Contents

1 Open Hardware

First we need to define what open hardware is - people mean several different things by the term.

What is Open Hardware?

- Documented Interface/hardware
- Free firmware
- VHDL (CPUs, subsystems) - `OpenCores.org`
- Open designs
- RepRap machine

The minimum definition is hardware which is well-enough documented that you can write drivers for it. There used to be an http://openhardware.com/ site for certifying this.

Following on from that is hardware that has free firmware, such that distros such as Debian can provide support for it without you having to dowload firmware from elsewhere.

Currently the most popular definition of open hardware is 'Soft hardware' - i.e. devices written in a hardware description language (CPUs, buses, controllers, interfaces) then compiled and programmed into an actual device (usually an FPGA) to make real hardware. Opencores.org has lots of examples, designs and info.

Finally we come to the definition I am interested in, and covering in this article: actual hardware designs which have open licences, so that they can be copied or derived-from or manaufactured freely. There is a wide range of such designs from trivial things like a parallel-port reset device through a lot of radio-ham stuff to complex SBC (Single Board Computer) designs. I will just be concentrating on the SBC designs here, although the principles apply to any open hardware design of sufficient complexity.

There are also open mechanical/electrical designs, of which the Reprap machine is a particularly interesting example, as it is a 3D printer which in theory can make all it's own parts and thus is a self-replicating open design. I don't believe anyone has actually made one make itself yet, but they are well on the way.

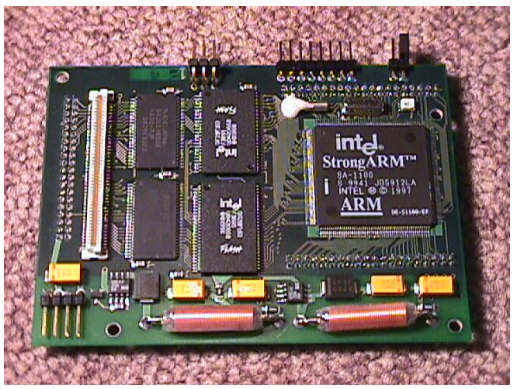
Open Designs

There have been quite a few open SBCs over the years - I will present a few examples to show the sorts of things we are talking about and the varying licences.

- LART
- Simputer
- Balloon
- Flavio Ribeiro ARM9 Camera
- Open Graphics Dev board
- Darell Harmon's SBC

Open Designs - LART

- SA1100, 32MB RAM, KSB add-ons
- MIT licence - do what you like, no guarantees.



`http://www.lart.tudelft.nl/`

This device was probably the first arm-based open hardware design. Done by Janderk Bakker and Erik Mouw of TU-Delft. It was (just about) home manufacturable and a few hardy souls made one. This was later manufactured by Aleph One and Remote 12 Ltd so that people who couldn't solder that well or didn't want to invest a lot of time tracking down all the parts, could get one. A fine example of how open hardware licences are supposed to work; the licence in this case being a dead simple MIT-style one.

This board was the inspiration for the Balloon project.

Open Designs - Simputer

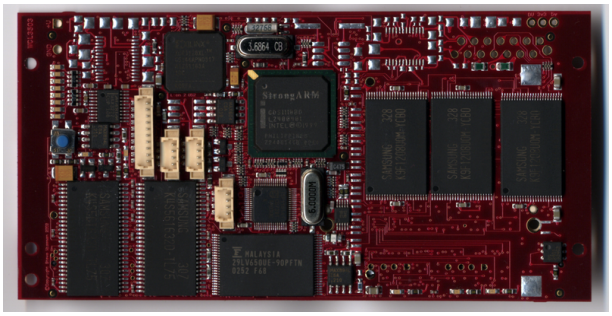
- StrongARM, Smart card, LCD
- Free manufacture, copyleft changes, licenced sales.
- 4000 sold

http://www.simputer.org/

This is perhaps the most famous open hardware project to date. It was intended to provide computing for the Indian masses by having one of these per village and individuals had smart-cards which stored their data/config. It was multilingual and provided net access over GSM. The licence was actually written by a lawyer and intended to be an open hardware verison of the GPL: 'Simputer GPL'. The Simputer trust decided whether a design counted as a simputer. The main problem was that if you wanted to sell simputers then you had to buy a licence from the Trust which cost $250,000. Only two companies took up this offer (and made it to production/sales). A few thousand were sold.

Open Designs - Balloon2

- StrongARM, CPLD, USB, Audio, Expansion bus
- Free manufacture and sales, restricted changes

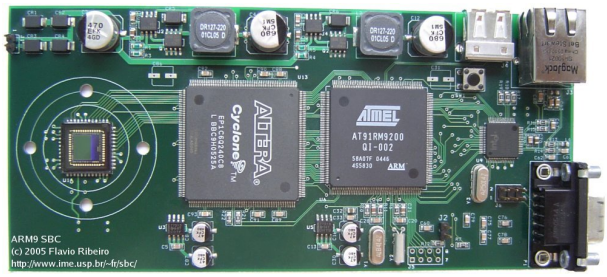


http://Balloonboard.org/

The Balloon was created by Steve Wiseman in Cambridge,UK who had made himself a LART and been impressed. The version that made it to manufacture used the next-generation chip from the the LART - the StrongARM 1110. It was manufactured and used by a few different companies in their devices. The licence allowed manufacture but for changes you had to ask Steve.

Open Designs - Flavio Ribeiro's ARM9 Camera

- ARM9, Altera FPGA, camera chip
- Distribution, acknowledgement, no changes.

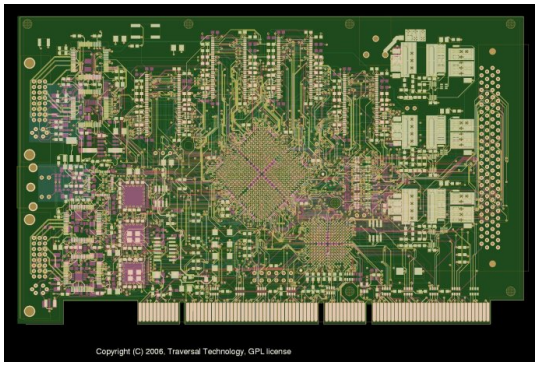


http://www.ime.usp.br/~fr/sbc/

This design was produced as a dissertation student project. Anyoine can make one but no changes to the design are permitted.

Open Designs - Open Graphics Dev board

- Big FPGA between PCI and video
- GPLed schematics and Gerbers: Open PCB.



http://opengraphics.org/

Part of the project to make truly open graphics cards available, this is a dev board for developing a graphics card. The board design is GPLed.

Open Designs - Darell Harmon's SBC

- Atmel ARM9 CPU+ Xilinx FPGA
- GPL

http://dlharmon.com/

An SBC design very similar to the Camera board, but using the GPL. This guy has done several open hardware designs.

2 The Balloon Project

The Balloon project grew from Steve Wiseman's original Balloon and Balloon2 designs, to become a sizeable collaboration, largely based around Cambridge people and companies.

Balloon Project

- Followed on from LART
- Started 2000 - Steve Wiseman
- Balloon2 protype 2002, shipping 2003 - ~3500 made
- Balloon3 started 2004, built 2006. Compatible size/bus.
- Companies - resources
  - Aleph One
  - Toby Churchill Ltd
  - Guralp
  - Cambridge University
  - iTechnic
  - Martin Jones Technology
  - Balloonz

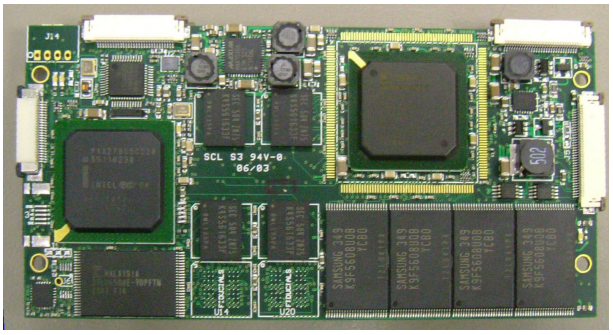
Toby Churchill got involved early on, helping get the design to manufacture, and have used thousands over the last few years in their Lightwriter products for people who cannot speak. The involvement of companies in open hardware development is generally necessary because the costs involved are usually beyond the means of individuals. I would like to thank all the above groups which have made significant contributions to the project so far. Aleph One and Guralp have also built Balloon2s and in fact it has shipped nearly as many as the simputer overall, despite being a lot less famous.

The project has produced the Balloon3 over the lasyt couple of years, driven by Cambridge University as well as TCL, and a start-up has been formed to manage production (for which I am now working part-time). It will be interesting to see whether a viable company can be based solely on open hardware or not.

Here is the basic spec. The design can be made in various flavours, for example a low-power CPLD version or a higher-power, more flexible FPGA version. It can be made single sided for low-profile use or with all the expansion connectors if you need the extendibility.

Balloon Spec

- PXA 270 - 520Mhz
- 784MB RAM, 1GB NAND, Max 32MB NOR
- FPGA - (1 million gates) or CPLD
- USB host, slave, OTG
- CF, MMC interface, ADC, GPIO
- Expansion bus, 16-bit ‘Samosa’ bus
- LCD, I2C, Audio, Camera, Touch screen



The intent is for it to be used as a computing component, with some add-on hardware for whatever you specifically need - power management, GPS, camera, motor-drivers for robotics, etc. A number of boards have been made by Cambridge University Engineering Dept for their robotics and computing teaching courses.

It is of course supplied with entirely free software to complement the open hardware - bootloader, VHDL for CPLD/FPGA, linux kernel+Debian.

3 Licencing

A number of different licences have been used for open hardware designs, as as been mentioned above.

Open Hardware Licences

- MIT
- Simputer - Lawyer-written, Trademark, Licence fee
- VHDL licences - Opencores, GPL
- Several GPL-based
  - Hardware Design Public Licence
  - Freedom CPU Licence
- TAPR Open Hardware Licence

- BOHL

The people doing 'soft hardware' have tended to use normal software licences as they are really just doing software. People making actual hardware have used both existing software licences and written (or tried to write) specific open hardware licences. There was a lot of activity around this subject around 2001, when the Simputer Licence was writtena and the unfinished HDPL and Freedom CPU Licenses were created. Then it went quiet again until recently when two new licences appeared - the TAPR Open Hardware Licence and the Balloon Open Hardware Licence.

There are good reasons why simply using a software licence for hardware is not ideal. Hardware is not the same as software in a couple of important ways, and these affect licence terms.

Differences from Software

- Copying cost is large, often very large
  - 4 prototype balloons - €5000
  - balloon3 derived from balloon2 - €125000
- Legal requirements
  - Sale of goods act.
  - EMC
  - Component use restrictions - Medical equipment
  - Batteries - safety, disposal
- Very expensive typos - duff boards

The fundamental difference is that the copying cost is much higher. I cannot just download a board over the internet if I want to hack on it - it actually has to be made, tested and shipped. The costs of this are quite high: even for the balloonbaord project where most of the designer time is donated, it has still cost quite a lot of money to get the design to the stage where it is manufacturable (3 revisions).

The other big issue is the legal environment. As soon as you are selling real hardware a whole load of laws apply, such as the sale of goods act, stating that things must be fit for purpose, the EMC regulations, and other stuff about battery disposal, end-of-life hardware return (in the EU) and so on.

It is also true that a typo can be a very expensive mistake. If someone manufactures a load of boards with some mistake in the files then they will be annoyed at the tens of thousands, or hundreds of thousands of pounds/dollars/euros they just wasted.

Nvertheless openness is important in hardware just as it is in software, so that people can develop better systems from existing ones, can understand their stuff, can fix associated software, can design additions, and can learn from existing designs.

So we have tried to write a licence which follows copyleft principles but which is practical to use in a hardware and maufacturing environment. It distinguishes between designers, manufacturers, distributors and users because they all have different legal and moral responsibilities.

Lets look at its requirements in a bit more detail.

4 Balloon Open Hardware Licence

Balloon Open Hardware Licence

- Open Source (copyleft) principles
- Distinguishes between designers, manufacturers, distributors and everyone
- Protect each group from litigation/liability
- Design group controls design
- Practical commercially
- Allows connection to prorietary hardware
- Has Logo to indicate licence terms
- Fully documented designs
- Firmware outside licence scope

Above are the main principles and aspects of the licence. It is a hardware licence so it doesn't cover software at all. Firmware comes under it's own licence. Attempting to include firmware in the scope caused problems and we decided a clean scope was better, even though it meant that someone could put non-free firmware on if they wanted.

The most unusual aspect of the licence is probably the concept of the design group.

Design Groups

- Set of people responsible for design
- Structure and management is up to each group
- Releases matter
- Defined group needed by manufacturers and distributors

The idea here is that for a complex design legal responsibility and defined releases are very important. You need to know which version you are building and thus that it will actually work (if you build a tested version properly). Thus the normal ad-hoc group of experts who understand a design is formalised a little so a manufacturer knows who to ask and check things with.

In order to discuss the licence we need to define some terms, and distinguish between the different aspects of design information.

Types of info

- Hardware Design Files (HDF) - The design itself
- Manufacturing Info (MI) - Gerbers, BOM
- Design Documentation (DD) - Schematics, pinouts, memory map, user guide

So we have the design files (which in practice are often in proprietary formats because the best design tools are still proprietary) which circulate in the design group, the manufacturing information needed to actuall make the devices, and all the informaiton describing the design which is needed by a user.

Below are the terms applying to each of the groups the licence distringuishes between. Much of this is to ensure traceability of versions whilst otherwise allowing people to do what they like, and making clear where legal responsibility falls.

BOHL - Everyone

- May:
  - Redistribute DD
  - Manufacture
  - Make minor MI changes
  - Make Component changes
  - Install firmware
- Must:
  - Pass on changes
  - Be reponsible for own use
- Must not:
  - Include in non-BOHL designs
  - Misrepresent or remove copyright notices/design mark
  - Apply for patents

BOHL - Manufactuers

- May:
  - Manufacture freely
  - Add identifying marks
  - Provide warranty
- Must:
  - Comply with legislation, and show compliance on request
  - Provide MI and DD to users (nominal fee permitted)
- Obligations remain, but rights lapse, if licence broken.

BOHL - Distributers

- May:
  - Market and distribute freely
  - Add identifying marks
  - Provide Warranty
- Must:
  - Comply with legislation
  - Inform users of Licence
  - Inform users of any use restrictions
- Obligations remain, but rights lapse, if licence broken.

Designers

- May:
  - Access and modify HDF freely
  - Base a new (BOHL) design on Design Files
  - Perform simulations
  - Leave design group
- Must:
  - Record HDF modifications (in DD)
  - Include visible design mark
  - Include release ID
  - Pass on HDF modifications
  - Ensure additions do not infringe 3rd parties
  - Provide info on use/config (normally in DD)
- Must not:
  - Claim rights over design
  - Pass on HDF outside design group

So, there is quite a lot of process mixed into the more fundamental principles there. I would very much like anyone interested in this subject to help review the licence and see if it can be simplified whilst still providing good legal 'insulation'. I think there is currently rather too much process encoded in the licence, but I also think the principles are sound.

It would be good if this licence was sufficiently well-written to be useful to a wide range of hardware projects, and to be acceptable to companies with the resources to make open hardware designs happen. For that to be true requires input from quite a number of people. The URL of the full text is below.

Please comment on the wiki, or on the mailing list.

Licence Needs Review

- Potentially a widely-used licence
- Designers, manufacturers, distributors, users - please comment
- Legal review to follow
- `http://balloonboard.org/balloonwiki/OpenHardwareLicense`