

# Open Hardware for Technology Transfer

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BE-CO Hardware and Timing section  
CERN, Geneva, Switzerland

CERN BE-KT Day

# Outline

- 1 **Open Hardware**
  - Open Hardware Intro
  - Open Hardware Repository
  - CERN Open Hardware Licence
- 2 **Case studies**
  - Case studies – SPEC & ADC
  - Experience with Industry
- 3 **Conclusions**

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# CERN Open products are real products

## Seven CERN designs commercialised by four companies

**SEVEN Solutions**

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### WR Switch (18/8 SFPs)

The White Rabbit Switch (WRS) is the key component for precision timing and high synchronization over an Ethernet network.

Actually it exists two standalone SFP versions:

- The WRS-3/18 version which is the standard version
- The WRS-3/8 version with only 8 SFP connectors

#### Main Features

- Virtex-6 FPGA (XC6VLX130T)
- ARM (Atmel AT91SAM9G45) @ 400MHz
- 18/8 x SFP cages
- 32M x 16 DDR2
- Two 512Kx36 QDRII SRAM
- Ethernet 10/100 PHY
- 256 MB NAND Flash
- 8 MB SPI Boot Flash
- 5 SMC coaxial Clocks (PPS I/O, 125MHz I/O, 10MHz)
- 1.6 GHz VCO (AD9516-4)

References

**INCA COMPUTERS** Design and Manufacturing of technical automation systems

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Products by Standard • **ADC** • 4ch 105 Mps 30 MHz 14 bit ADC

### 4ch 105 Mps 30 MHz 14 bit ADC

Features:

**4 channel FMC ADC module**

Max. sample rate 105 Mps  
Analog bandwidth 30 Mhz, DC-coupled  
80k/sample 14 bit  
ENOB 11, 11.5, 11.7 bit @ +/-50mV, +/-0.5V, +/-5V range)  
Channels 4  
Connectors 4 x LEMO 03 for signals, 1 x LEMO 00 for far trigger  
Input impedance 1 kOhm / 50 Ohm - software

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# Create the Impossible

Products List

- Simple PCIe FMC carrier (SPEC)

The FMC PCIe Carrier is an FMC carrier that can hold one FMC card and an SFP connector. On the PCIe side it has a 4-lane interface, while the FMC mezzanine slot uses a low-pin count connector. This board is optimized for cost and will be usable with most of the FMC cards designed within the QIR project (e.g. ADC cards, FMC Delay). For boards needing more programmable logic resources, fast SRAM, fast interconnect between carriers), the FMC PCIe Carrier or its VME counter part can be used.

Ask about the product  
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Custom Design

Custom Products

**VME**

VME-32  
VME-32

QC Pass  
JC  
137405  
Simple VME FMC Carrier  
(SPEC) v1.0  
KOP-FMC-04-REC0  
www.janztec.com  
HCCV070 CRO00970



# Why we use Open Hardware

## Design re-use

When it's Open, people are more likely to re-use it: feedback.

## Dissemination of knowledge

One of CERN's key missions!

## Healthier relationship with companies

No vendor-locked situations. Companies selected solely on the basis of technical excellence, good support and price.

## Spend money where you or your funding agencies want

Opens the door to smaller companies with local support.

# Dispelling the commercial vs open myth

	Commercial	Non-commercial
Open	<b>Winning combination. Best of both worlds.</b>	Whole support burden falls on developers. Not scalable.
Proprietary	Vendor lock-in.	Dedicated non-reusable projects.

# CERN FMC projects in OHWR.org – some examples

## FMC Carriers

- VME64x (BE/BI & BE/CO), VXS (BE/RF)
- PCIe (BE/CO), PXIe (EN/ICE & BE/CO), AMC (PH/ESE)

## FMC Mezzanines

- ADC sampling speed: 100 MSPS
- TDC and Fine delay: 1 ns resolution
- Digital I/O: 5 channels

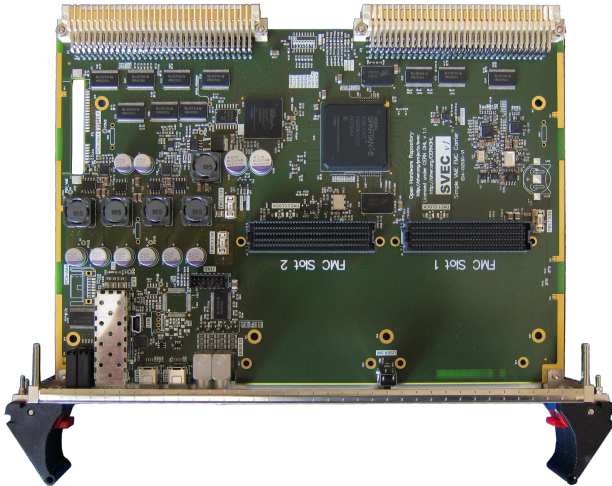
## Stimulates collaboration between CERN groups

- VME64x: BE/BI & BE/CO
- TDC: TE/ABT, TE/CRG & BE/CO



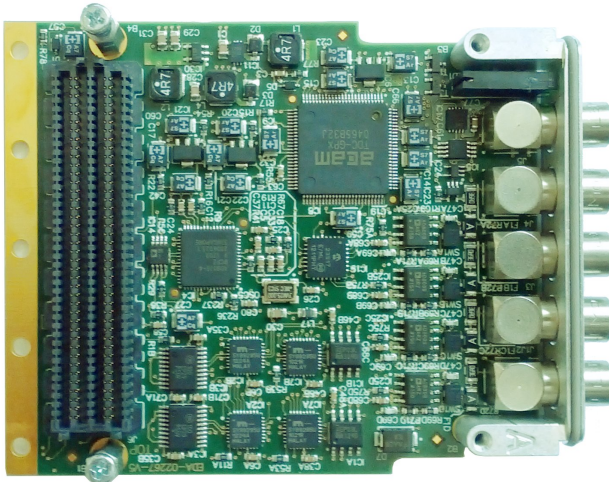
# SVEC - Simple VME FMC Carrier

Produced and sold in Germany



# FMC mezzanine: 4-channel Fine Delay

Produced and sold in Spain



# CERN Open Hardware License – [ohwr.org/cernohl](http://ohwr.org/cernohl)

## Provides a solid legal basis

- Developed by Knowledge and Technology Transfer Group at CERN
- Open Software licences not usable (GNU, GPL, ...)
- Defines conditions of using and modifying licenced material

## Practical: makes it easier to work with others

- Upfront clear that anything you give will be available to everyone
- Makes it clear that anyone can use it for free

# CERN Open Hardware License – [ohwr.org/cernohl](http://ohwr.org/cernohl)

## Same principles as Open Software

- Anyone can see the source (design documentation)
- Anyone is free to study, modify and share
- Any modification and distribution under same licence
- Persistence makes everyone profit from improvements

## Hardware production

- When produce: licensee is invited to inform the licensor

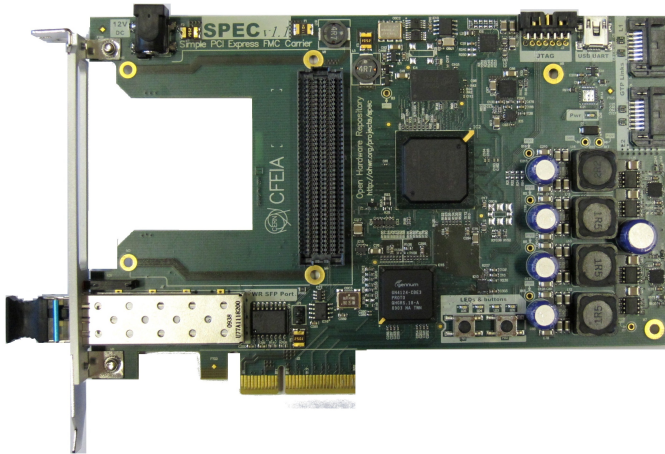


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# Case study – SPEC: Simple PCI Express FMC carrier

Made in Spain, The Netherlands & Poland



## Case study – SPEC

### Development

- Used a small Polish **company** to help with the design
- Review and quality documentation by CERN

### Make it a testable product

- Developed go/no-go test suite

### First series of 70 boards (production, guarantee)

- Solid specification, IPC norms for PCB fab and assembly
- Price Enquiry to 7 **companies** *having already PCIe products*. First delivery in March 2012. Now 3 produce!
- CERN helped company to get quality right

# Case study – SPEC

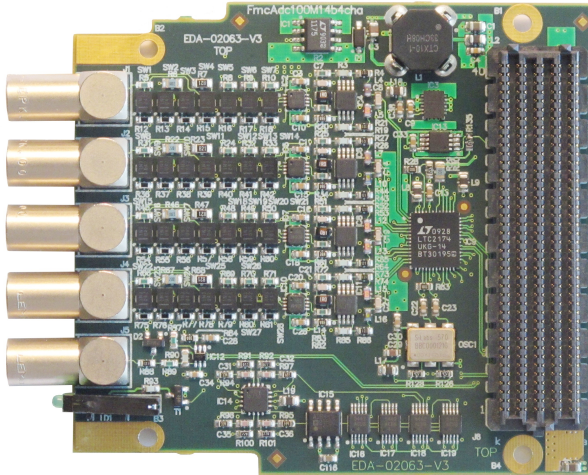
## Users, incomplete list

- B-train system (CERN TE/MS)
- CLIC Interlock System study (CERN TE-MPE)
- ATLAS Pixel IBL readout concept prototyping
- CNGS
- GEM detector readout (Creotech, PL)
- FAIR accelerator timing network (GSI)
- LHAASO telescope (Tsinghua University, China)
- Metrology Institutes for Time transfer (NL, UK, ...)
- Industry (isolated high-voltage measurement station, NL)

<http://www.ohwr.org/projects/spec/wiki/Users>

# Case study – 100 MSPS 14-bit 4-channel ADC

## Made in The Netherlands



# Case study – 100 MSPS 14-bit 4-channel ADC

## Design

- Design by CERN student
- A small specialist **company** designed the front-end
- Reviews at CERN
- Design process well documented (mails, documents)

## CERN Price Enquiry for 40 boards (production, guarantee)

- Price Enquiry to five companies *that produce ADC boards*
- Useful design feedback (schematics and PCB layout) from **company**. Delivered in April 2012.
- Company adapted the design for 2 new products

# Case study – 100 MSPS 14-bit 4-channel ADC

## Potential users

- BPM Linac4 (CERN BE/BI)
- Frame grabber for BSRT emittance meter (CERN BE/BI)
- PSB pick-ups (CERN BE/BI)
- Septum. Booster Trajectory Measurement (CERN TE/ABT)
- **OASIS general purpose (CERN BE/CO)**
- Italian Hadron Therapy Centre, BPM system (CNAO)
- **Culham Centre for Fusion Energy (CCFE)**
- **ESS: European Spallations Source**
- Advanced Photon Source (Argonne National Laboratory)
- Radio Telescope (Oregon State University)
- **Industry: high-voltage measurement station**

# Experience with Industry

May 2013

## Companies used (usually paid for)

- 15 European companies

## Types of work

- Hardware: development, production
- Software: VHDL firmware, drivers
- Usually small projects (<2 months work), speeds up projects, gets in specialist knowledge
- Small companies can play a large role
- Production: follows CERN purchasing rules (competition)



# Experience with Industry

## Examples of re-use of work

- Two companies modified SPEC carrier design.
  - larger FPGA (for software radio), PXIe bus version
- A company modified ADC100M design.
  - other input filter, high-voltage front-end
- A company re-used nanoFIP code for renovating trains.

## Generates interaction

- Companies work together – building an ecosystem:
  - One sells a carrier, others sell mezzanines
  - One sells a WR switch, others sell WR nodes
- Once company makes its own designs available on OHR.
- Could negotiate component pricing for all partners.

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# Conclusions

- Open Hardware has many advantages.
  - Anyone can help in developments and make improvements.
  - Allows to work differently with industry (design work, smaller companies).
  - Not tied to a single company for production and support.
- CERN Open Hardware Licence provides a legal basis.
- OHWR.org site is practical for engineers and users.
- **Seven of CERN's designs are already commercialized.**
- Companies receive new clients.
- Companies get knowledge of CERN (design, production).
- Companies use CERN designs to make new products.
- The scalable model attracts users to CERN technology.

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## Simple VME FMC Carrier (SPEC)

Custom Products

VMECue

VMEC-32

VMEC-32

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# Create the Impossible

## Simple PCIe FMC carrier (SPEC)

Products List

- FMC DIO 5ch T5, x
- FMC ADC 320k 144-4ns
- FMC ADC 320k 150-1ns
- FMC DIO 1m 4ns
- Simple FMC carrier (SPEC)
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# CERN's use of the Open Hardware paradigm generates technology transfer and stimulates innovation

