xTCA evaluation project status and HPM modules development at CERN

4TH MIcroTCA Workshop - DESY

CERN PH-ESE-BE collaboration

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Outline

- Introduction
- MicroTCA evaluation project
- CERN MMC
- AdvancedTCA evaluation project

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xTCA for LHC experiments at CERN

- Off-detector electronics of the LHC experiments mostly based on VME
  - Working very reliably
  - "Old" technology and doubts about long-term availability
- Major upgrades of the LHC experiments are foreseen over >10 years
  - Aligned with LHC upgrade long shutdowns: 2013/14, 2018, 2023
- Experiments planning to use MTCA & ATCA for upgrades of their back-end electronics
  - MTCA (and ATCA): CMS
  - ATCA: ATLAS
- MTCA and ATCA developments already on-going at CERN and collaborating institutes
  - xTCA Evaluation project
    - Focus effort on infrastructure components (shelves, power supplies, …)
    - Establish a purchasing framework and provide support

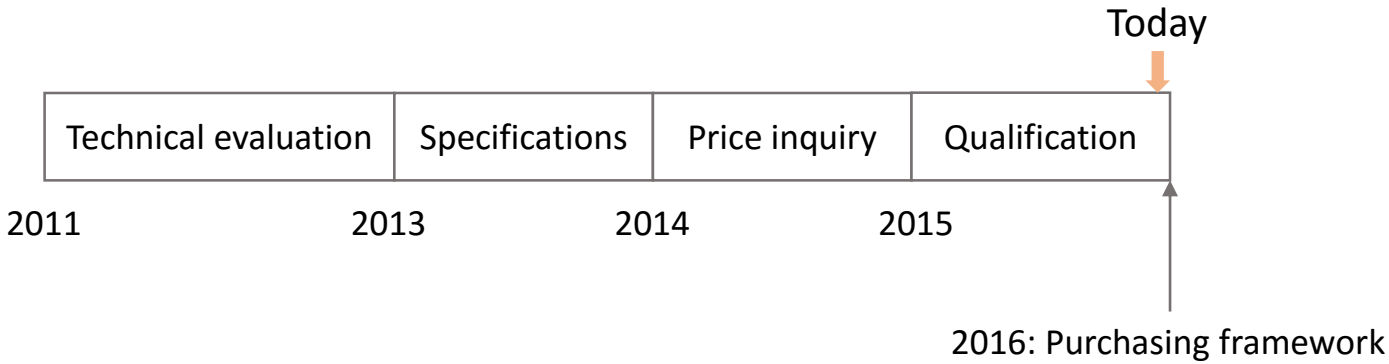
Outline

- Introduction
- MicroTCA evaluation project
  - Introduction
  - Power module
  - Crates
- CERN MMC
- AdvancedTCA evaluation project

MicroTCA evaluation project

- MicroTCA evaluation project main goal
  - Specifying MicroTCA infrastructure equipment (shelves and power modules) for use in the LHC experiments
  - Simplifying equipment procurement for CERN users

- Roadmap



MicroTCA power module

- Specifications
  - Output power: 800W
  - Input voltage range: -40V to -60V
  - Payload power:
    - 12V ± 10%
    - 80W per channel
    - Output voltage stability: ±200 mV
    - Maximum output noise and ripple: 100 mV (pk-pk)
  - Management power
    - 3.3V ± 5%
- Selection of the NAT DC840 power module
  - Output power: 840W
  - Compliant (CERN Specs): Yes
  - Pros: Efficiency and IPMI compliance
- Qualification with 3 pre-series units of the NAT power module

MicroTCA power module

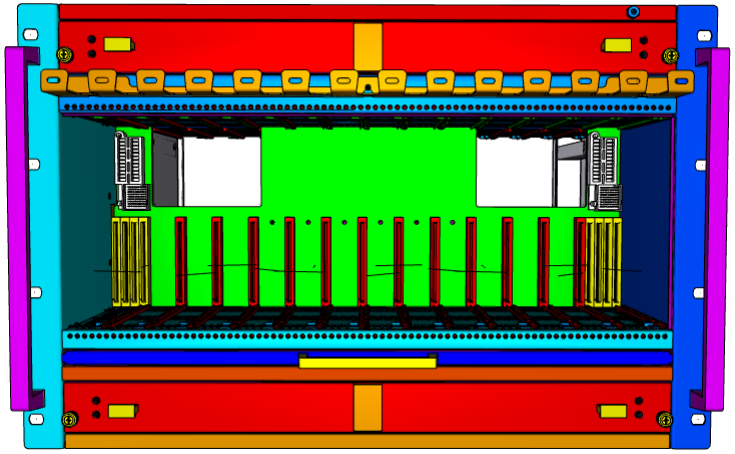
- Qualification tests carried out
  - Functionality (IPMI compliance, sensor thresholds, FRU information)
  - Load regulation (payload power)
  - Line regulation (payload power)
  - Efficiency
  - Ripple and noise
- Outcomes

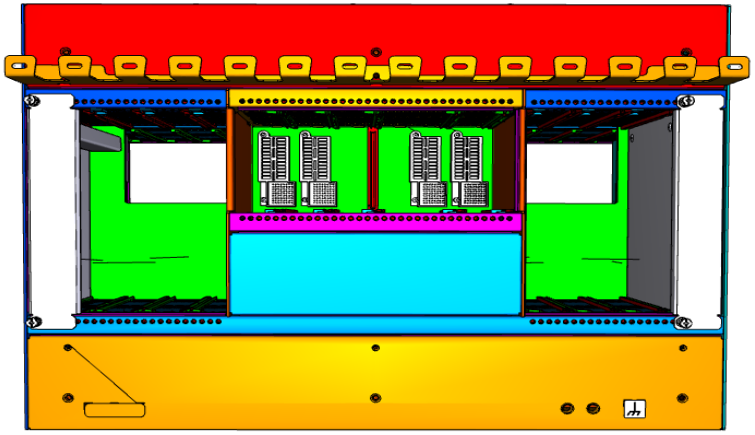
*1: Load variation on all AMCs
*2: Load variation on only 1 AMC

	Test Conditions	Measured	DC840 Specs	CERN Specs
Maximum Power	Vi=-48V	880W	840W	800W
Input Voltage		-39V to -60V	-40V to -60V	-40V to -60V
Load Regulation	-48V input voltage	> 500mV *1 < 200mV *2	10% (±600mV)	**±200mV**
Line Regulation	multi load values, Vin: -40V to -60V	< 32 mV	Not specified	±200mV
Efficiency	Vi = -48V, 40-105% of full power	91.01% (min)	**95.5% (min)**	90% (min)
Ripple	Full power, no CU, 50W x 12	< 250mV (pk-pk)	Not specified	**100mV (pk-pk)**
Current sensors accuracy	Channel out current from 1A to 5A	< 312 mA	Not specified	5% of the max. current (About 400 mA)

- Qualification report available on request

MicroTCA shelves





- Specifications
  - Slots:
    - Up to 12 double width/full-size AMCs
    - 2 MCHs
    - 2 PMs (front) and 4 PMs (rear)
    - 6 RTMs
    - 1 JSM
  - 2 interchangeable backplanes
    - Custom backplane connections
    - MTCA.4 compliant
  - Max. output air temperature 55°C (ambient: 25°C and 80W per slots)
  - Vertically cooled (bottom – top airflow)
- Selection of the Schroff crate
  - Compliant (CERN spec): Yes
  - Pros: cooling homogeneity, mechanical robustness and remote support
- Qualification with 3 pre-series units of the Schroff crate

MicroTCA shelves

- Qualification tests carried out
  - Functionality (FRU info, HPM.1 support)
  - Backplane connections
  - AMC, RTM and PM Slots cooling
  - Power distribution
- Outcomes

	Test Conditions	Measured	CERN Specs
Mechanical aspect	Visual check	Compliant	Custom configuration
CU functionalities	Operating test	Compliant	Hot swap, HPM.1 support and redundancy
AMC slot cooling	12 ALBs at 80W CU at full speed	25 deg. C max delta	Air outlet < 55°C for 25°C air inlet
PM slot cooling	PM at 800W CU at full speed Ambient 26 deg. C	Absolute brick temp. 72 deg C.	Air outlet < 55°C for 25°C air inlet
RTM slot cooling	6 RTMs at 40W CU at full speed	16 deg. C max delta	Air outlet < 55°C for 25°C air inlet
Backplane voltage drop	80W / slot	207 mV (max)	< 300 mV

- Qualification report available on request

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- ❑ Introduction
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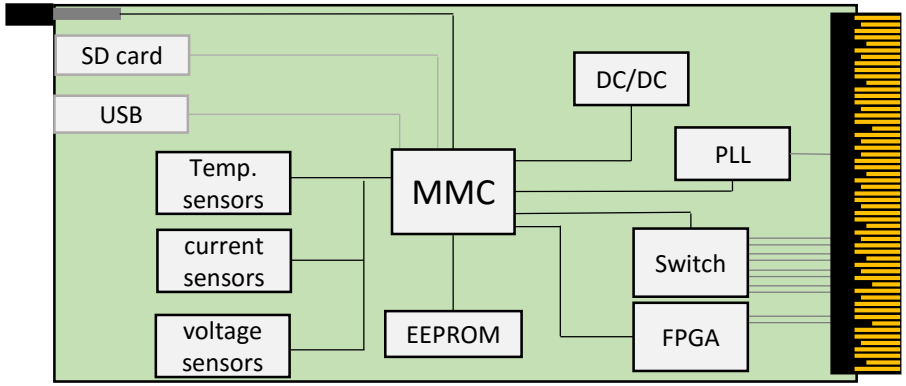
- ❑ CERN MMC
  - Introduction
  - Development roadmap
  - New architecture
  - AMC specific customization (user code)
  - Summary
- ❑ AdvancedTCA evaluation project

CERN MMC: Introduction

- CERN MMC source code was inherited from DESY / CPPM
- MMC Role
  - Activating / De-activating an AMC card
  - Providing information about the AMC card
    - Maximum current
    - Ports configuration
    - Clock configuration
  - Sending alert events (sensor exceed threshold)
  - Executing IPMI commands
- Features
  - Power management
  - Sensor monitoring
  - Clock and ports management (E-Keying)
  - *Debug terminal (USB)*
  - *FAT32 filesystem (SD Card)*



CERN MMC: Development roadmap

- 2011-2015: MMC V.1.0
  - Basic version
  - Support of the Atmega128 microcontroller
  - User customization difficult
  - E-keying not supported

- 2015: MMC V.2.0
  - Almost all the code was re-written
  - Simplified user customization
  - Improved standard compliance
  - Supported port and clock e-keying feature
  - Supported HPM.1 remote upgrade standard

- 2015-2016: MMC V.3.0
  - New source code architecture
  - Support of 3 different microcontrollers

CERN MMC: new architecture

- **HPM**
  - **Application**
    - Application source code (.h, .c)
  - **Drivers**
    - uC drivers source code (.h, .c) ← **driver.h: Low level interface**
  - **User**
    - Configuration file (.h)
  - **uC project**
- **MMC**
  - **Application**
    - Application source code (.h, .c)
  - **Drivers**
    - uC drivers source code (.h, .c) ← **driver.h: Low level interface**
  - **User**
    - **User_code**
    - **Sensors**
  - **uC_MMC project**

CERN MMC: AMC specific customization (user code)

- ❑ General configuration
- ❑ FRU Information
- ❑ Power sequences
- ❑ AMC port and clock e-keying
- ❑ User LEDs
- ❑ User geographical address (specific for benchtop use)
- ❑ Sensors

```
#define LM82                                    \
    {                                           \
        {                                       \
            sensor_number: TEMPERATURE_SENSOR1, \
            init_time: MP_PRESENT,              \
            name: "LM82-IC1",                   \
            i2c_addr: 0x2A,                     \
            p1: POINT(0,0),                     \
            p2: POINT(1,1),                     \
            upper_non_rec: 85,                  \
            upper_critical: 75,                 \
            upper_non_critical: 70,             \
            lower_non_critical: 10,             \
            lower_critical: 5,                  \
            lower_non_rec: 0                    \
        }                                       \
    }
```

CERN MMC: Summary

- New architecture
  - Source code divided in 3 parts: application, drivers and user
  - Support of standardized sensor drivers
- Almost all Polaris Tester automatic test passed (standard compliance tester)
  - 26 passed
  - 2 failed (MCH related: p2p connectivity and set blue led command)
- External tools:
  - MTCA C library (including FRU writer and event reader examples)
  - HPM.1 tool (including programing feature)
  - Sensor driver generator
- Used with many AMC cards
  - CERN projects:
    - CMS: TwinMux (Atmega128), MP7/FC7 (AT32UC3A3256), MTF7 (AT32UC3A1512)
    - ATLAS: Liquid Argon (Atmega128)
  - External projects:
    - IN2P3: Nebula, Sirocco, Stereo acquisition system, EX2, Gamahadron
- The CERN MMC source code is based on the GNU-GPL licence
  - https://espace.cern.ch/ph-dep-ESE-BE-uTCAEvaluationProject/MMC_project/default.aspx (Web page)

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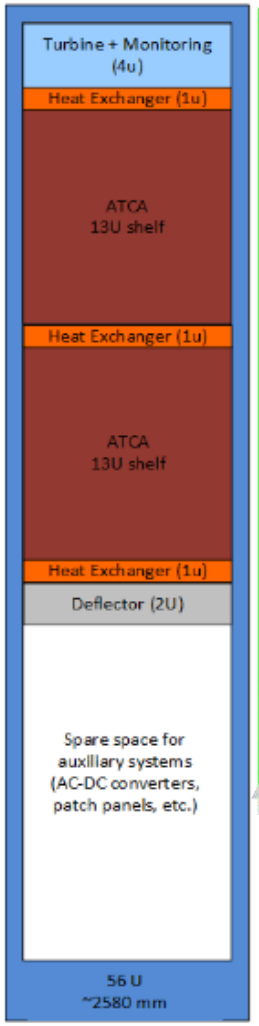
  - Shelves cooling
  - CERN IPMC

AdvancedTCA: Shelves cooling

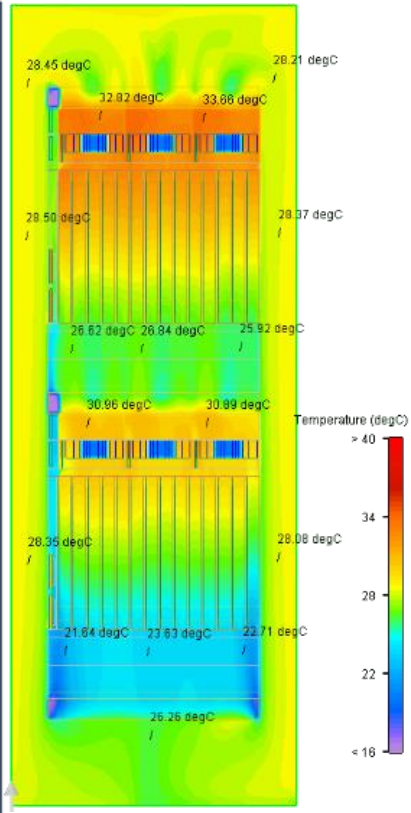
- Goal: Assess the possibility of reusing the existing rack infrastructure towards a common specification.

- AdvancedTCA shelves cooling simulation (CERN rack)
  - Simulation are on-going
  - Searching for possible rack improvement

- AdvancedTCA shelves cooling measurements (CERN rack)
  - Measurement using a commercial ATCA load blade
  - Comparison with simulation
  - Horizontally vs. vertically cooled
  - Testing multiple rack configuration



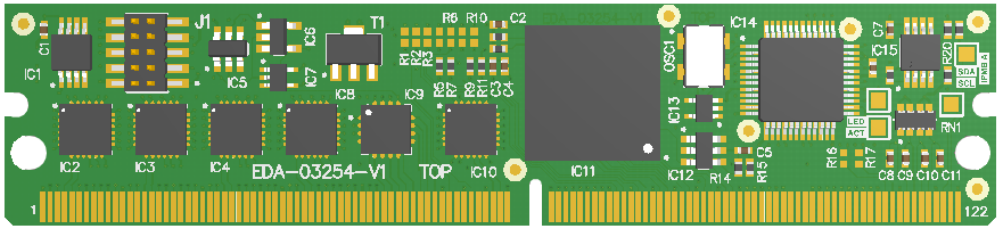
ATCA rack



Thermal simulation view

AdvancedTCA: CERN IPMC

- Based on the Pigeon Point solution
- Design of a custom IPMC mezzanine card
  - Form factor compliant with already designed ATCA blades (DIMM-DDR3 VLP)
  - Management of up to 8 AMCs + 1 intelligent RTM
  - Ethernet, I2C and I/O interfaces
- Roadmap:
  - 2015
    - Evaluation of the Pigeon Point solution
    - Study of the design feasibility of a mezzanine
    - Design of the CERN IPMC mezzanine
  - 2016
    - Debug of the CERN IPMC mezzanine
    - Creation of a user space into the source code
    - Make the mezzanine available to CERN users/developers



IPMC mezzanine card top view

Thank you

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