Making Copyleft Hardware

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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

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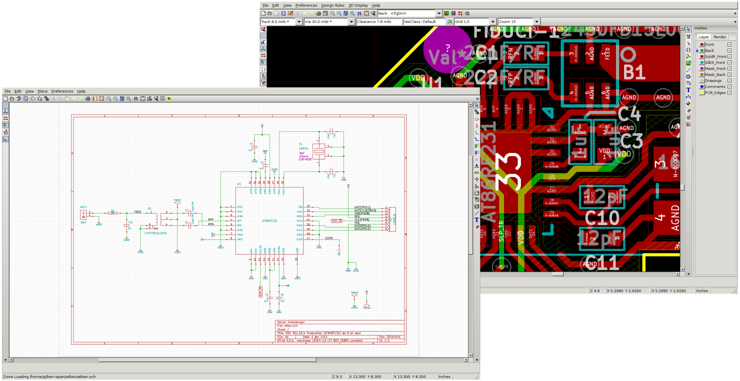
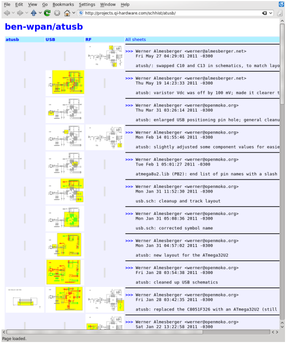
Tools: KiCad



Done Loading /home/qi/ben-wpan/atben/atben.sch

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

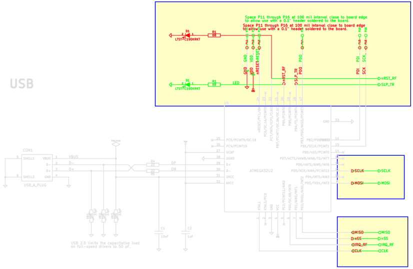
Tools: Schematics History


File Edit View Go Bookmarks Settings Window Help
http://projects.qi-hardware.com/schhist/atusb/
Page loaded.

ben-wpan/atusb

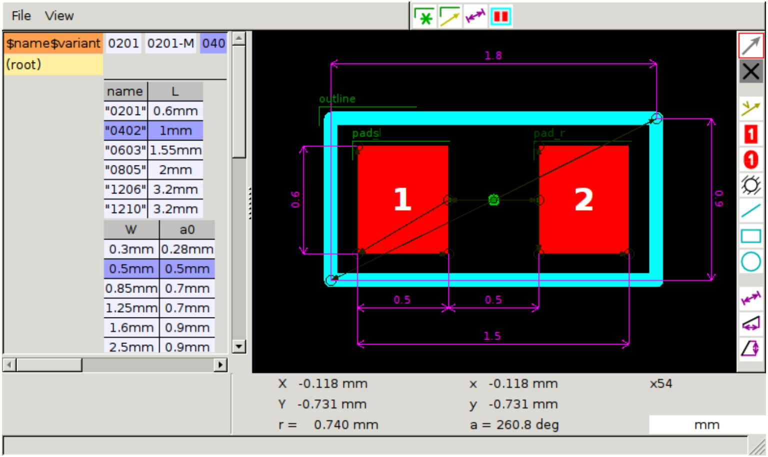
atusb | USB | RF | All sheets

```
>>> Werner Almesberger <werner@almesberger.net>
    Fri May 27 04:29:01 2011 -0300

    atusb/: swapped C10 and C13 in schematics, to match layo

>>> Werner Almesberger <werner@almesberger.net>
    Thu May 19 14:23:33 2011 -0300

    atusb: varistor Vdc was off by 100 mV; made it clearer t

>>> Werner Almesberger <werner@openmoko.org>
    Thu Mar 31 03:26:14 2011 -0300

    atusb: enlarged USB positioning pin hole; general cleanu

>>> Werner Almesberger <werner@openmoko.org>
    Mon Feb 14 01:55:46 2011 -0300

    atusb: slightly adjusted some component values for easie

>>> Werner Almesberger <werner@openmoko.org>
    Tue Feb 1 05:01:27 2011 -0300

    atmega8u2.lib (PB2): end list of pin names with a slash

>>> Werner Almesberger <werner@openmoko.org>
    Mon Jan 31 11:52:30 2011 -0300

    usb.sch: cleanup and track layout

>>> Werner Almesberger <werner@openmoko.org>
    Mon Jan 31 05:08:36 2011 -0300

    usb.sch: corrected symbol name

>>> Werner Almesberger <werner@openmoko.org>
    Mon Jan 31 04:57:02 2011 -0300

    atusb: new layout for the ATmega32U2

>>> Werner Almesberger <werner@openmoko.org>
    Fri Jan 28 03:54:38 2011 -0300

    atusb: cleaned up USB schematics

>>> Werner Almesberger <werner@openmoko.org>
    Fri Jan 28 03:42:35 2011 -0300

    atusb: replaced the C8051F326 with an ATmega32U2 (still

>>> Werner Almesberger <werner@openmoko.org>
    Sat Jan 22 13:22:58 2011 -0300
```


USB
Space P11 through P16 at 100 mil interval close to board edge
to allow use with a 0.1" header soldered to the board.
D1
LTST-C190KRKT
R1
68
LED
GND
VDD
nRESET
nRST_RF
SLP_TR
PDO
PDI
SCK
CON1
USB_A_PLUG
ATMEGA32U2
SCLK
MOSI
MISO
nSS
IRQ_RF
CLK
USB 2.0 limits the capacitative load
on full-speed drivers to 50 pF.

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

Tools: Footprint Editor (fped)



name	L
"0201"	0.6mm
"0402"	1mm
"0603"	1.55mm
"0805"	2mm
"1206"	3.2mm
"1210"	3.2mm

W	a0
0.3mm	0.28mm
0.5mm	0.5mm
0.85mm	0.7mm
1.25mm	0.7mm
1.6mm	0.9mm
2.5mm	0.9mm

X -0.118 mm x -0.118 mm x54
Y -0.731 mm y -0.731 mm
r = 0.740 mm a = 260.8 deg mm

- Parametric
- GUI or text-based
- Automatic measurements

Tools: BOM Processing System

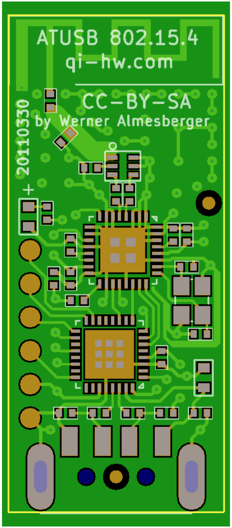
@@@

- ...
- ...

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
- Makefiles
  - Shortcuts
  - Fab output



Qi-Hardware

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

Products:

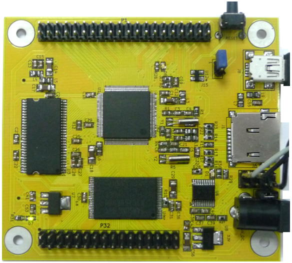
- Ben NanoNote (Handheld computer)
- SIE (Development board)
- Universal Breakout Board (UBB)
- Ben-WPAN (IEEE 802.15.4 wireless)
- Milkymist One (FPGA-based Video synthesizer)

Ben NanoNote

- Objective: validate manufacturing process
- OEM dictionary design
- Runs Linux: OpenWrt, Jlime (OE-based)
- 336 MHz MIPS CPU (Ingenic Jz4720)
- 32MB RAM, 2GB

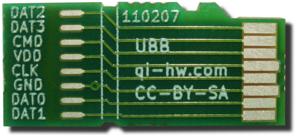
- QVGA LCD, keyboard
- USB device, 8:10 card, audio
- Manufactured by Sharism at Work Ltd.
- ≈1300 units sold
- Schematics open (KiCad)

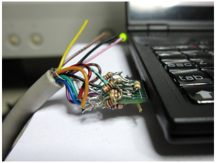
SIE



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

UBB

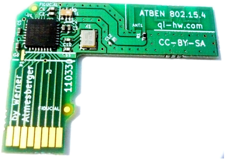


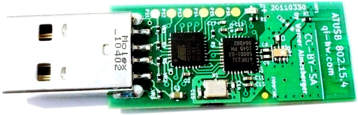


Universal Breakout Board

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

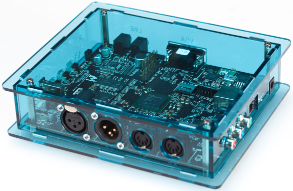
Ben-WPAN





- 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



- Objective:
- 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	Schematics	Layout	Verilog	Firmware	Drivers	Case 2.5D	Case 3D	Manufacturing
Ben NanoNote	🔴	🟡	🔴	⚪	⚪	🟢	⚪	🔴	🔴
MilkyMist One	🟡	🟡	🟡	🟡	⚪	▨	🟢	⚪	▨
SIE	🔴	🟢	🟢	🟡	⚪	▨	⚪	⚪	?
UBB	⚪	🟢	🟢	⚪	⚪	🟢	⚪	⚪	⚪
Ben–WPAN	🟡	🟢	🟢	⚪	▨	▨	▨	⚪	▨
SDR GPS	🟡	▨	▨	?	⚪	🟢	?	?	?
Ya NanoNote	🔴	🟢	🟢	⚪	⚪	🟢	⚪	🟢	🟢
MilkyMist Two	🟡	🟢	🟢	🟢	⚪	🟢	🟢	⚪	🟢

Hypothetical

🔴 Closed 🟡 Open; proprietary format/tools 🟢 Fully open

⚪ Does not apply/insignificant ▨ WIP; fully open

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
    $\Rightarrow$ Delays
  - Try to be as up to date as possible
    $\Rightarrow$ Redesigns $\Leftrightarrow$ 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 samples
  - Some chips are test balloons
  - Need a few revisions to mature
  - 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
- Smarter marketing: sell our story better

URLs

This presentation:
`...`
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/`