

Making Copyleft Hardware

Werner Almesberger
werner@almesberger.net

June 30, 2011

Overview

- Copyleft Hardware: what and why ?
- Tools
- Qi-Hardware projects
- DOs and DON'Ts

What is Copyleft Hardware ?

- Principles similar to Free Software, applied to hardware
- Design and manufacturing
- All material under open licenses: GPL, GFDL, CC-BY, CC-BY-SA
- Friendly to Free Software

Hardware vs. Software

| Concept | Software | Hardware |
|--------------|----------------------------|---------------------------|
| Source | Program text | Schematics, Layout |
| Editor | Text editor | EDA system |
| Conversion | Compiler, etc. | EDA system |
| Testing | Run | Prototype(s) |
| Debugging | Debugger | Lab instruments |
| Duplication | Download (perfect copy) | Manufacturing, Testing |
| Distribution | Internet | Shipping, Customs |

The Four Freedoms

According to The Free Software Definition: [1]

- 0 Run the program
 - Use the hardware
- 1 Study the source
 - Study design files (schematics and layout)
- 1 Adapt the source to your needs
 - Adapt design files
 - Access to the tools
- 2–3 Redistribute copies (including modifications)
 - Redistribute design files
 - Build or produce the hardware

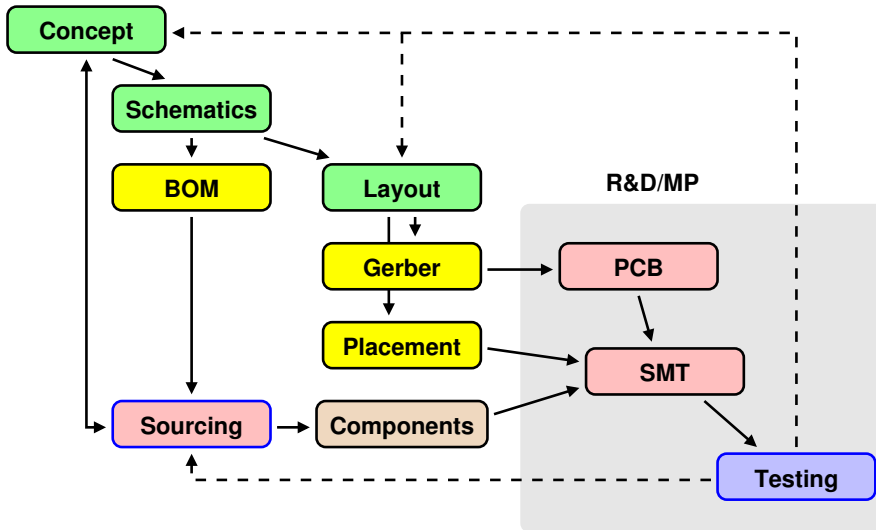
[1] <http://www.gnu.org/philosophy/free-sw.html>

Why Copyleft Hardware ?

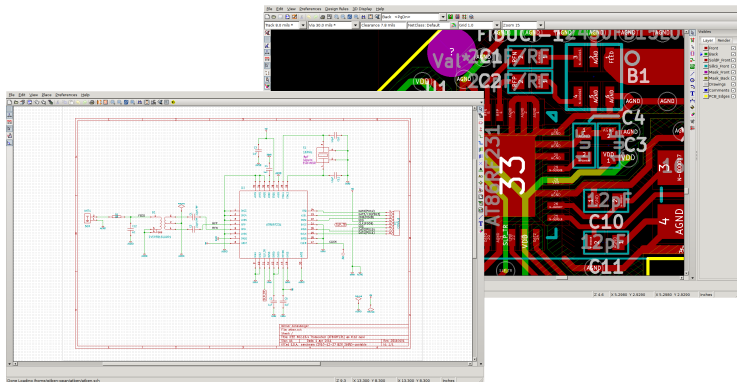
One can ...

- ▶ learn from it (also small details)
- ▶ know what is happening inside the “black box”
 - ▶ No spyware
 - ▶ Analyze (mis)behaviour
- ▶ adapt design for new uses or contexts
- ▶ reuse parts of design in other projects
- ▶ achieve longevity by ...
 - ▶ fixing/updating/enhancing the design
 - ▶ repairing/modifying devices
 - ▶ producing more/updated devices
- ▶ choose suitable manufacturing site

Workflow

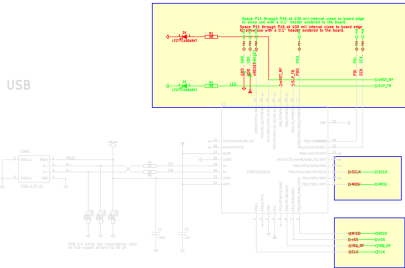
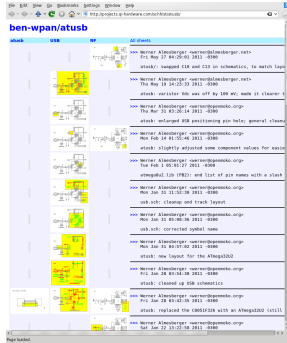


Tools: KiCad



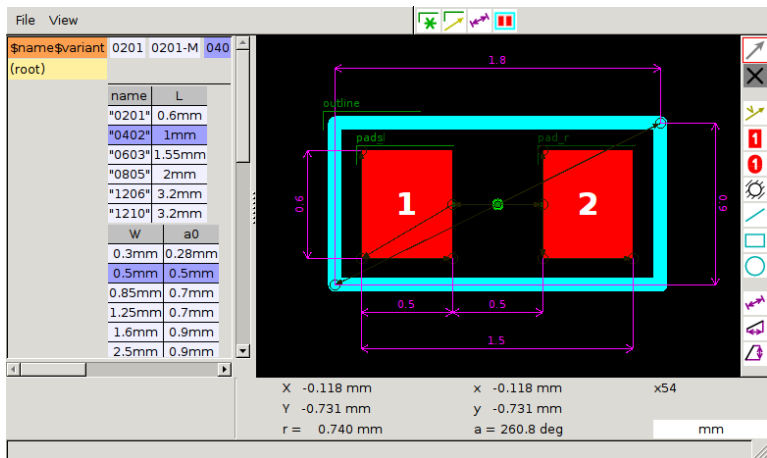
- Main devs: Jean-Pierre Charras, Dick Hollenbeck
- Complete EDA solution
- Text files → extensible
- Free Software: GPL, LGPL

Tools: Schematics History



- Schematics revision history
- Visual highlighting of changes
- Web output (HTML, PNG, PDF)

Tools: Footprint Editor (fped)

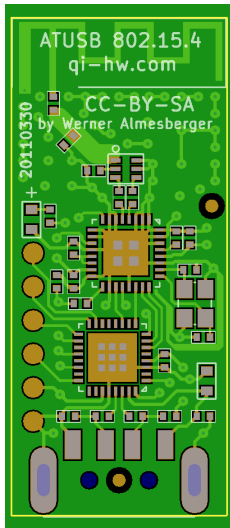


- Parametric
- GUI or text-based
- Automatic measurements

More Tools

- Data sheet viewer (dsv)
 - Work around non-distribution
 - Download and cache
 - Quick access

dsv mcu
- Gerber renderer (prettygerbv)
 - Combine Gerber and Excellon
 - Realistic coloring
- BOM processor
 - Select components
 - Find best supplier
 - Make shopping list
- Makefiles
 - Shortcuts
 - Fab output



Qi-Hardware

- Started by ex-Openmokoers
- Collection of loosely connected projects
- Copyleft Hardware with Free Software
- Development and manufacturing

Products:

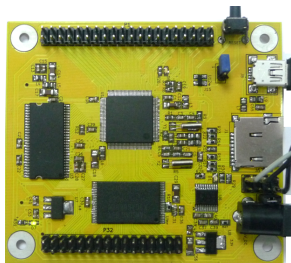
- Ben NanoNote (Handheld computer)
- SIE (Development board)
- Universal Breakout Board (UBB)
- Ben-WPAN (IEEE 802.15.4 wireless)
- Milkymist One (FPGA-based Video synthesizer)

Ben NanoNote



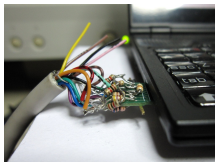
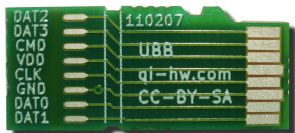
- Objective: validate manufacturing process
- OEM dictionary design
- Runs Linux: OpenWrt, Jlime (OE-based)
- 336 MHz MIPS CPU (Ingenic Jz4720)
- 32MB RAM, 2GB
- QVGA LCD, keyboard
- USB device, 8:10 card, audio
- Manufactured by Sharism at Work Ltd.
- \approx 1300 units sold
- Schematics open (KiCad)

SIE



- Objective: development board (educational)
- Loosely based on Ben design
- Joint work of
 - Universidad Nacional de Colombia (UNAL)
 - Tuxbrain S.L.
 - Sharism Ltd.
- Design 100% open (with KiCad)
- Continues as Linux en-Caja

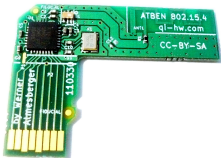
UBB



Universal Breakout Board

- Objective: easy DIY connection to Ben
- Original idea by Rikard Lindstrom
- Design 100% open (with KiCad)
- Manufactured by Tuxbrain S.L.
- Example: ubb-vga

Ben-WPAN



- Objective: unencumbered wireless for the Ben
- IEEE 802.15.4 (LR-WPAN)
- 250 kbps (2 Mbps non-standard)
- Ben 8:10 card (atben), USB (atusb)
- Designed by Werner Almesberger
- Design 100% open (with KiCad)
- Largely automated fabrication workflow
- Manufactured by ~~Sharism~~ Tuxbrain S.L.

Milkymist One



- Video synthesizer
- By “one man army” Sebastien Bourdeauducq
- Video in/out, audio, Ethernet, USB host, MIDI, ...
- FPGA-based (Lattice LM32 core)
- Verilog under GPL
- Proprietary FPGA tools
- LLHDL: work on Open synthesis tool
- Design files open (use Altium)
- Manufactured by Sharism

Freedom Status

| | | Components | | | | | Firmware | | Manufacturing | | |
|---------------|---|------------|---|---|---|---------|----------|-----------|---------------|---|--|
| | | Schematics | | | | Drivers | | Case 2.5D | | | |
| | | Layout | | | | | | Case 3D | | | |
| | | Verilog | | | | | | | | | |
| | | | | | | | | | | | |
| Ben NanoNote | — | ■ | ◆ | ■ | — | — | ● | — | ■ | ■ | |
| MilkyMist One | — | ◆ | ◆ | ◆ | ◆ | — | ● | ● | — | ● | |
| SIE | — | ■ | ● | ● | ◆ | — | ● | — | — | ? | |
| UBB | — | — | ● | ● | — | — | ● | — | — | — | |
| Ben-WPAN | — | ◆ | ● | ● | — | ● | ● | ● | — | ● | |
| SDR GPS | — | ◆ | ● | ● | ? | — | ● | ? | ? | ? | |
| Ya NanoNote | — | ■ | ● | ● | — | — | ● | — | ● | ● | |
| MilkyMist Two | — | ◆ | ● | ● | ● | — | ● | ● | — | ● | |

■ Closed

◆ Open; proprietary format/tools

● Fully open

— Does not apply/insignificant

● WIP; fully open

Hypothetical

Running an Open Hardware Project

- Have clear objectives
- Create opportunities to participate
- Pick your challenges wisely
 - Set realistic goals
 - Know what you can sacrifice
 - Pay attention to manufacturability
- Think about what follows

Common Misconceptions

- “Let’s make an iPhone/iPad”
 - Bleeding edge components are hard to get
 - They are hard to design for
 - They are expensive
 - There is fierce competition
 - You’re joining the race late
 - “Boy, did we patent it !”
- “There is no tomorrow” or “It must be perfect”
 - Rampant featuritis
 - ⇒ Delays
 - Try to be as up to date as possible
 - ⇒ Redesigns ⇔ Delays

Sourcing Pitfalls

- “I can get any chip I see on a vendor’s Web site”
 - You are too small
 - Non-refundable fees
 - Consider documentation
- “Once a chip is announced, we can use it”
 - Delays until first (buggy) samples
 - Some chips are test balloons
 - Revisions may introduce drastic changes
- Distributors
 - Even large distributors don’t stock everything
 - Minimum Order Quantity
 - Lead time

Dodging Patents

Potential opponents:

- Big players (Apple, Nokia, Oracle, ...)
- Licensing firms (Sisvel, MPEG-LA, ...)
- Patent trolls

Some avoidance strategies:

- Do not sell hardware
- Stay remote, small, poor, and out of the news
- Use old technology
- Avoid areas of on-going patent wars:
Mobile communication, A/V codecs,
Multitouch, ...
- Hope for the best

The Future

- Finishing Milkymist One
- Ben-WPAN firmware and Linux support
- Dreaming of Ya NanoNote
- Improve tools (BOM, LLHDL, layout history)
- Get better control of mechanical design
- Smarter marketing: sell our story better

URLs

This presentation:

`downloads.qi-hardware.com/people/werner/fisl12.pdf`

The Qi-Hardware project:

`www.qi-hardware.com/`

Schematics history:

`projects.qi-hardware.com/schhist/`

Footprint editor (fped):

`svn.openmoko.org/trunk/eda/fped/README`

Milkymist:

`milkymist.org/`