xTCA evaluation project status and HPM modules development at CERN

xTCA interest group meeting

CERN EP-ESE-BE collaboration

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Outline

- Introduction
- MicroTCA evaluation
- CERN MMC
- AdvancedTCA evaluation
- Pigeon Point based IPMC
Outline

- Introduction
  - MicroTCA evaluation
  - CERN MMC
  - AdvancedTCA evaluation
  - Pigeon Point based IPMC
xTCA for LHC experiments at CERN

- 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
- Pigeon Point based IPMC
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

<table>
<thead>
<tr>
<th>Technical evaluation</th>
<th>Specifications</th>
<th>Price inquiry</th>
<th>Qualification</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>2013</td>
<td>2014</td>
<td>2015</td>
</tr>
</tbody>
</table>

2016: Purchasing framework
MicroTCA power module

- CERN 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 (MicroTCA compliance)
  - Load regulation (payload power)
  - Line regulation (payload power)
  - Efficiency
  - Ripple and noise

- Outcome

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

*1: Load variation on all AMCs
*2: Load variation on only 1 AMC
Power module: summary

- Most of the results are within the specification
- Qualification process finished successfully
- Qualification report available on request
- Purchase framework is established
  - [https://espace.cern.ch/ph-dep-ESE-BE-uTCAEvaluationProject/Procurement/_layouts/15/start.aspx#/SitePages/Home.aspx](https://espace.cern.ch/ph-dep-ESE-BE-uTCAEvaluationProject/Procurement/_layouts/15/start.aspx#/SitePages/Home.aspx)
- Few issues being addressed by NAT:
  - Detection of critical temperature (thresholds)
  - Detection of input voltage failure
  - Heat sink
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

- Outcome

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

- Qualification report available on request

10/03/2016
MicroTCA crates: summary

- All of the results are within the specification
- Qualification process finished successfully
- Purchase framework is established in 2016
  - [https://espace.cern.ch/ph-dep-ESE-BE-uTCAEvaluationProject/Procurement/_layouts/15/start.aspx#/SitePages/Home.aspx](https://espace.cern.ch/ph-dep-ESE-BE-uTCAEvaluationProject/Procurement/_layouts/15/start.aspx#/SitePages/Home.aspx)

- Few issues being addressed by Schroff:
  - Separated management of front and rear cooling
  - Slot identification

- Lane quality measurements (VNA) are currently being carried out
  - Compliant with 10Gbe standard

- Recommendations to user:
  - Power module redundancy to be used with care
  - Limitation of the power module to 600W
Outline

- Introduction
- MicroTCA evaluation project
  - CERN MMC
    - Introduction
    - Development roadmap
    - New architecture
    - AMC specific customization (user code)
    - Summary
- AdvancedTCA evaluation project
- Pigeon Point based IPMC
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

```c
#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
  - Standardized sensor interface (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](https://espace.cern.ch/ph-dep-ESE-BE-uTCAEvaluationProject/MMC_project/default.aspx) (Web page)
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  - Shelves cooling
- Pigeon Point based IPMC
AdvancedTCA: Shelves cooling

- **Goals:**
  - Common specifications for shelves
  - Assess the possibility to re-use existing racks system or specify rack infrastructure for horizontally cooled crates

- **AdvancedTCA shelves cooling simulation (CERN rack):**
  - Simulation have been performed
  - Rack improvement had been proposed
  - Report available on request

- **AdvancedTCA shelves cooling measurements (CERN rack):**
  - Detailed by Claudio Bortolin
    - ATLAS ATCA cooling evaluation project
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CERN IPMC: Introduction

- Based on the Pigeon Point solution
- Licence: EP-ESE-BE (xTCA Evaluation Project)
  - Licence for use at CERN
  - Software and Hardware documentation
  - Starter kit
  - User guide
CERN IPMC: Evaluation of the Pigeon Point solution

- Pigeon solution was evaluated using the starter kit IPMC mezzanine card
- Adapter card (CERN) was used to evaluate the solution with existing ATCA blade
CERN IPMC

- **Status:**
  - Evaluation of the Pigeon Point solution
  - Study of the design feasibility of a mezzanine
  - Design of the CERN IPMC mezzanine

- **Roadmap (2016):**
  - Prototype production (ongoing)
  - Debug of the CERN IPMC mezzanine
  - Creation of a user space into the source code
  - Goal: Make the mezzanine available to CERN users/developers
Summary

- **MicroTCA:**
  - Evaluation of commercial modules finished
  - Specifications written
  - Qualification almost finished
  - Purchase framework is established

- **AdvancedTCA:**
  - Evaluation is almost finished
  - Writing specification has just started

- **MMC:**
  - New release is available on SVN

- **IPMC:**
  - Prototype will be debugged and used as a demonstrator
Thank you

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