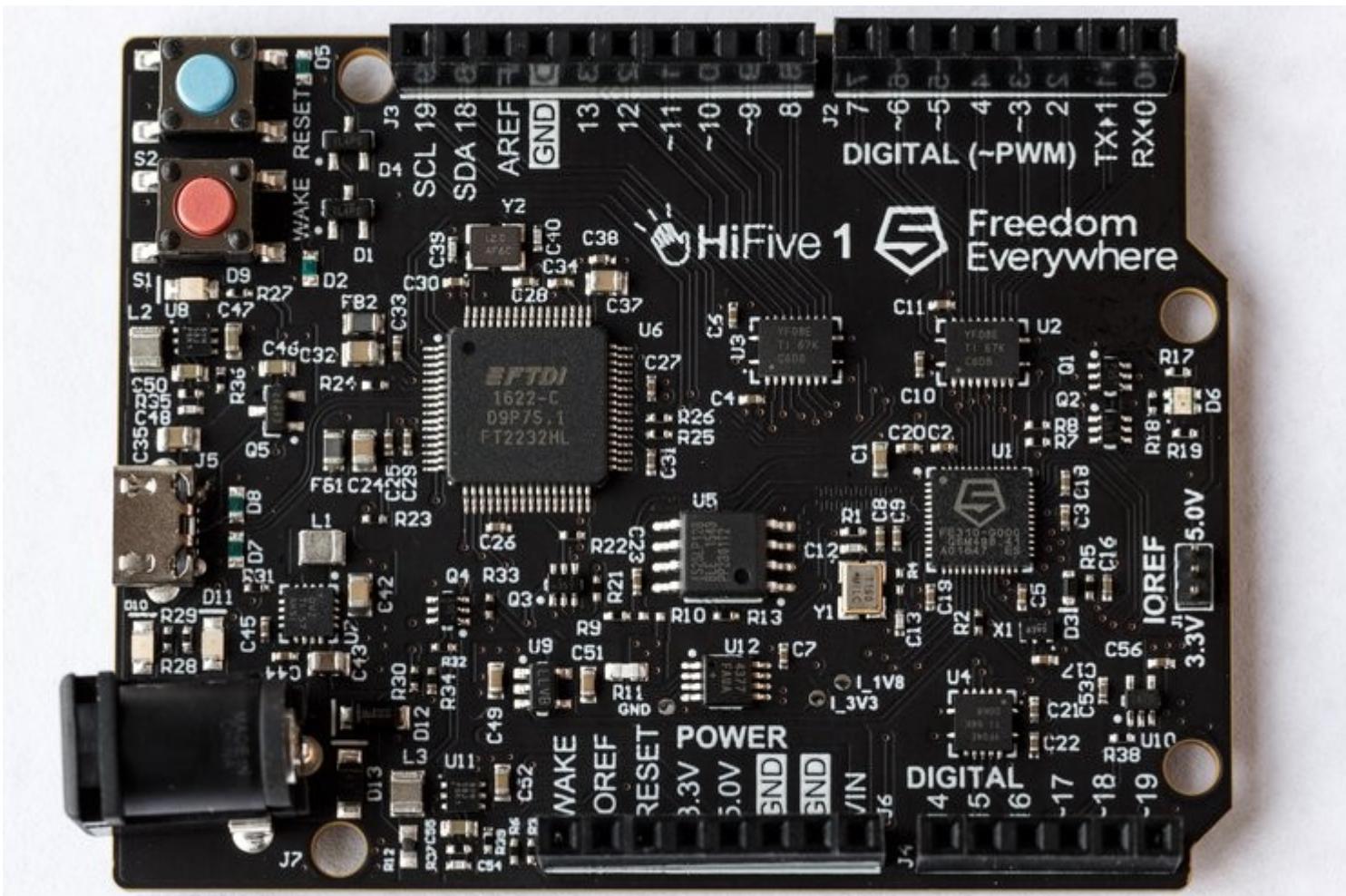
RISC-V ecosystem

- RISC-V Keynote at Embedded Linux Conf
 - March 12th, 2018
 - Yunsup Lee, Co-Founder and CTO, SiFive
 - Designing the Next Billion Chips: How RISC-V is Revolutionizing Hardware



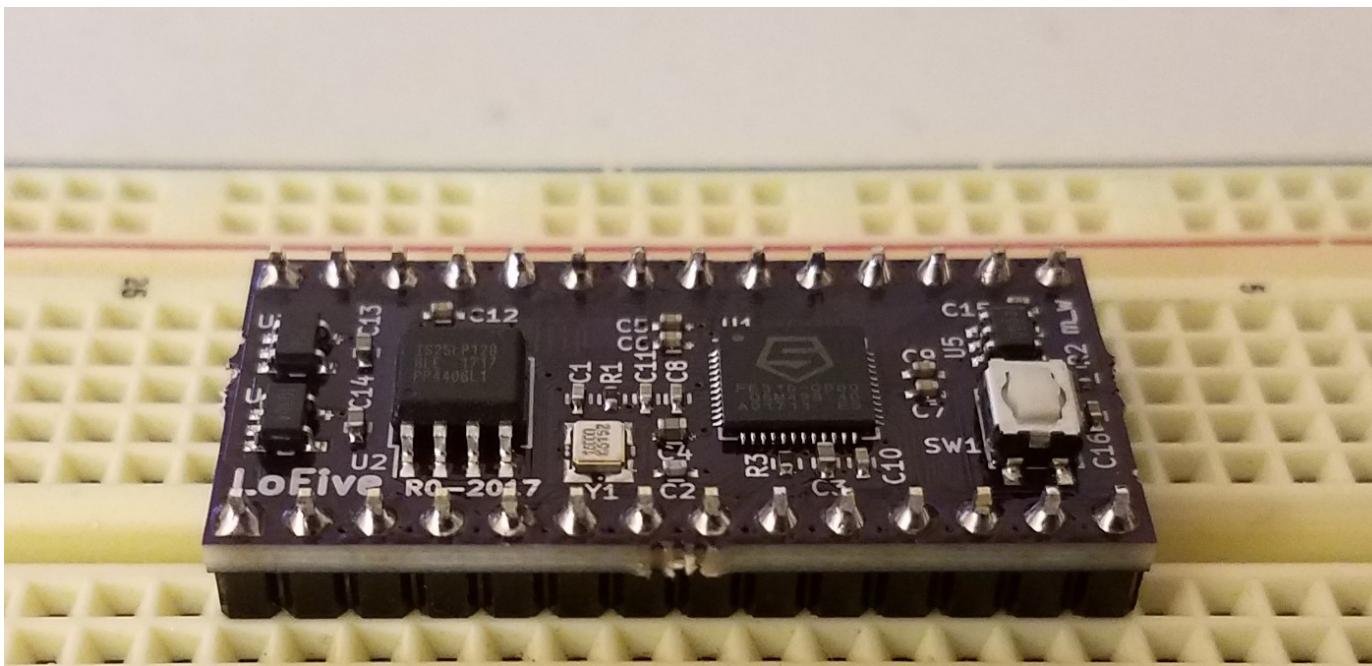
SiFive FE310 microcontroller

- HiFive1: Arduino-Compatible RISC-V Dev Kit



SiFive FE310 microcontroller

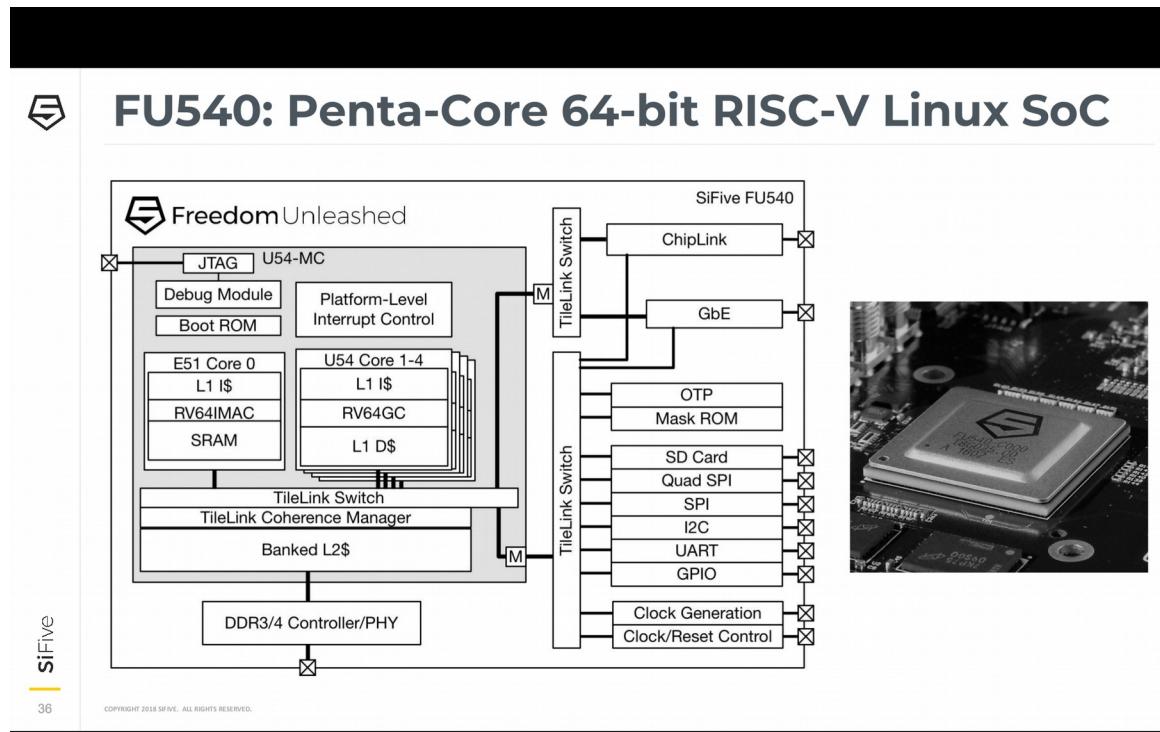
- [LoFive](#) designed by [Michael Welling](#)
(QWERTY Embedded Design)
- Lower cost eval board for SiFive FE310.
- [Open Source Hardware design files](#)
- Sold as group buy on [GroupGets](#)



SiFive: Linux on RISC-V

- FOSDEM 2018 talk

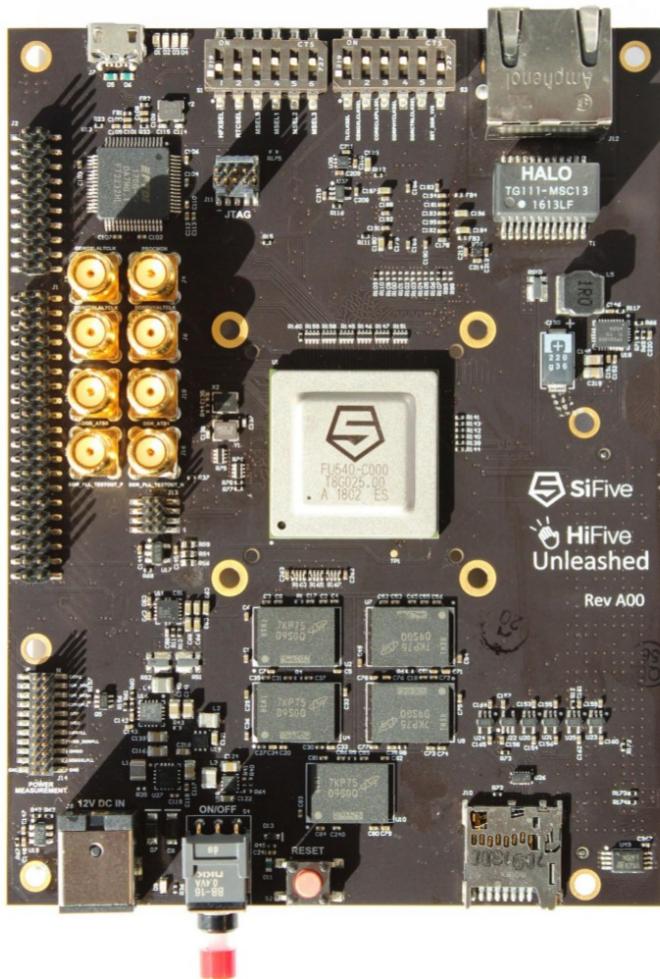
- YouTube: “Igniting the Open Hardware Ecosystem with RISC-V: SiFive's Freedom U500 is the World's First Linux-capable Open Source SoC Platform”
- Interview with Palmer Dabbelt of SiFive



SiFive: Linux on RISC-V



HiFive Unleashed



- World's First Multi-Core RISC-V Linux Development Board
 - SiFive FU540-C000 (built in 28nm)
 - 4+1 Multi-Core Coherent Configuration, up to 1.5 GHz
 - 4x U54 RV64GC Application Cores with Sv39 Virtual Memory Support
 - 1x E51 RV64IMAC Management Core
 - Coherent 2MB L2 Cache
 - 64-bit DDR4 with ECC
 - 1x Gigabit Ethernet
 - 8 GB 64-bit DDR4 with ECC
 - Gigabit Ethernet Port
 - 32 MB Quad SPI Flash
 - MicroSD card for removable storage
 - FMC connector for future expansion with add-in cards

OSHW RISC-V Linux board for less than \$100?

- Goal: Sub-\$100 Open Source Hardware board that can run Linux on RISC-V
- Possible by OHS 2020?
- Interested in working together?
 - drew@oshpark.com / Twitter: [@pdp7](https://twitter.com/pdp7)
 - create a mailing list?

Slides:
<https://github.com/pdp7/talks/blob/master/oshw-garage-2019.pdf>

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