

Slides: github.com/pdp7/talks/blob/master/fossn20light.pdf

Linux on RISC-V

FOSS North 2020: Virtual Lightning Talk



Drew Fustini
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- When you write a program in the Arduino IDE, it is compiled into instructions for the microcontroller to execute.
- How does the compiler know what instructions the chip understands?
 - defined by the **Instruction Set Architecture**
 - The **ISA** is a standard, a set of rules that define the tasks the processor can perform.
 - Examples: x86 (Intel/AMD) and ARM
 - Both are proprietary and need commercial licensing



- **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”



- Keynote at Hackday Supercon 2019 by Dr. Megan Wachs of SiFive
- **“RISC-V and FPGAs: Open Source Hardware Hacking”**
 - https://www.youtube.com/watch?v=vCG5_nxm2G4

- My column in the latest Hackspace Magazine is an introduction to RISC-V and how it is enabling open source chip design:
 - hackspace.raspberrypi.org/issues/27/



Drew Fustini

COLUMN

Open-source chips

Breaking free of chip design monopolies with RISC-V



Drew Fustini

When we think about what open-source hardware means, we usually think about the board design being freely available. But what about the processor? Is there a way to make hardware that is truly open source? This month's column is dedicated to an existing – and surprisingly political – development in chip design.

When you write a program in the Arduino IDE, it is compiled into instructions for the microcontroller to execute. How does the compiler know what instructions the chip understands? This is defined by the Instruction Set Architecture. The ISA is a standard, a set of rules that define the tasks the processor can perform.

Chances are that both your laptop and the data centre streaming your favourite movie are using an ISA owned by Intel or AMD. The processor in your smartphone is almost certainly using a proprietary ISA licensed from ARM. Proprietary standards can be overpriced, prevent innovation, or even disappear altogether when companies change strategy.

Enter RISC-V, a free and open ISA created by researchers at UC Berkeley, led by Krste Asanović and David Patterson. "We were always jealous that you could get industrial-strength software that was

open," Patterson explained to VentureBeat at the RISC-V Summit back in December. "But when it came to hardware, it was proprietary. Now, with RISC-V, we get the same kind of benefit. It helps education, and it helps competition."

This open standard proved to be useful outside of academia. Nvidia and Western Digital are now shipping millions of devices with RISC-V processors. These companies have the freedom to leverage open-source implementations while avoiding ARM licensing fees – which can really add up when shipping large volumes.

The ISA is a standard, a set of rules that define the tasks the processor can perform

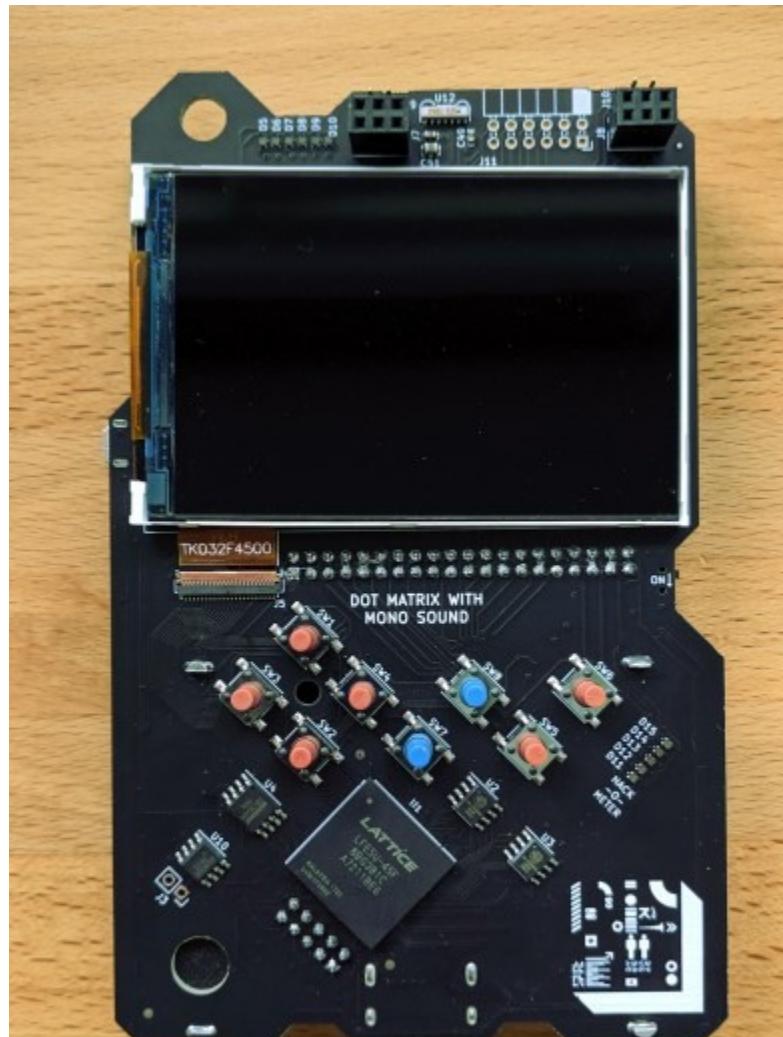
Nations such as India see the importance of being able to create processors that are not under the control of a foreign corporation, who may be forced to build in backdoors for their own government. There is also strong interest from chipmakers in China, especially now that US companies have been banned from doing business with Huawei.

With these financial and political motivations, plus an increasingly mature software ecosystem, including Linux support, it won't be long before you have a device with a RISC-V processor in your home or pocket.

You can learn more about the exciting possibilities that RISC-V unleashes from Dr. Megan Wachs by pointing your web browser to hsmag.cc/qw-led.

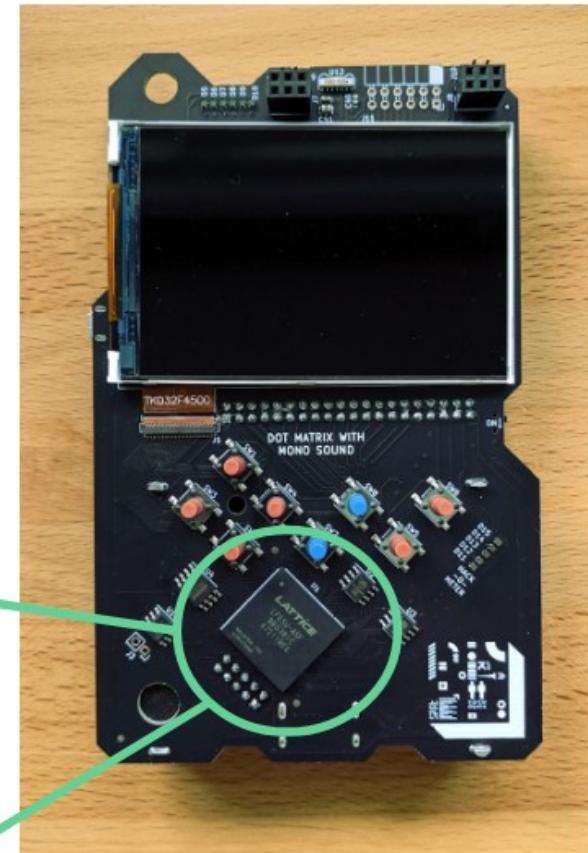
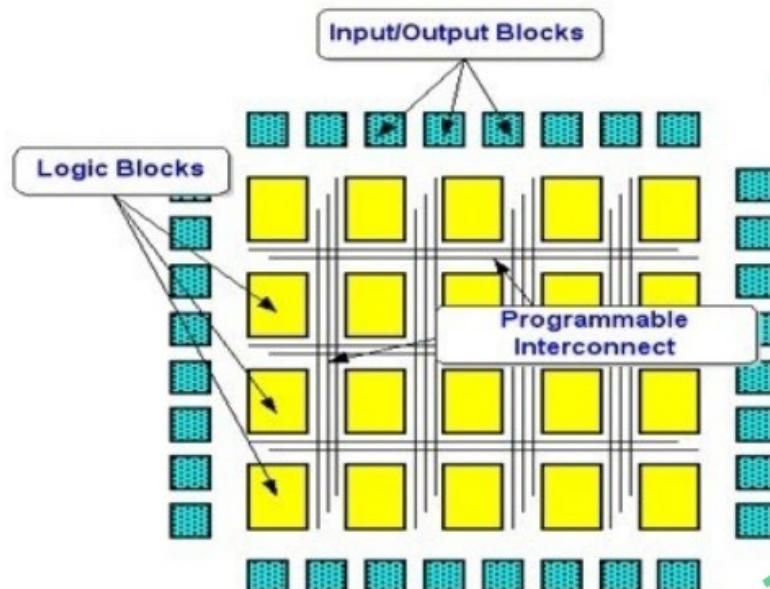
Hackaday 2019 Supercon badge

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



Where do FPGAs Come In?

- Field Programmable Gate Array
- Change a chip's HARDWARE in a few minutes
- Make it act like a new chip!



Open Source and FPGAs

- Hackspace Magazine column about how open source FPGA tools developed by [Claire Wolf \(oe1cxw\)](#), [David Shah](#) and others have made FPGAs more accessible than ever before to makers and hackers:
 - hackspace.raspberrypi.org/issues/26/

MAKE | BUILD | HACK | CREATE **132 PAGES** OF MAKING

HackSpace

TECHNOLOGY IN YOUR HANDS

hsmag.cc | January 2020 | Issue #26

WHAT 3D PRINTER?

Find the ultimate replicator for 2020

CIRCUIT PYTHON

SOLDERING WITH GAS

PICKING AN IMPACT DRIVER

SEWING MACHINES

Building a kiln

Melting glass with a Raspberry Pi

Drew Fustini

@pdpf

Drew Fustini is a hardware designer and embedded Linux developer. He is the Vice President of the Open Source Hardware Association, and a board member of the BeagleBoard Foundation. Drew designs circuit boards for OSH Park, a PCB manufacturing service, and maintains the Adafruit BeagleBone Python library.

FPGA

FPGAs have been the talk of the town at many of this year's hacker conferences. But what exactly is an FPGA, and why are they so hot right now?

FPGA stands for Field Programmable Gate Array, a digital logic chip that can be programmed to reconfigure the internal hardware. An FPGA does not run software – it physically changes the configuration of its gate arrays to adapt to the task at hand. Is an FPGA an incredibly versatile tool? Need 25 PWM pins for a project? No problem. Want to replicate the functionality of a vintage CPU? Your FPGA has you covered. Not only is an FPGA versatile, but it is also better at handling timing-critical tasks than a microcontroller. You can filter high-speed sensor data before it's read by your processor, or offload repetitive tasks like debouncing buttons from the burden on your microcontroller.

FPGAs are hot right now but they're not a new technology – they've been used in industry for decades

The Lattice ECP5 FPGA is capable of more advanced features than the iCE40, and it's easier to get started with too, thanks to Project Trellis led by David Shah. This enabled the ECP5-powered Supercon badge to have cool features like HDMI video, while still being open for anyone to hack on without requiring proprietary tools.

FPGAs are a fascinating technology with lots of awesome applications. If you want to find out more, start off by reading Luke Valenty's *The Hobbyists Guide to FPGAs on Hackaday.io*. (hsmag.cc/GOAQnR), and watch Tim Ansell's Supercon talk to learn about the exciting future of open-source FPGA tools (hsmag.cc/kY5IPD). □

The rise of the FPGA

Reconfigure your chips to suit your project

FPGAs are hot right now but they're not a new technology – they've been used in industry for decades

This opened the door for low-cost, open hardware boards such as myStorm Blackice, TinyFPGA, iCEBreaker, and Fomu, which are great tools for teaching workshops and building projects.

The Lattice ECP5 FPGA is capable of more advanced features than the iCE40, and it's easier to get started with too, thanks to Project Trellis led by David Shah. This enabled the ECP5-powered Supercon badge to have cool features like HDMI video, while still being open for anyone to hack on without requiring proprietary tools.

FPGAs are a fascinating technology with lots of awesome applications. If you want to find out more, start off by reading Luke Valenty's *The Hobbyists Guide to FPGAs on Hackaday.io*. (hsmag.cc/GOAQnR), and watch Tim Ansell's Supercon talk to learn about the exciting future of open-source FPGA tools (hsmag.cc/kY5IPD). □

HackSpace

23

- Open Source toolchains for FPGAs!
 - Project Trellis for Lattice ECP5
 - “Project Trellis and nextpnr FOSS FPGA flow for the Lattice ECP5”
 - David Shah (@fpga_dave)
 - youtube.com/watch?v=0se7kNes3EU

Project Trellis and nextpnr FOSS FPGA flow for the Lattice ECP5

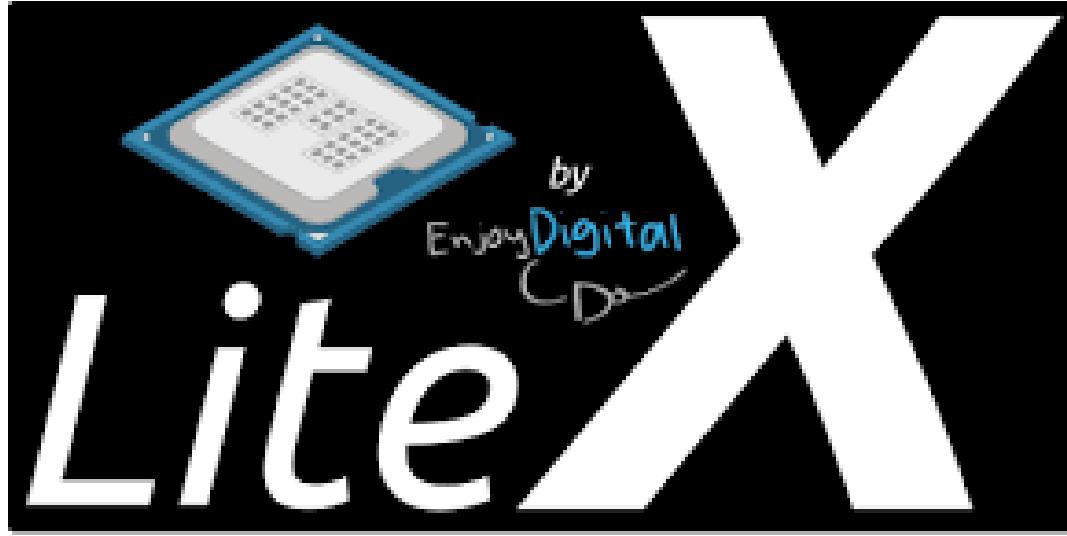
Project Trellis & nextpnr

FOSS Tools for ECP5 FPGAs

David Shah
@fpga_dave
Symbiotic EDA || Imperial College London

FOSDEM 19
.org

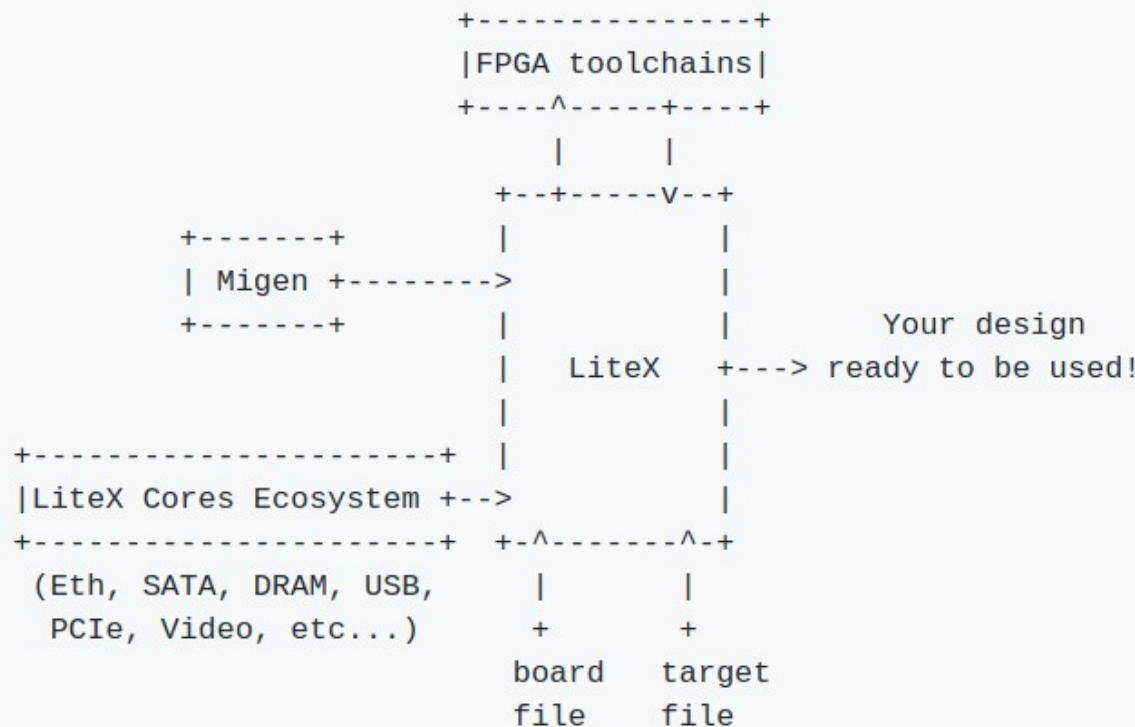




Build your hardware, easily!

- LiteX used to build cores, create SoCs and full FPGA designs.
- LiteX is based on Migen
- Migen lets you do FPGA design in Python!
- <https://github.com/enjoy-digital/litex>

Typical LiteX design flow:



LiteX already supports various softcores CPUs: LM32, Mor1kx, PicoRV32, VexRiscv and is compatible with the LiteX's Cores Ecosystem:

Name	Build Status	Description
LiteDRAM	build passing	DRAM
LiteEth	build passing	Ethernet
LitePCIe	build passing	PCIe
LiteSATA	build passing	SATA

Linux on LiteX-VexRiscv

- VexRiscv: 32-bit Linux Capable RISC-V CPU
 - SoC built using VexRiscv core and LiteX modules like LiteDRAM, LiteEth, LiteSDCard, ...
 - github.com/litex-hub/linux-on-litex-vexriscv

“Team Linux on Badge”

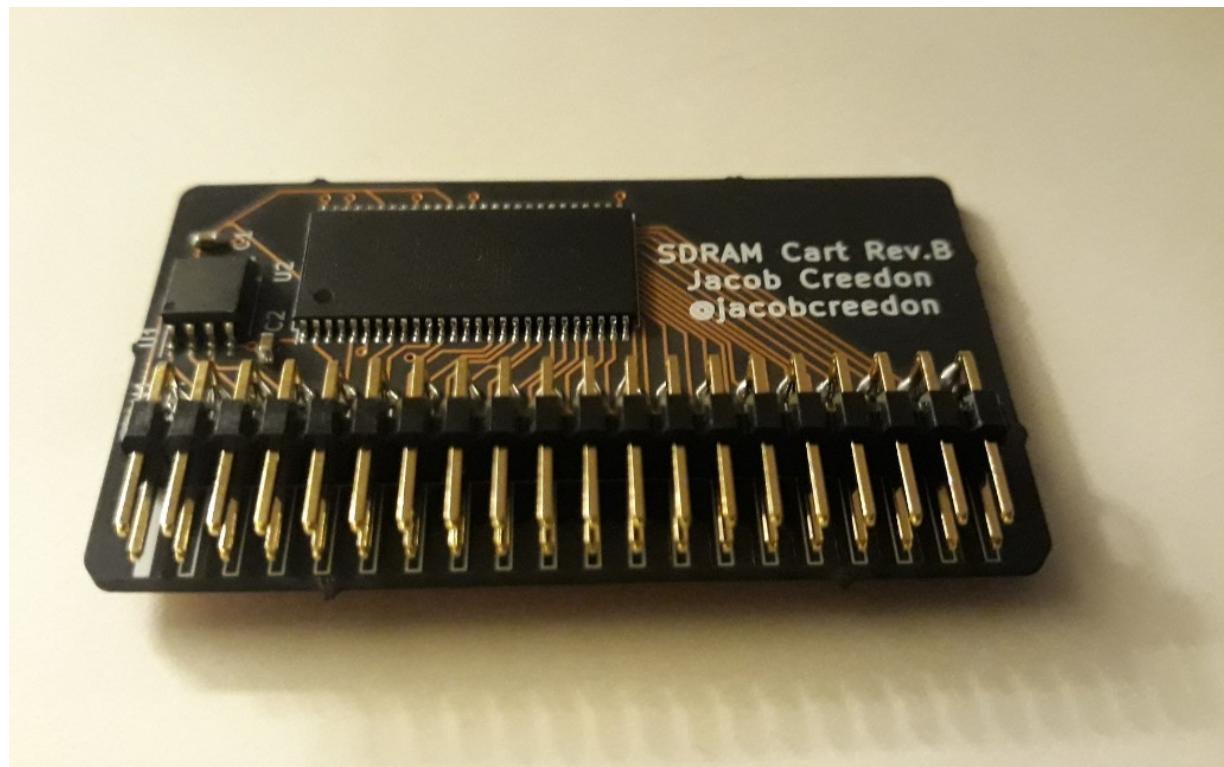


“Team Linux on Badge”

- Blog post: Hackaday Supercon badge boots Linux using SDRAM cartridge
 - <https://blog.oshpark.com/2019/12/20/boot-linux-on-this-hackaday-supercon-badge-with-this-sdram-cartridge/>
- Michael Welling (@QwertyEmdedded), Tim Ansell (@mithro), Sean Cross (@xobs), Jacob Creedon (@jacobcreedon)
- First attempt: use the built-in 16MB SRAM... no luck :(
 - (*though xobs now might have a way to do it*)

“Team Linux on Badge”

- Second attempt:
 - Jacob Creedon designed an a cartridge board that adds 32MB of SDRAM to the Hackaday Supercon badge... before the event!







- upstream support for Hackaday Supercon badge:
 - <https://github.com/litex-hub/litex-boards/pull/31>

[litex-hub / litex-boards](#)

Unwatch 7 Unstar 17 Fork 24

Code Issues 2 Pull requests 1 Actions Projects 0 Wiki Security Insights

add the Hackaday Supercon ECP5 badge #31

Merged enjoy-digital merged 1 commit into `litex-hub:master` from `pdp7:master` 21 days ago

Conversation 18 Commits 1 Checks 1 Files changed 2 +461 -0

 pdp7 commented 22 days ago • edited

Contributor + ...

Add the [Hackaday Supercon 2019 badge](#) which has an ECP5 FPGA.

These changes are from a [fork](#) by Michael Welling (@mwelling)

During Supercon, we tried two approaches:

- use the built-in 16MB QSPI SRAM
- use add-on cartridge with 32MB SDRAM by Jacob Creedon

We were not able to get the QSPI SRAM working so I've removed those changes, and I have just added the changes that are needed to boot Linux with the 32MB SDRAM.

In addition to @mwelling, thank you to Jacob Creedon (@jcreedon), @gregdavill, Tim Ansell (@mithro), and Sean Cross (@xobs) who all helped get Linux working on this badge.

Reviewers
No reviews

Assignees
No one assigned

Labels
None yet

Projects
None yet

Milestone

- upstream support for Hackaday Supercon badge:
 - <https://github.com/litex-hub/litex-boards/pull/31>

Merged add the Hackaday Supercon ECP5 badge #31 Changes from all commits ▾ File filter... ▾ Jump to... ▾ ⚙ Review changes ▾

215 litex_boards/partner/platforms/hadbadge.py

```

@@ -0,0 +1,215 @@
+ from litex.build.generic_platform import *
+ from litex.build.lattice import LatticePlatform
+
+ # IOs -----
+
+ _io = [
+     ("clk8", 0, Pins("U18"), IOStandard("LVCMOS33")),
+     ("programn", 0, Pins("R1"), IOStandard("LVCMOS33")),
+     ("serial", 0,
+         Subsignal("rx", Pins("U2"), IOStandard("LVCMOS33"), Misc("PULLMODE=UP")),
+         Subsignal("tx", Pins("U1"), IOStandard("LVCMOS33")),
+     ),
+     ("led", 0, Pins("E3 D3 C3 C4 C2 B1 B20 B19 A18 K20 K19"), IOStandard("LVCMOS33")), # Anodes
+     ("led", 1, Pins("P19 L18 K18"), IOStandard("LVCMOS33")), # Cathodes via FET
+     ("usb", 0,
+         Subsignal("d_p", Pins("F3")),
+         Subsignal("d_n", Pins("G3")),
+         Subsignal("pullup", Pins("E4")),
+         Subsignal("vbusdet", Pins("F4")),
+         IOStandard("LVCMOS33")
+     ),
+     ("keypad", 0,
+         Subsignal("left", Pins("G2"), Misc("PULLMODE=UP"))
+     )
+ ]

```

- upstream support for Hackaday Supercon badge:
 - <https://github.com/litex-hub/litex-boards/pull/31>

Merged add the Hackaday Supercon ECP5 badge #31 Changes from all commits ▾ File filter... ▾ Jump to... ▾ ⚙ ▾ Review changes ▾

246 litex_boards/partner/targets/hadbadge.py

Viewed ...

```
@@ -0,0 +1,246 @@
+#!/usr/bin/env python3
+
+ # This file is Copyright (c) 2018-2019 Florent Kermarrec <florent@enjoy-digital.fr>
+ # This file is Copyright (c) 2018 David Shah <dave@ds0.me>
+ # License: BSD
+
+ import argparse
+ import sys
+
+ from migen import *
+ from migen.genlib.resetsync import AsyncResetSynchronizer
+
+ from litex_boards.platforms import hadbadge
+
+ from litex.soc.cores.clock import *
+ from litex.soc.integration.soc_sdram import *
+ #from litex.soc.integration.soc_core import *
+ from litex.soc.integration.builder import *
+
+ #from .spi_ram_dual import SpiRamDualQuad
+
+ from litedram import modules as litedram_modules
+ from litedram.phy import GENSDRPHY
```

[Code](#)[Issues 17](#)[Pull requests 2](#)[Actions](#)[Security](#)[Insights](#)

add the Hackaday Supercon ECP5 badge #68

Mergedenjoy-digital merged 1 commit into [litex-hub:master](#) from [pdp7:master](#)  21 days ago[Conversation 2](#)[Commits 1](#)[Checks 0](#)[Files changed 1](#)

pdp7 commented 22 days ago

Contributor

+ ...

Add the [Hackaday Supercon 2019 badge](#) which has an ECP5 FPGA.

These changes are from [a fork](#) by Michael Welling (@mwelling)

During Supercon, we tried two approaches:

- use the built-in 16MB QSPI SRAM
- use add-on cartridge with 32MB SDRAM by Jacob Creedon

We were not able to get the QSPI SRAM working so I've removed those changes, and I have just added the changes that are needed to boot Linux with the 32MB SDRAM.

In addition to @mwelling, thank you to Jacob Creedon (@jcreedon), @gregdavill, Tim Ansell

Merged

add the Hackaday Supercon ECP5 badge #68

Changes from all commits ▾ File filter... ▾ Jump to... ▾ ⚙

▼ 13 [make.py] ↗

```
@@ -160,6 +160,16 @@ def __init__(self):  
160      160          def load(self):  
161      161              os.system("ujprog build/ulx3s/gateware/top.svf")  
162      162  
163 + # HADBadge support -----  
164 +  
165 + class HADBadge(Board):  
166 +     def __init__(self):  
167 +         from litex_boards.targets import hadbadge  
168 +         Board.__init__(self, hadbadge.BaseSoC, {"serial"})  
169 +  
170 +     def load(self):  
171 +         os.system("dfu-util --alt 2 --download build/hadbadge/gateware/top.bit --reset")  
172 +  
163      173      # OrangeCrab support -----  
164      174  
165      175      class OrangeCrab(Board):  
@@ -209,6 +219,7 @@ def load(self):  
209      219          # Lattice
```

[Code](#)[Issues 21](#)[Pull requests 3](#)[Actions](#)[Projects 0](#)[Wiki](#)[Security](#)[In](#)

add 32MB SDRAM for hadbadge #97

Mergedenjoy-digital merged 1 commit into [enjoy-digital:master](#) from [pdp7:master](#)  21 days ago[Conversation 2](#)[Commits 1](#)[Checks 0](#)[Files changed 1](#)

pdp7 commented 22 days ago

Contributor



...

Add AS4C32M8SA-7TCN 32MB SDRAM used on cartridge PCB by Jacob Creedon (@jcreedon) for the [Hackaday Supercon 2019 badge](#) which has an ECP5 FPGA.

These changes are from [a fork](#) by Michael Welling (@mwelling)

In addition to @mwelling, thank you to Jacob Creedon (@jcreedon), @gregdavill, Tim Ansell (@mithro), and Sean Cross (@xobs) who all helped get Linux working on this badge.

KiCad design files by @jcreedon for the SDRAM cartridge are [available on GitHub](#).

There is also a [shared project](#) to order the SDRAM cartridge PCB.

Refer to [my blog post](#) for more information.

Merged

add 32MB SDRAM for hadbadge #97

Changes from all commits ▾

File filter... ▾

Jump to... ▾



9 litedram/modules.py



```
@@ -190,6 +190,15 @@ class AS4C32M16(SDRAMModule):
190      technology_timings = _TechnologyTimings(tREFI=64e6/8192, tWTR=(2, None), tCCD=(1,
191      speedgrade_timings = {"default": _SpeedgradeTimings(tRP=18, tRCD=18, tWR=12, tRFC=
192
193 +     class AS4C32M8(SDRAMModule):
194 +         memtype = "SDR"
195 +         # geometry
196 +         nbanks = 4
197 +         nrows  = 8192
198 +         ncols   = 1024
199 +         # timings
200 +         technology_timings = _TechnologyTimings(tREFI=64e6/8192, tWTR=(2, None), tCCD=(1,
201 +         speedgrade_timings = {"default": _SpeedgradeTimings(tRP=20, tRCD=20, tWR=15, tRFC=
193
194     # DDR -----
195
```



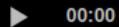
- Opened GitHub issue:
 - optimize performance on Hackaday Badge #35
 - <https://github.com/litex-hub/litex-boards/issues/35>
- Now 10x faster!
 - <https://asciinema.org/a/Pcm3vd1BEdEKY9srYX6MsNfCE>
 - Thanks to [enjoy-digital](#)



Asciicast updated.

```
[ 7.896093] Initramfs unpacking failed: junk in compressed archive
[ 7.953813] workingset: timestamp_bits=30 max_order=13 bucket_order=0
[ 9.236463] Block layer SCSI generic (bsg) driver version 0.4 loaded (major 253)
[ 9.239004] io scheduler mq-deadline registered
[ 9.240102] io scheduler kyber registered
[ 13.977920] f0001000.serial: MMIO 0xf0001000 (irq = 0, base_baud = 0) is a liteuart
[ 13.980290] printk: console [liteuart0] enabled
[ 13.980290] printk: console [liteuart0] enabled
[ 13.982965] printk: bootconsole [sbi0] disabled
[ 13.982965] printk: bootconsole [sbi0] disabled
[ 14.058778] libphy: Fixed MDIO Bus: probed
[ 14.074959] i2c /dev entries driver
[ 14.247461] NET: Registered protocol family 10
[ 14.307974] Segment Routing with IPv6
[ 14.315214] sit: IPv6, IPv4 and MPLS over IPv4 tunneling driver
[ 14.455698] Freeing unused kernel memory: 140K
[ 14.457905] This architecture does not have kernel memory protection.
[ 14.459170] Run /init as init process
mount: mounting tmpfs on /dev/shm failed: Invalid argument
mount: mounting tmpfs on /tmp failed: Invalid argument
mount: mounting tmpfs on /run failed: Invalid argument
Starting syslogd: OK
Starting klogd: OK
Running sysctl: OK
Initializing random number generator... [ 23.063050] random: dd: uninitialized urandom read (512 bytes read)
done.
Starting network: OK
Starting dropbear sshd: [ 27.336210] random: dropbear: uninitialized urandom read (32 bytes read)
OK
```

Welcome to Buildroot



00:00



Linux boots on Hackaday Supercon FPGA badge [10x faster!]

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optimize performance on Hackaday Badge #35

[Edit](#)[New issue](#)[Open](#)

pdp7 opened this issue 17 days ago · 7 comments



pdp7 commented 17 days ago

Contributor



...

Assignees

No one assigned

Labels

None yet

Projects

None yet

Milestone

No milestone

Notifications

Customize

[Unsubscribe](#)

You're receiving notifications because
you're watching this repository.

[Related to comments in PR #31 \(comment\)](#)

The performance of the ECP5 Hackaday Badge with 32MB SDRAM is "painfully" slow.

@mithro suggested there could be some issue with the configuration.

@enjoy-digital has attempted some optimizations:

[#31 \(comment\)](#)

With [enjoy-digital/litedram@ 34e6c24](#) and [enjoy-digital/litex@ fa22d6a](#) we have a ~10% boot time speedup on designs using SDRAM:

- De0Nano: 94.6.s to 84.6s
- ULX3S: 75.9s to 68.2s

On Arty with DDR3 the gain is effect more limited: 8.7s to 8.4s. That would be interesting to test this on the badge.

I will measure if the boot time improve

Open

optimize performance on Hackaday Badge #35

pdp7 opened this issue 17 days ago · 7 comments



pdp7 commented 15 days ago • edited

Contributor

Author

+ 😊 ...

@enjoy-digital WOW! much faster! It gets to login in 28 seconds (previous version was 258 seconds).

Recording:

<https://asciinema.org/a/Pcm3vd1BEdEKY9srYX6MsNfCE>

Text:

```
pdp7@x1:~/dev/enjoy/linux-on-litex-vexriscv$ lxterm --images=images.json /dev  
[LXTERM] Starting....  
lBIOS CRC passed (561ab1e2)
```

```
Migen git sha1: 063188e  
LiteX git sha1: -----
```

```
-===== SoC =====  
CPU: VexRiscv @ 48MHz  
ROM: 32KB  
SRAM: 4KB  
Lo:
```



enjoy-digital committed 15 days ago

1 parent 2317519

commit 39ce39a298f5



Showing **1 changed file** with **5 additions** and **3 deletions**.

8 litex/soc/integration/soc_sdram.py

@@ -26,12 +26,13 @@ class SoCSDRAM(SoCCore):

26 26 }

```
27      27      csr_map.update(SoCCore.csr_map)
```

28

```
-      def __init__(self, platform, clk_freq, l2_size=8192, **kwargs):
```

```
29 +     def __init__(self, platform, clk_freq, l2_size=8192, l2_data_width=128, **kwargs):
```

```
30      30          SoCCore.__init__(self, platform, clk_freq, **kwargs)
```

```
31      31          if not self.integrated_main_ram_size:
```

```
32      32          if self.cpu_type is not None and self.csr_data_width > 32:
```

```
raise NotImplementedException("BIOS supports SDRAM initialization only for c
```

34 - self.l2_size = l2_size

34 + self.l2_size = l2_size

35 + self.l2_data_width = l2_data_width

35 36

36 37 self, s dram phy = []

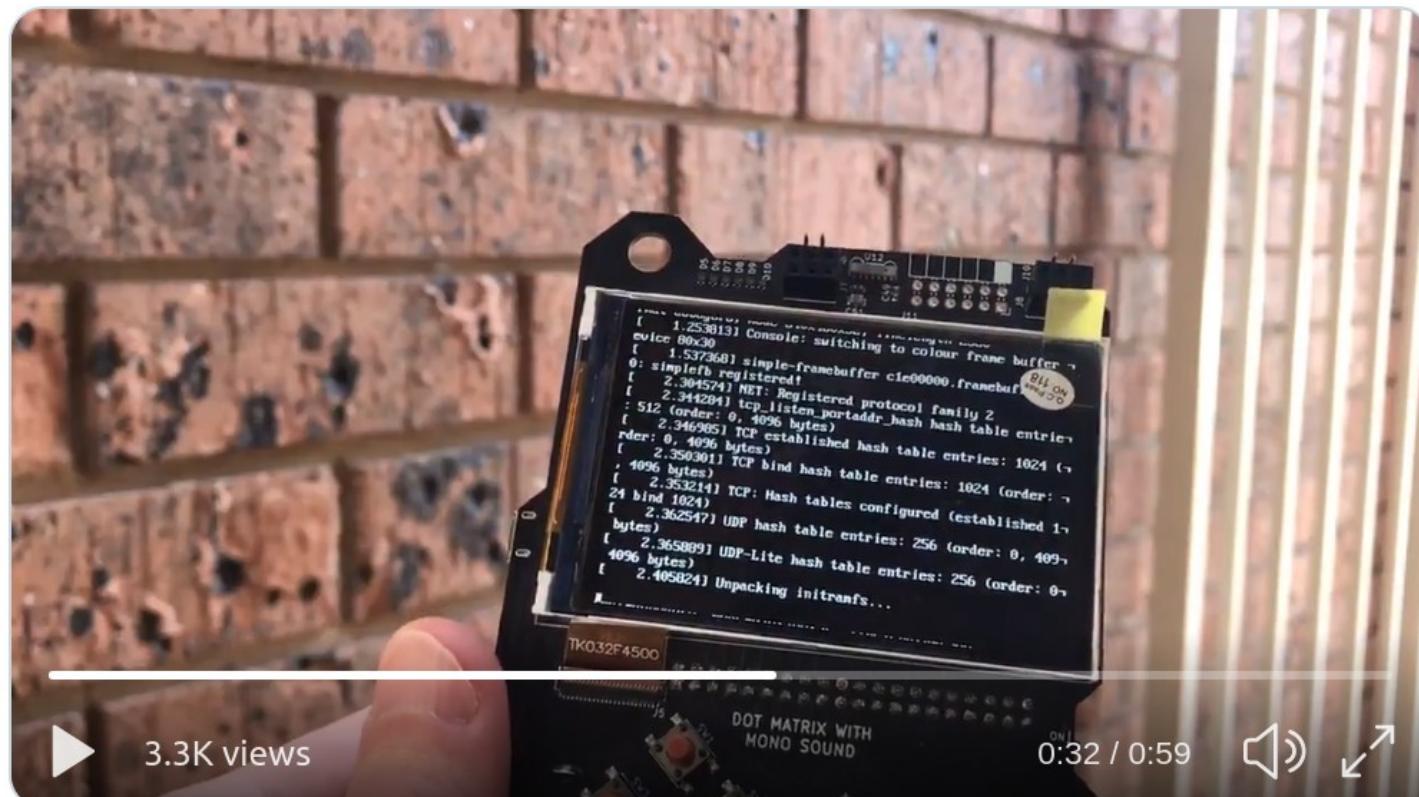
```
37      38          self.wb_sdram_ifs = []
```

- Greg Davill got the screen working with LiteVideo!
 - twitter.com/GregDavill/status/1231082623633543168



A screenshot of a Twitter post from user @GregDavill. The profile picture shows a man with short hair. The tweet text reads: "Now you can enjoy watching Linux boot while outside!! 😊". The timestamp is 8:03 AM · Mar 10, 2020.

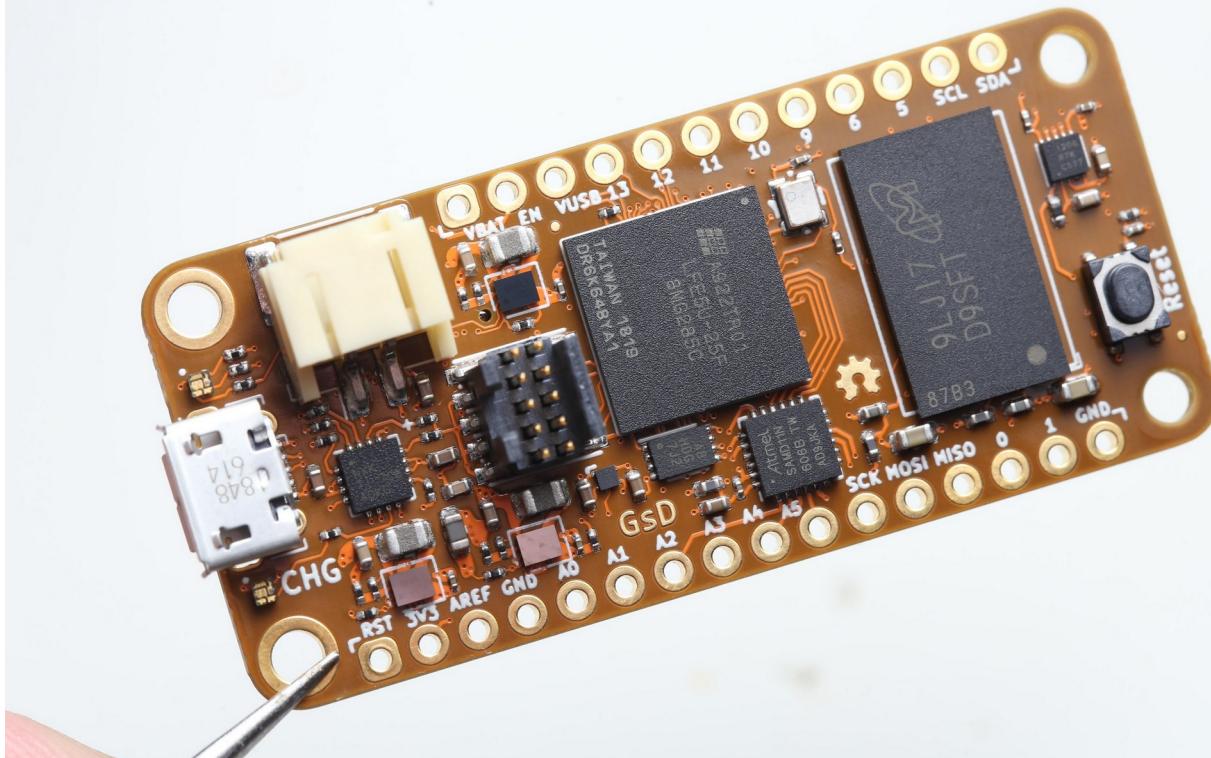
No PC tether required.



Bonus:
Open Source boards with
ECP5 FPGA
(can run Linux)

Open Source ECP5 boards

- Lattice ECP5 FPGA in Adafruit Feather form factor and 128MB DDR RAM:
 - Orange Crab by Greg Davill
 - <https://github.com/gregdavill/OrangeCrab>
 - <https://groupgets.com/campaigns/710-orangecrab>





Greg @ #36c3
@GregDavill



Replying to @mithro @pdp7 and 2 others

Done. 😊

```
File Edit View Terminal Tabs Help
SRAM:      4KB
L2:        8KB
MAIN-RAM: 131072KB

----- Initialization -----
Initializing SDRAM...
SDRAM now under software control
Read leveling:
m0, b0: |11100000| delays: 01+-01
best: m0, b0 delays: 01+-01
m1, b0: |11100000| delays: 01+-01
best: m1, b0 delays: 01+-01
SDRAM now under hardware control
Memtest OK

----- Boot -----
Booting from serial...
Press Q or ESC to abort boot completely.
sL5DdSMmkekro
[LXTERM] Received firmware download request from the device.
[LXTERM] Uploading buildroot/Image to 0xc0000000 (4545524 bytes)...
[LXTERM] Upload complete (85.6KB/s).
[LXTERM] Uploading buildroot/rootfs.cpio to 0xc0800000 (8029184 bytes)...
[ 0:43 ] 1.2K views => | 98%
```



Open Source ECP5 boards

- Radiona.org ULX3S
 - <https://www.crowdsupply.com/radiona/ulx3s>
-

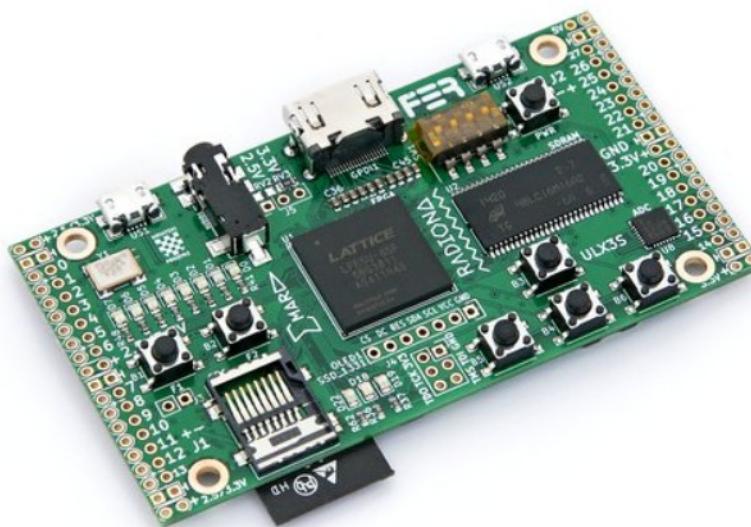
ULX3S

A powerful, open hardware ECP5 FPGA dev board

This project is coming soon. Sign up to receive updates and be notified when this project launches.

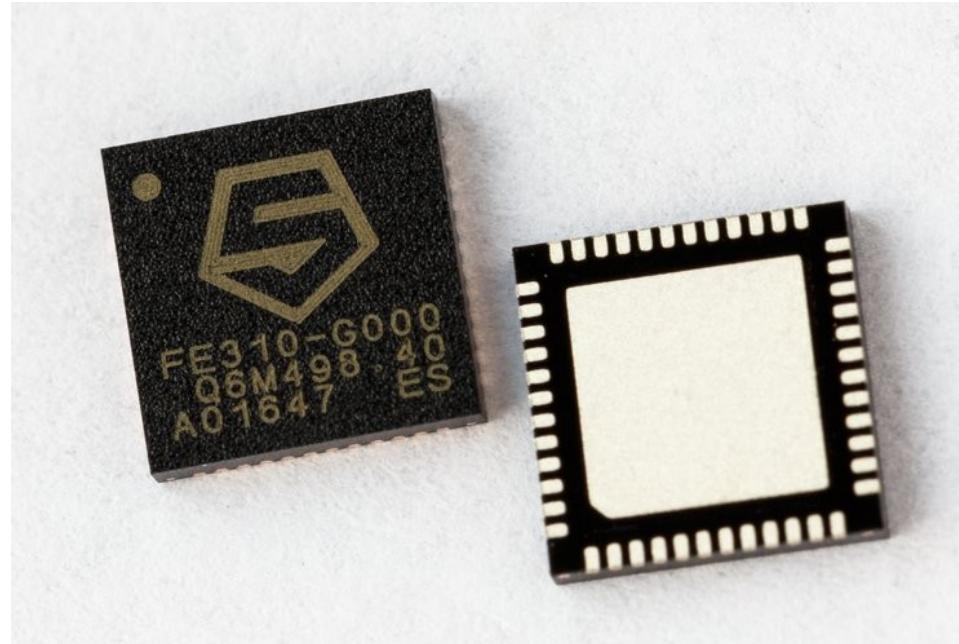
me@example.com

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Bonus:
Linux-capable RISC-V chips

SiFive

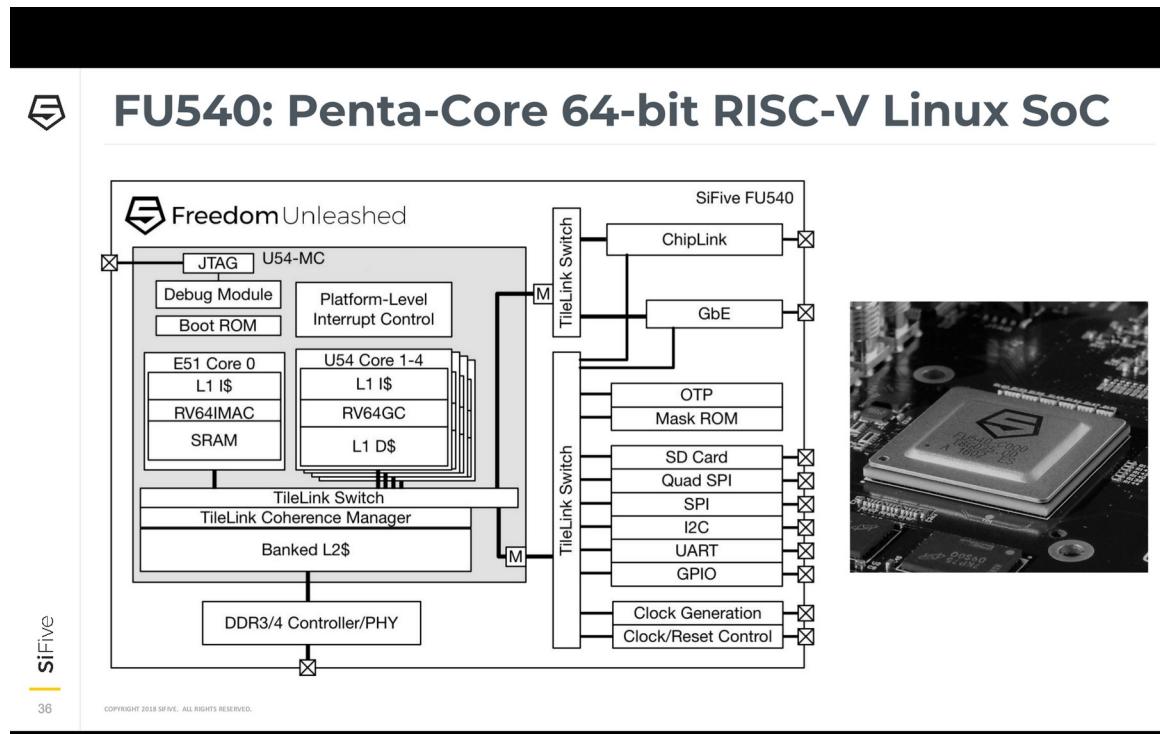


- “founded by the creators of the free and open RISC-V architecture as a reaction to the end of conventional transistor scaling and escalating chip design costs”

SiFive: Linux on RISC-V

- FOSDEM 2018 talk

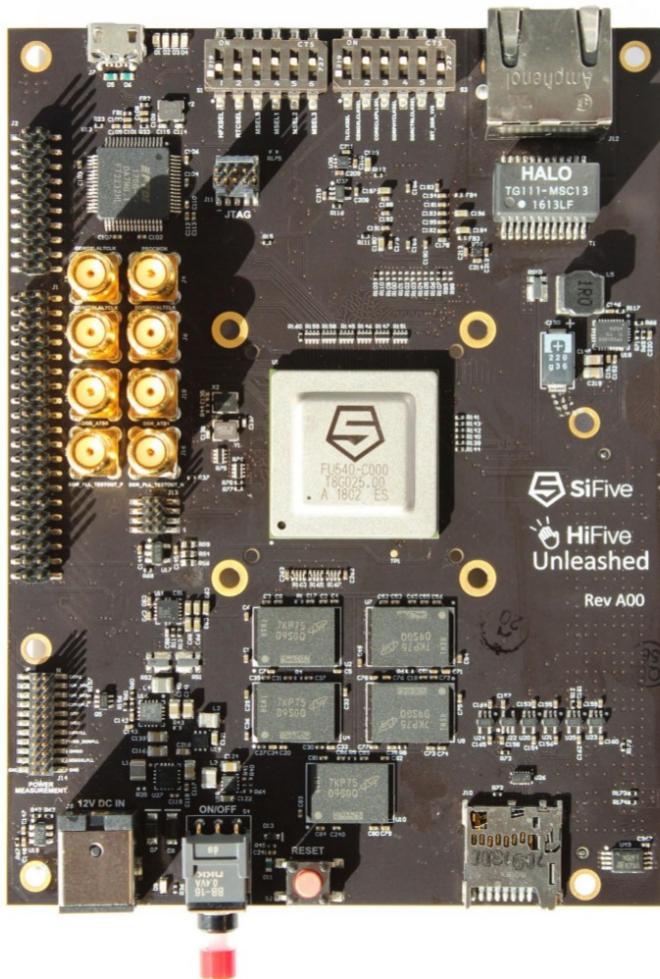
- YouTube: “Igniting the Open Hardware Ecosystem with RISC-V: SiFive's Freedom U500 is the World's First Linux-capable Open Source SoC Platform”
- Interview with Palmer Dabbelt of SiFive



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

RISC-V Summit 2019: Linux on RISC V Fedora and Firmware Status Update

- <https://www.youtube.com/watch?v=WC6e3g8uWdk>
- Wei Fu – Software Engineer, Red Hat

The slide features a central diagram with a green arrow pointing from a green box labeled 'Rich Software EcoSystem' to a blue box labeled 'RISC-V' and 'Instruction Sets Want to be Free!'. A blue arrow points from the blue box to another blue box labeled 'Rich Hardware EcoSystem'. To the right of the diagram is the 'Fedora always OPEN' logo with a penguin wearing a fedora hat. Below the diagram is a link 'From www.codasip.com'. At the bottom of the slide, there is a caption: 'We would like to support more targets based on standard RISC-V Spec.' The video player interface at the bottom includes a play button, a timestamp '9:56 / 18:37', a URL '#RISCVSUMMIT | tmt.knect365.com/risc-v-summit/', and a Red Hat logo.

Fedora on RISC-V

Rich Software EcoSystem

RISC-V
Instruction Sets Want to be Free!

Rich Hardware EcoSystem

From www.codasip.com

We would like to support more targets based on standard RISC-V Spec.

#RISCVSUMMIT | tmt.knect365.com/risc-v-summit/

RISC-V Summit 2019: 10 Linux on RISC V Fedora and Firmware Status Update

183 views • Jan 16, 2020

13 9:56 / 18:37

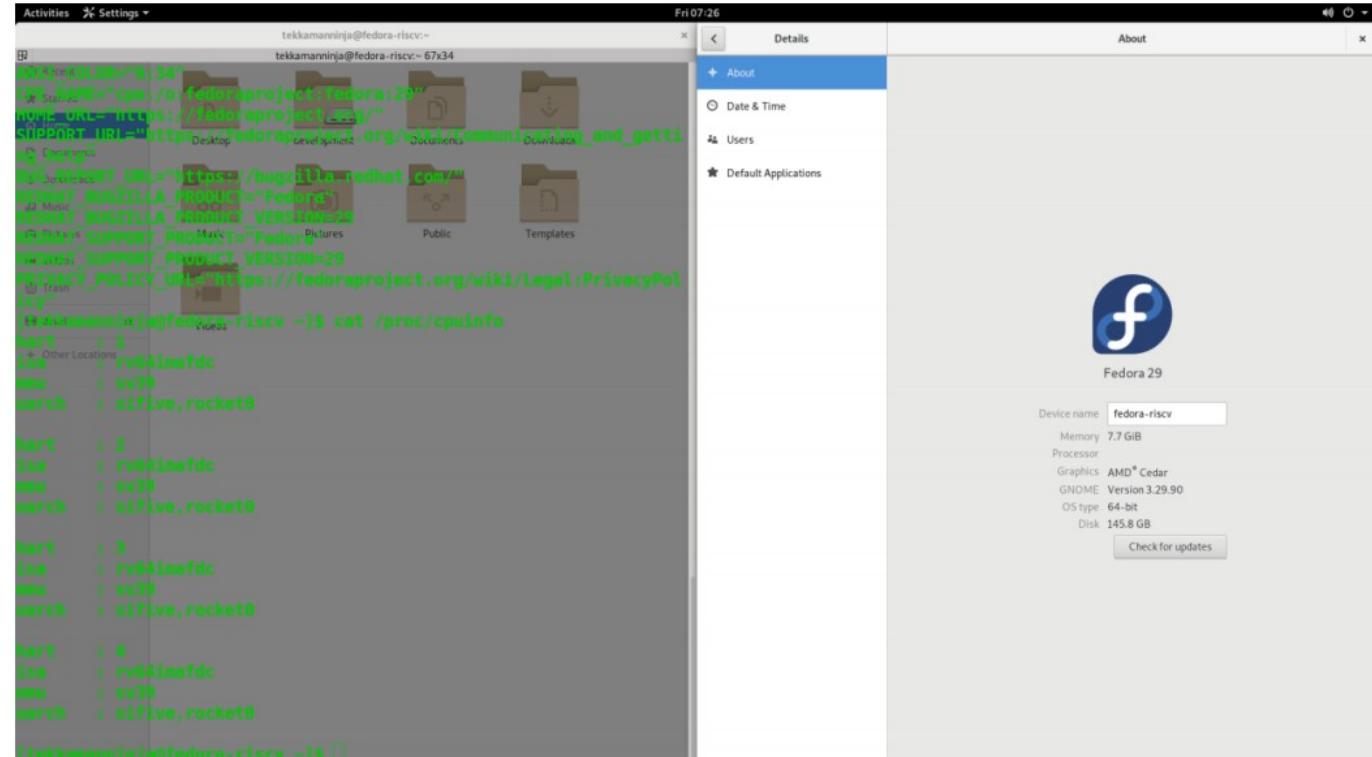
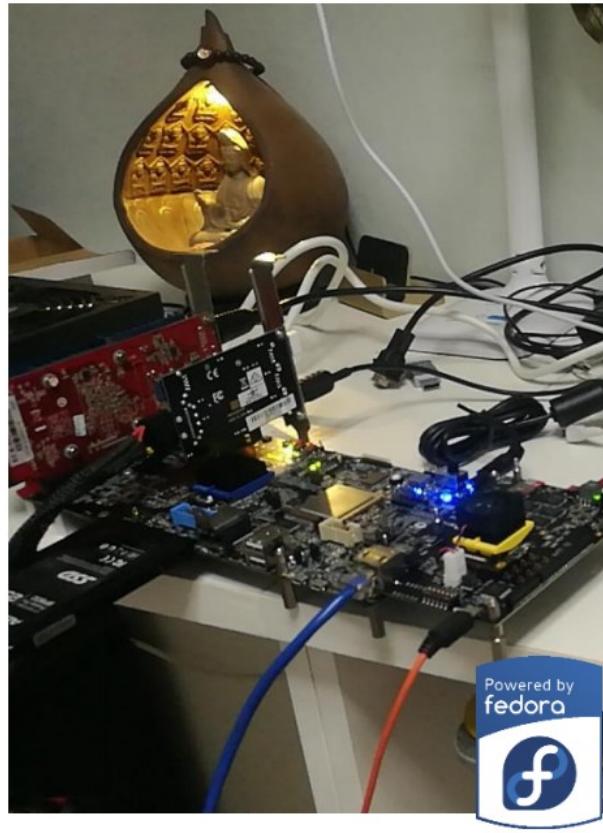
Red Hat

Like 6 Dislike 0 Share Save

RISC-V 7.91K subscribers

Subscribed

Fedora GNOME Image on SiFive Unleashed



#RISCVSUMMIT | tmt.knect365.com/risc-v-summit/

Targets

Supported



Virtual: libvirt + QEMU

with graphics parameters (Spice).



Real Hardware: SiFive Unleashed

with Expansion Board, PCI-E graphic Card & SATA SSD

Tested



QEMU for AndeStar V5 && ADP-XC7KFF676

Andes QEMU and AndeShape **FPGA** board



中国科学院计算技术研究所
INSTITUTE OF COMPUTING TECHNOLOGY, CHINESE ACADEMY OF SCIENCES



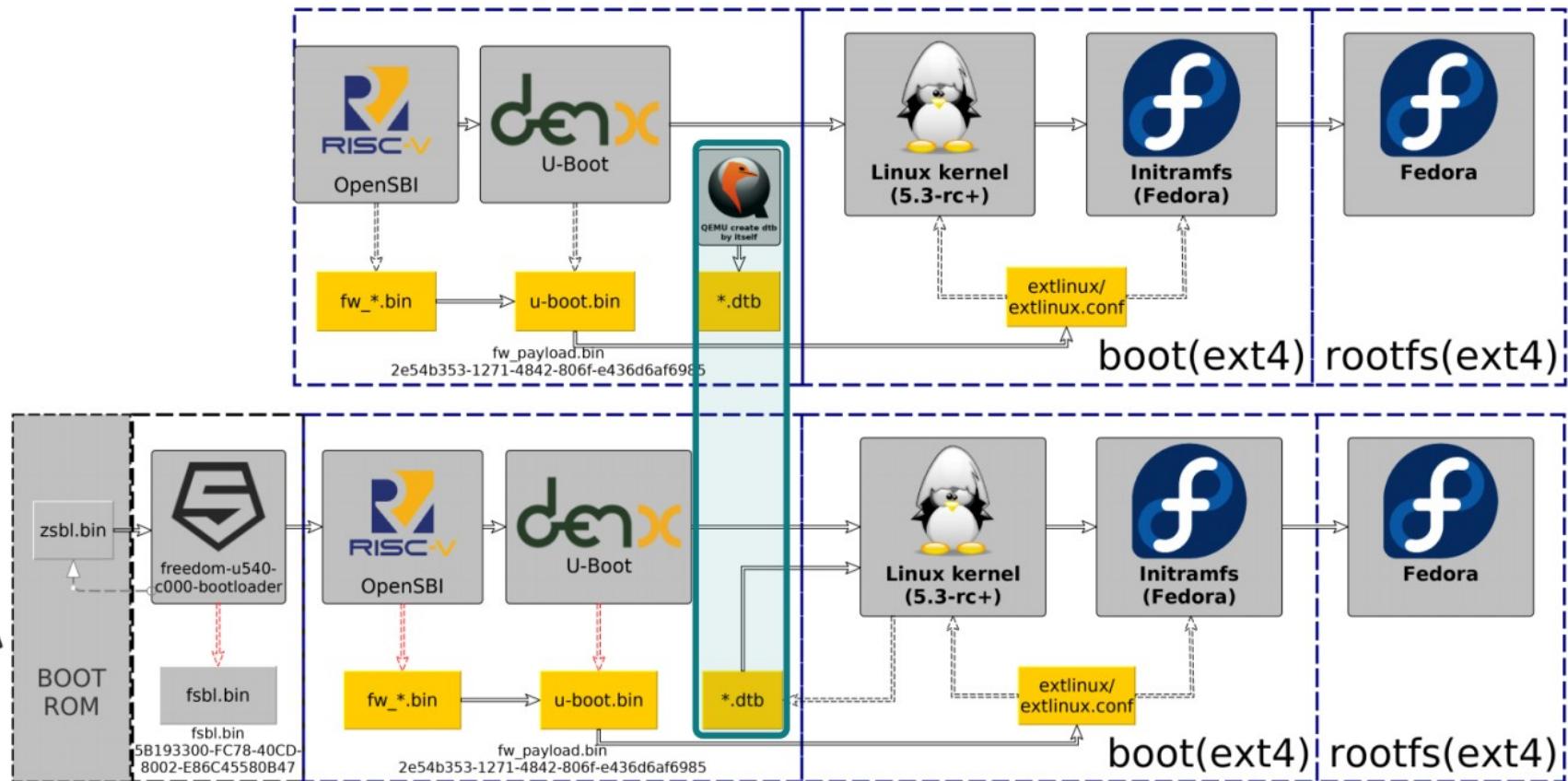
ICT SERVE Platform: FlameCluster

FPGA Cloud development platform (with PCI-E SSD and graphic Card)



#RISCVSUMMIT | tmt.knect365.com/risc-v-summit/

The current boot flow for Fedora on RISC-V





RISC-V

This page contains details about a port of Debian for the RISC-V architecture called **riscv64**.

Contents

[1. In a nutshell](#)

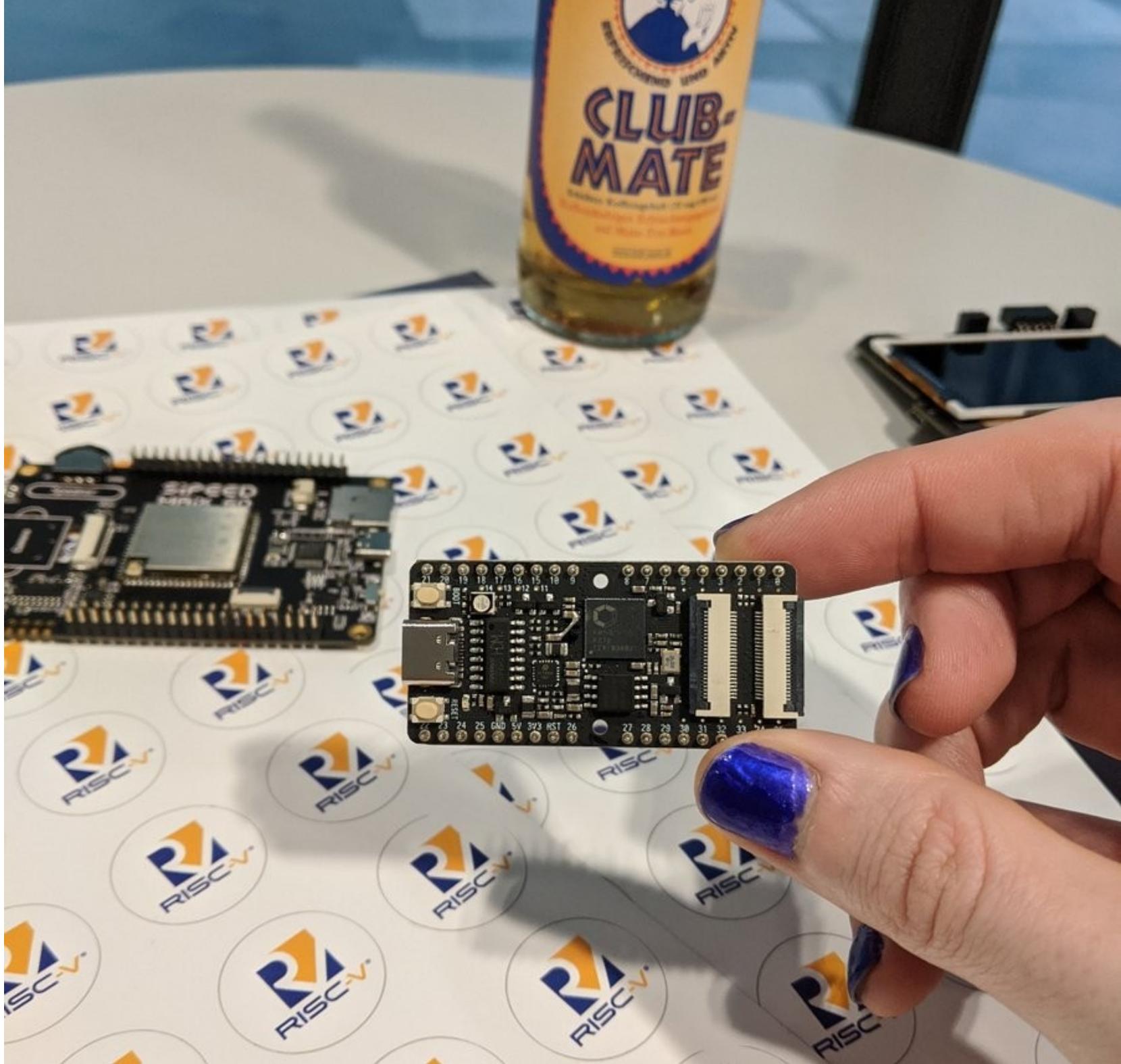
- [1. What is RISC-V?](#)
- [2. What is a Debian port?](#)
- [3. What are the goals of this project in particular?](#)
- [4. Progress](#)

[2. Upstream project / Architecture](#)

- [1. Upstream project / Community](#)
- [2. Architecture details](#)
- [3. Toolchain upstreaming status](#)

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- [1. ASIC implementations, i.e. "real" CPU chips](#)
 - [1. SiFive "Freedom U540" SoC \(quad-core RV64GC\) / "HiFive Unleashed"](#)
 - [2. Planned](#)
- [2. FPGA implementations](#)



Kendryte K210 SoC + Busybox

Sipeed MAIX Go Board (6+2 MB SRAM)

```
[ 0.000000] Linux version 5.1.0-rc5-00314-g375c2321604f (damien@washi) (gcc version 8.2.0 (Buildroot 2018.11-rc2-00003-ga0787e9)) #221 SMP Fri May 10 15:17:17 JST 2019
[ 0.000000] earlycon: sb10 at I/O port 0x0 (options '')
[ 0.000000] printk: bootconsole [sb10] enabled
[ 0.000000] initrd not found or empty - disabling initrd
[ 0.000000] Zone ranges:
[ 0.000000]   DMA32    [mem 0x0000000080000000-0x00000000807fffff]
[ 0.000000]   Normal    empty
[ 0.000000] Movable zone start for each node
[ 0.000000] Early memory node ranges
[ 0.000000]   node  0: [mem 0x0000000080000000-0x00000000807fffff]
[ 0.000000] Initmem setup node 0 [mem 0x0000000080000000-0x00000000807fffff]
[ 0.000000] elf_hwcap is 0x112d
[...]
[ 0.000000] Built 1 zonelists, mobility grouping off. Total pages: 2020
[ 0.000000] Kernel command line: console=hvc0 earlycon=sbi init=/bin/bash
[ 0.000000] Dentry cache hash table entries: 1024 (order: 1, 8192 bytes)
[ 0.000000] Inode-cache hash table entries: 512 (order: 0, 4096 bytes)
[ 0.000000] Sorting __ex_table...
[ 0.000000] Memory: 6284K/8192K available (920K kernel code, 101K rwdta, 158K rodata, 393K init, 95K bss, 1908K reserved, 0K cma-reserved)
[ 0.000000] SLUB: HwAlign=64, Order=0-3, MinObjects=0, CPUs=2, Nodes=1
[ 0.000000] rcu: Hierarchical RCU implementation.
[ 0.000000] rcu: RCU calculated value of scheduler-enlistment delay is 25 jiffies.
[ 0.000000] NR_IRQS: 0, nr_irqs: 0, preallocated irqs: 0
[...]
[ 0.251433] Freeing unused kernel memory: 392K
[ 0.254361] This architecture does not have kernel memory protection.
[ 0.259473] Run /bin/bash as init process

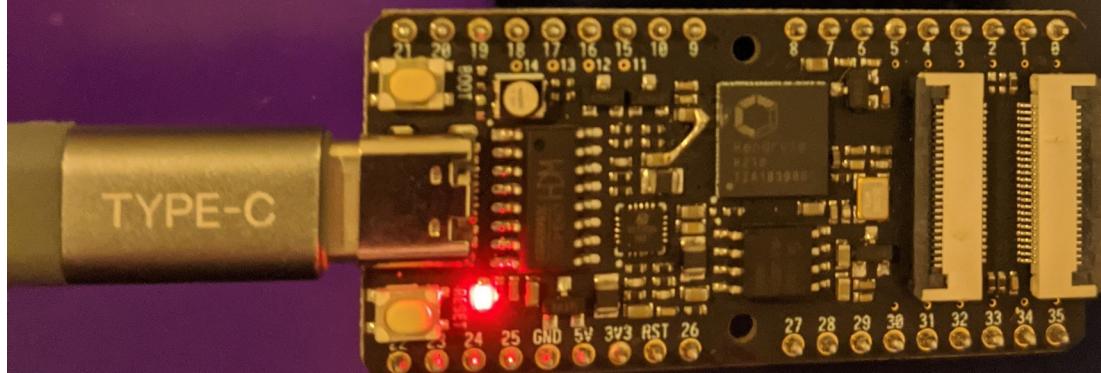
BusyBox v1.30.1 (2019-05-10 14:49:46 JST) hush - the humble shell

# mount -t proc none /proc
# cat /proc/cpuinfo
processor : 0
hart : 0
isa : rv64imafdc

processor : 1
hart : 1
isa : rv64imafdc
```

- **Linux now runs the low cost Kendryte K210 RISC-V processor**
 - dual core 64-bit RISC-V at 400MHz with 8MB SRAM
 - Sipeed MAix BiT for RISC-V is only \$13!
- Damien Le Moal at Linux Plumbers Conf:
RISC-V NOMMU and M-mode Linux
 - youtube.com/watch?v=ycG592N9EMA&t=10394
 - jump to 2h 53m
- Many RISC-V Improvements Ready For Linux 5.5: M-Mode, SECCOMP, Other Features
- How to Build & Run Linux on Kendryte K210 RISC-V NOMMU Processor

```
File Edit Log Configuration Control signals View Help  
/ # uname -a  
Linux k210 5.6.0-rc1vowstar #1 SMP Mon Feb 17 23:  
/ # cat /proc/meminfo |head  
MemTotal:           6656 kB  
MemFree:            2496 kB  
MemAvailable:       2080 kB  
Buffers:             0 kB  
Cached:              1916 kB  
SwapCached:          0 kB  
Active:              0 kB  
Inactive:            0 kB  
Active(anon):        0 kB  
Inactive(anon):      0 kB  
/ # cat /proc/cpuinfo  
processor      : 0  
hart          : 0  
isa           : rv64imafdc  
  
processor      : 1  
hart          : 1  
isa           : rv64imafdc  
  
/ # tcc -run -nostdlib hello.c  
hello.c:2: warning: implicit declaration of function  
hello show 'n tell  
/ #
```



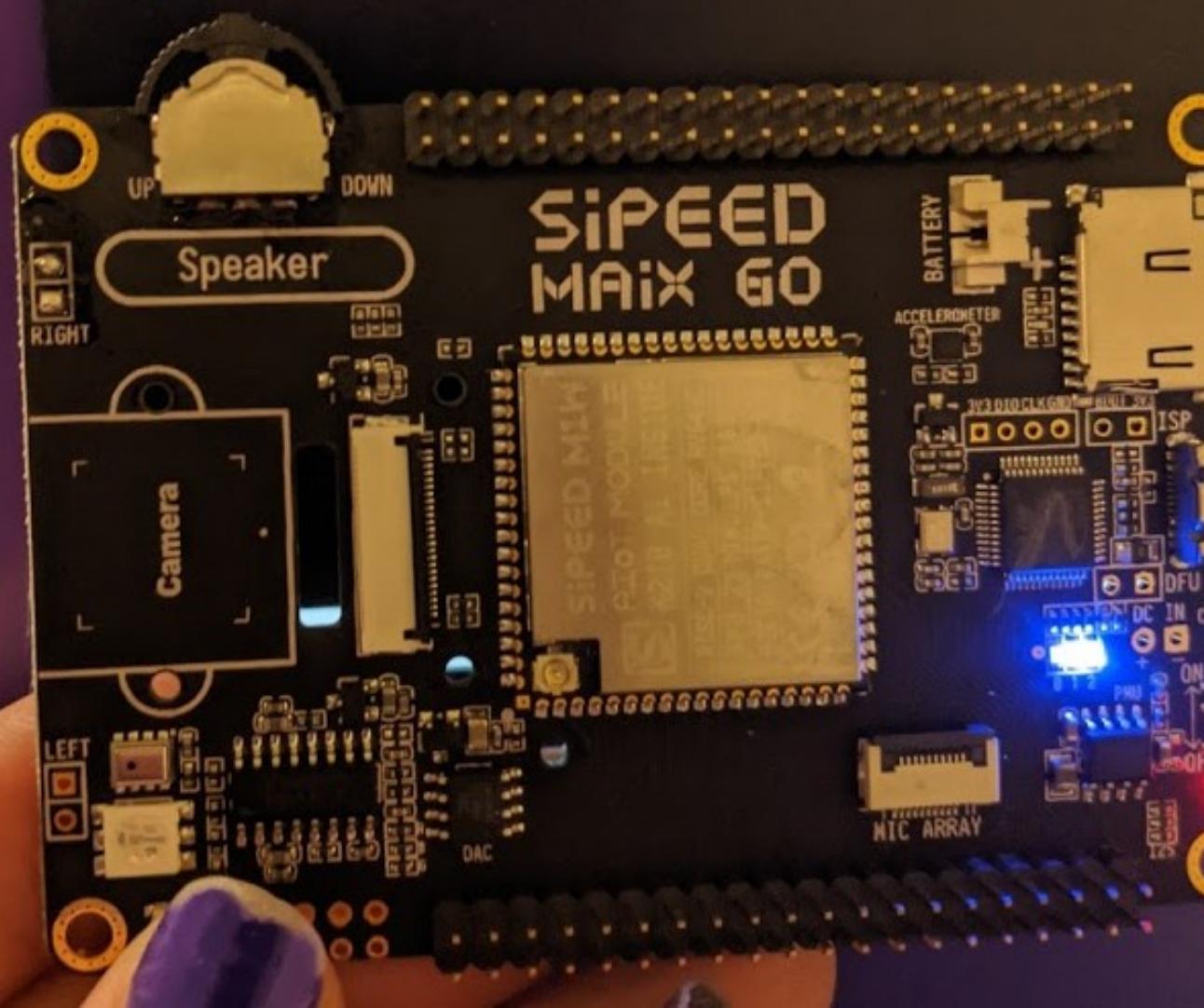
pdp

GtkTerm - /dev/ttyUSB1 115200-8-N-1

pdp7@: File Edit Log Configuration Control signals View Help

pdp7@:

```
/ #  
/ #  
/ #  
/ # uname -a  
Linux k210 5.6.0-rc1vowstar #1 SMP Mon Feb 17 23:36:34 CET 202  
U/Linux  
/ #
```



- Sipeed now has prebuilt Linux 5.6

- <https://twitter.com/SipeedIO/status/1228594799675990016/> ← Tweet



Sipeed

@SipeedIO

The prebuild linux-5.6.0-rc1 image for Maix Boards,
Just burn and try it~
dl.sipeed.com/MAIX/MaixLinux...

```
version 5.6.0-rc1-gdbcd412b (vorstar@yzen) (gcc version 9.2.0 (Buildroot 2020.02-git-g2ceb6f4a3f
n: sifive0 at MMIO 0x0000000038000000 (options '')
bootconsole [sifive0] enabled
not found or empty - disabling initrd
names:
    [mem 0x0000000080000000-0x00000000807fffff]
1 empty
zone start for each node
empty node ranges
    0: [mem 0x0000000080000000-0x00000000807fffff]
setup_node 0 [mem 0x0000000080000000-0x00000000807fffff]
ap is 0x112d
max_distance=0x18000 too large for vmalloc space 0x0
Embedded 12 pages/cpu s18272 r0 d30880 u49152
zonelists, mobility grouping off. Total pages: 2020
command line: earlycon console=ttySIF0
cache hash table entries: 1024 (order: 1, 8192 bytes, linear)
ache hash table entries: 512 (order: 0, 4096 bytes, linear)
    ex_table...
einit: stack off, heap alloc off, heap free:off
6024K/8192K available (918K kernel code, 110K rdata, 166K rodata, 629K init, 91K bss, 2168K res
archical ECU implementation
calculated value of scheduler-enlistment delay is 25 jiffies.
: 0, nr_irqs: 0, preallocated irq: 0
apped 65 interrupts with 2 handlers for 4 contexts.
inner_init_dt: Registering clocksource cpuid[0] hartid [0]
ure: riscv_clocksource: mask: 0xffffffffffff max_cycles: 0x3990be68, max_idle_ns: 881590404 in
lock: 64 bits at 7MHz, resolution 128ns, wraps every 4398046511054ns
: colour dummy device 80x25
ting delay loop (skipped), value calculated using timer frequency.. 15.60 BogoMIPS (lpj=31200)
: default: 4096 minimum: 301
ache hash table entries: 512 (order: 0, 4096 bytes, linear)
int-cache hash table entries: 512 (order: 0, 4096 bytes, linear)
archical SRCU implementation.
ing up secondary CPUs ...
ought up 1 node, 2 CPUs
s: initialized
ure: jiffies: mask: 0xffffffff max_cycles: 0xffffffff, max_idle_ns: 7645041785100000 ns
ash table entries: 16 (order: -2, 1024 bytes, linear)
e K210 SoC sysctl
ure: Switched to clocksource riscv_clocksource
set: timestamp_bits=62 max_order=11 bucket_order=0
0 serial: ttySIF0 at MMIO 0x38000000 (irq = 1, base_baud = 0) is a SiFive UART v0
console: [ttySIF0] enabled
console: [ttySIF0] enabled
bootconsole [sifive0] disabled
bootconsole [sifive0] disabled
get_random_bytes called from 0x00000000800a2128 with crng_init=0
s: mounted
unused kernel memory: 628K
chitecture does not have kernel memory protection.
in/init as init process
e/init as init process
v/init as init process
```

/proc	shell						
v	etc	proc	root	sbin	sys	tmp	usr
chown	grep	ls	printenv	set:			
cp	hush	mkdir	ps	sh			
date	init	mknod	pwd	sleep			
dmesg	kill	more	rm	stty			
echo	link	mount	rmdir	tou			
false	ln	mv	sed	true			
usr/bin							
env	id	seq	tty	wall			
expr	last	tail	uniq	wc			
find	printf	tcc	unlink	who			
head	readlink	tee	users	yes			
hostid	realpath	test	w				

Coming in 2020?

- Microchip PolarFire SoC FPGA
 - Hard RISC-V with FPGA fabric... like the Xilinx Zync for ARM
- NXP iMX with RISC-V instead of ARM!
 - [“OpenHW Group Unveils CORE-V Chassis SoC Project, Building on PULP Project IP”](#)

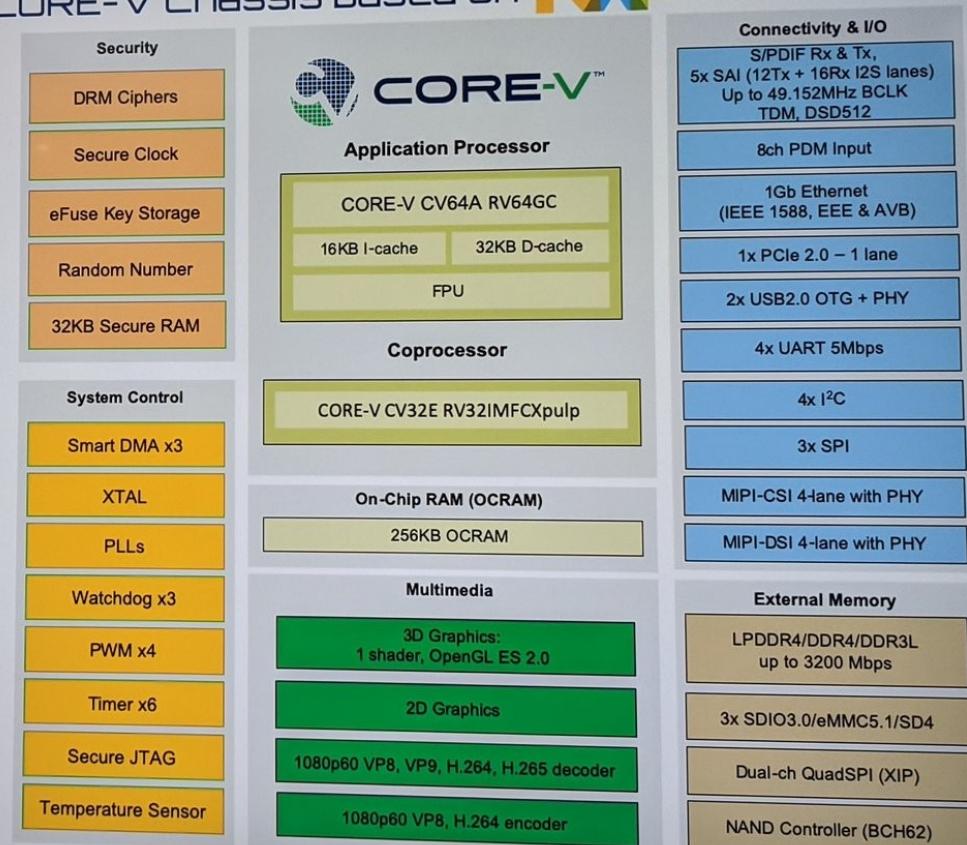


CORE-V™ chassis – tapeout 2H 2020



CORE-V Chassis based on **NXP** iMX Platform **CORE-V**

- Linux capable 1.5GHz CV64A host CPU and CV32E coprocessor
- X32/x16 (LP)DDR4, DDR3L memory
- 3D / 2D GPUs with OpenGL support
- MIPI-DSI / CSI display / camera controllers
- Security: DRM Ciphers, key storage, random number generator, etc.
- GigE MAC
- PCIe 2.0 x1 port
- 2 USB 2.0 interfaces
- 3 SDIO interfaces for boot source, storage, etc



© OpenHW Group

10 & 11 December 2019

17

Bonus:
FPGAs and Python

Fomu – great way to learn FPGAs!

- workshop.fomu.im
- crowdsupply.com/sutajio-kosagi/fomu

- Fits in USB port

Fomu by Sutajio Kosagi

An FPGA board that fits inside your USB port

- Learn:

- MicroPython
- Verilog
- LiteX



Designing Hardware in Python?

- Yes!
- “Using Python for creating hardware to record FOSS conferences!”
- Tim “mithro” Ansell
- youtube.com/watch?v=MkVX_mh5dOU

Why is this powerful?

- Python is a **powerful** language
- Python is a **productive** language
- Can generate exact Verilog as needed

hdmi2usb.tv

@mithro

j.mp/pyhw-lca2017



Using Python for creating hardware to record FOSS conferences!

1,041 views • Jan 19, 2017

16 0 SHARE SAVE ...

Up next



AUTOPLAY

Python HDL?

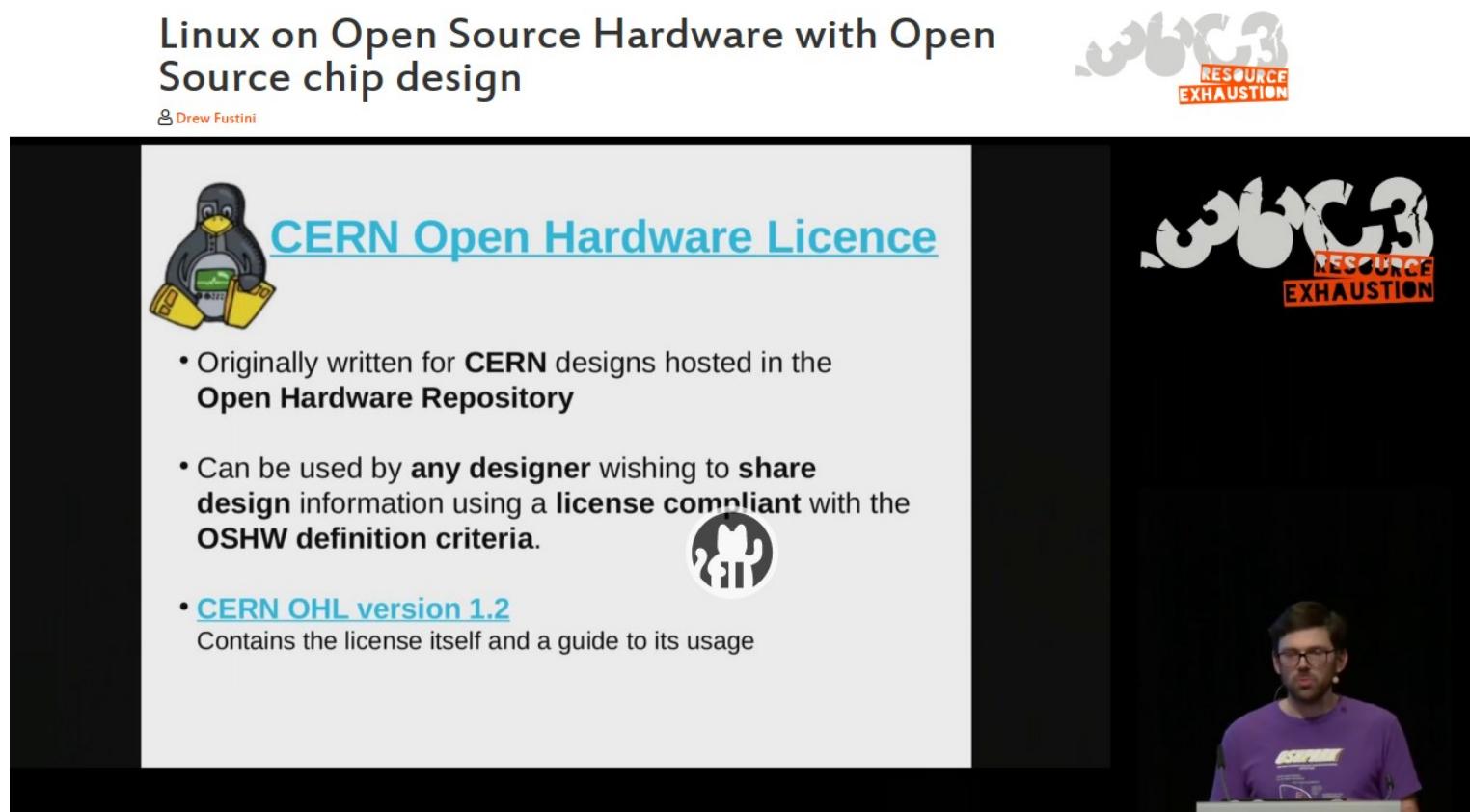
You can think of Migen as
*"an easy way
to generate Verilog"*

Blink Led - Migen

```
class Blinker(Module):
    def __init__(self, led, cycles=15000000):
        counter = Signal(max=cycles)
        self.sync += counter.eq(counter - 1)
        self.comb += led.eq(counter[-1])
```

Most significant bit
connected to LED signals

- Slides:
github.com/pdp7/talks/blob/master/fosn20light.pdf
- e-mail: drew@oshpark.com
- 36c3 talk:
media.ccc.de/v/36c3-10549-linux_on_open_source_hardware_with_open_source_chip_design



The image shows a presentation slide with the following content:

Linux on Open Source Hardware with Open Source chip design
by Drew Fustini

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- 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



