MicroTCA and AdvancedTCA equipment evaluation and customization for LHC Experiments

M. Di Cosmo, V. Bobillier, S. Haas, M. Joos, S. Mico, F. Vasey

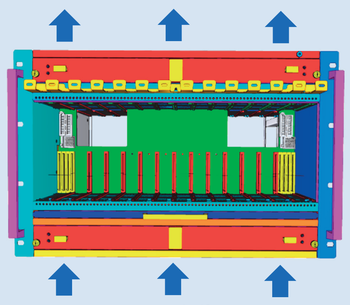
PH-ESE-BE Section, CERN, 1211 Geneva, Switzerland

xTCA Evaluation Project

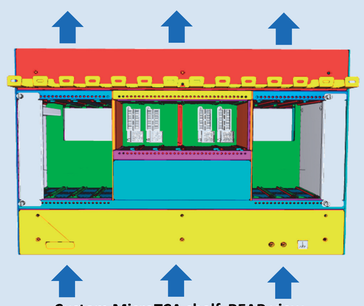
Originally developed for the telecommunication industry, MicroTCA and AdvancedTCA have gained momentum also in the high energy physics community where they are going to be deployed as platforms for data acquisition, trigger and control systems. Several independent groups at CERN and in external institutes have started to develop ATCA and MTCA modules and the question arises as to how these modules should eventually be housed. In this framework, the PH-ESE group at CERN launched the xTCA Evaluation Project with the goal of providing technical evaluation of xTCA systems as well as support service and tools to the community. The experience and know-how gained during the evaluation phases allowed us to define technical specifications and test procedures for the main xTCA components in view of future equipment procurement.

Tested MicroTCA and AdvancedTCA equipment (commercial and custom)

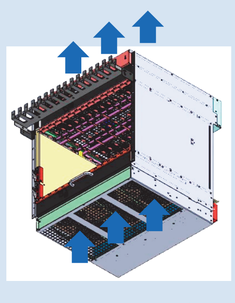
Different commercial devices from different vendors have been acquired and evaluated with a clear focus on the infrastructure equipment such as shelves, power supplies, power modules and cooling units. The evaluation did not only involved commercially available components but also customized equipment specifically developed for the LHC Experiments such as two custom MicroTCA and AdvancedTCA shelves. Both platforms implement a vertical airflow design in order to adapt with the existing rack thermal management infrastructure. Additionally, the MicroTCA shelf implements a unique backplane topology providing the necessary infrastructure for up to 12 full-size/double-width AMCs, 6 RTMs and two MCHs. The six power module slots, two located on the front and four on the rear, ensure maximum power availability and installation flexibility to the user.



Custom MicroTCA shelf, FRONT view.



Custom MicroTCA shelf, REAR view.



Custom AdvancedTCA shelf, 3D view.

Table 1. Commercial MicroTCA equipment list.

Manufacturer	Reference	Description
Power Modules		
NAT	DC780	DC/DC, 792W
NAT	DC840	DC/DC, 840W
Vadatech	UTC010	DC/DC, 792W
Wiener	AC1000	AC/DC, 1KW
TreNew	CM100	AC/DC, 300W
Telkoor	PS-1138	AC/DC, 600W
Shelves		
ELMA	043-012	MTCA.4 shelf
Vadatech	VT892	MTCA.0 shelf
Schroff	11850-019	MTCA.4 shelf
Schroff	11890-035	MTCA.4 shelf
MCHs		
NAT	NAT MCH	MTCA.4
Kontron	AM4904	MTCA.4
Vadatech	UTC001	MTCA.4

Table 2. Commercial AdvancedTCA equipment list.

Manufacturer	Reference	Description
Shelves		
Schroff	11596-150	14 slots, 13U + ShM
ELMA	190186	14 slots, 13U + ShM
Comtel	470 05578-19	14 slots, 13U + ShM
ASIS	AS5144D422-000	14 slots, 13U + ShM

Table 3. Custom equipment list.

Manufacturer	Description
Shelves	
Schroff	MicroTCA 12AMCs, 6RTMs, 6PMs, 2MCHs vertical airflow.
ELMA	MicroTCA 12AMCs, 6RTMs, 6PMs, 2MCHs vertical airflow.
ASIS	AdvancedTCA 14 slots, 13U, vertical airflow.

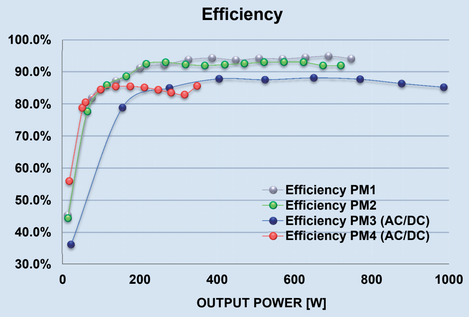
Test performed and evaluation results

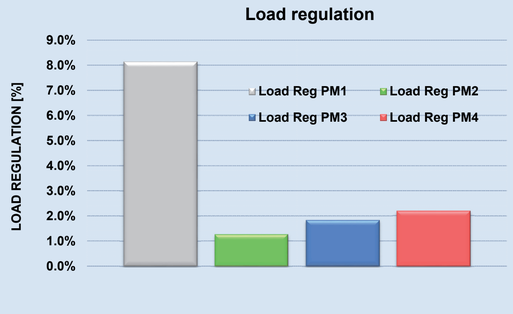
The tests performed can be classified into electrical tests, cooling tests, mechanical analysis as well as IPMI software tests. The electrical evaluation mainly concerns the MicroTCA systems since their power management is handled by the power module, a standard-defined component. By contrast, cooling performance test and mechanical aspect analysis involve both platforms.

Table 4. Tests performed on MicroTCA and AdvancedTCA components.

	MicroTCA	AdvancedTCA
Electrical tests	- Static regulation - Dynamic regulation - Ripple and noise - Efficiency and PF - Overcurrent protection	
Cooling and mechanics	- Cooling performance - Mechanical aspect and layout - Backplane alignment	- Cooling performance - Mechanical aspect and layout
Software (IPMI)	- IPMI interoperability tests - IPMI conformity (MMCs, EMMCs, MCMCs)	- IPMI interoperability tests - IPMI conformity (Shelf Managers)

Test conditions and procedures have been chosen to match with the manufacturer test conditions described in the technical sheet. When comparing different modules, the same procedures and formulas were applied.





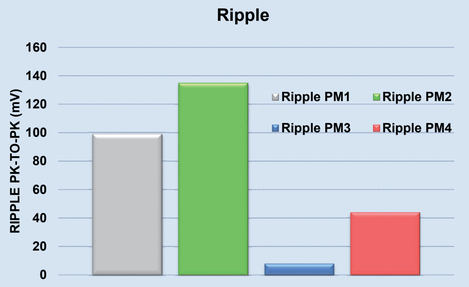
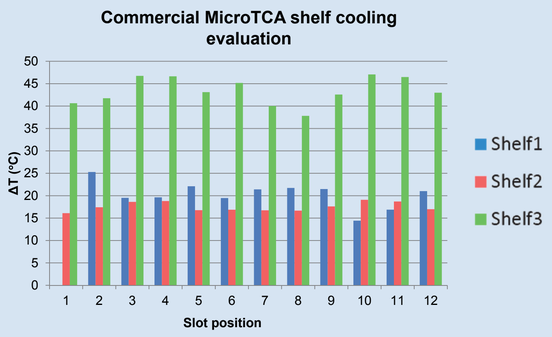
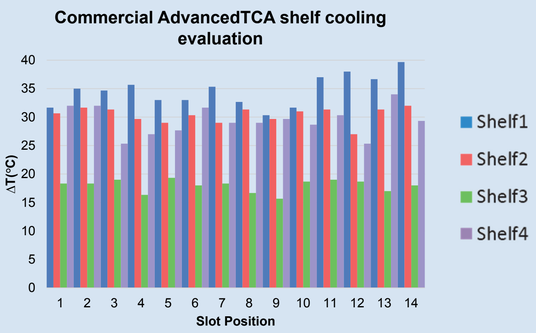


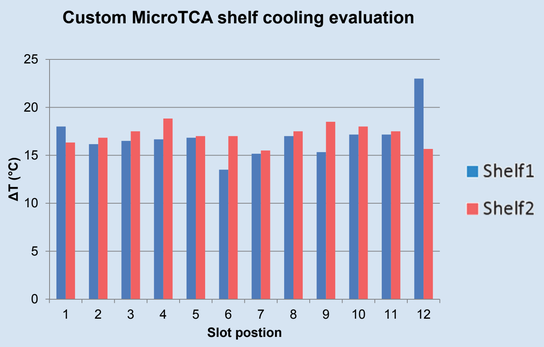
Table 5. Power modules evaluation summary

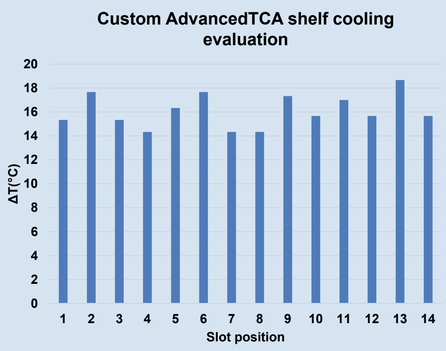
PM	Efficiency (max)[1]	Load regulation [%] [2]	Pk-to-Pk Ripple [mV] [3]
PM1	95%	8	100
PM2	94%	1.5	130
PM3	87%	1.8	8
PM4	82%	2	40

[1] Efficiency is measured from 1 to 100% of full power and Vi = -48V
[2] Load regulation is the payload power deviation at full power and Vi = -48V
[3] The ripple is measured at full power and Vi = -48V









Specifications of custom MicroTCA shelf and PM

The specifications include electrical, mechanical, cooling as well as software requirements. Additionally, safety and environmental operating conditions are also taken into account. The specification defines also a possible physical implementation of a MicroTCA shelf as well as its backplane and power topology.

Shelf

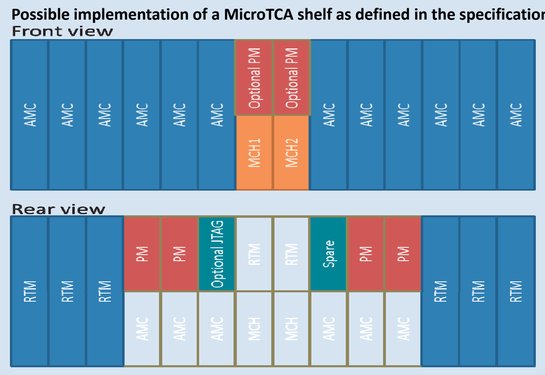
Physical requirements

- 19" rack system compatible with a maximum height of 10U.
- 12 full-size, double width AMC slots.
- 6 RTM slots (as defined in the PICMG MTCA.4 standard).
- 2 MCH slots.
- 4 (optionally up to 6) full size, single width PM slots
- 1 mid-size or full-size (preferred) JSM (JTAG switch module) slot (optional).
- The card cage shall be compatible with installation in a rack with vertical forced air flow.
- Cable management trays (retractable) shall be provided on front and rear.
- Module location and accessibility:

Located in the front:
- 2 MCH
- 12 AMC
- 2 CU
- 2 PM (optional)

Located in the rear:
- 4 PM
- 6 RTM
- 1 JSM (optional)

Possible implementation of a MicroTCA shelf as defined in the specification.



Power topology

As defined in the MicroTCA standard, only four out of the six power modules can be handled at one time. The front/rear distribution of the PM slots allows the implementation of different power topologies assuring cabling and installation flexibility.

Table 6. Possible power topologies (P = Primary, R = Redundant).

	1 PM	2 PM (front or rear)		4 PM (2 front,2rear)		4 PM (all rear)	
Policy	(basic)	Redundant	Shared	Redundant	Shared w redundant	Redundant	Shared w redundant
PM1	P	P	P	P	P	P	P
PM2		R	P	R	P	R	P
PM3				R	R	R	R
PM4				R	R	R	R

Backplane Requirements

Two different backplane topologies are allowed:

Option 1 (MTCA.4):

Port topology:
a) All AMC ports routed as per PICMG MTCA.4 standard.

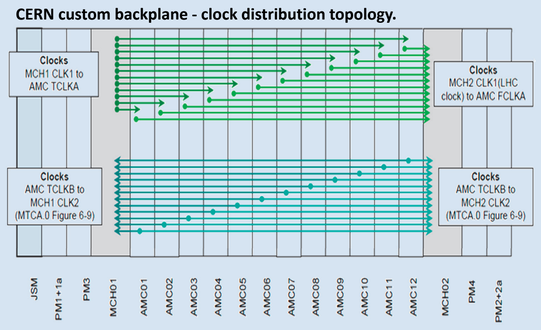
Clock distribution topology:
a) All clock lines routed as per PICMG MTCA.4 standard.

Option 2 (CERN custom):

Port topology:
a) Dual-star routing of AMC Fabrics A, B, D, E, F, G to MCH1/MCH2
b) AMC ports 12-15 routed as per PICMG MTCA.4 standard.
c) AMC ports 17-20 routed as per PICMG MTCA.4 standard.

Clock distribution topology:
a) MCH1 CLK1 to AMC TCLKA
b) MCH2 CLK1 to AMC FCLKA
c) AMC TCLKB to MCH1 CLK2 and MCH2 CLK2

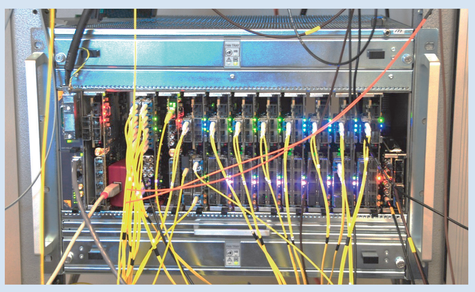
CERN custom backplane - clock distribution topology.



Power Module

- Dual -48VDC inputs.
- Minimum total (MP + PP) output power: 800W
- Total efficiency above 40% of maximum load: 90% minimum
- Support for 16 output channels: 12 AMCs, 2 CUs, 2 MCHs with individual control management and PP current monitoring
- Support for N+1, 2+2 redundancy and shared load topologies.
- Full HPM.1 support (EMMC FW field upgrade via IPMI commands)
- Input voltage range: -40 to -60 Vdc
- Minimum isolation voltage: 1500V
- PP output voltage accuracy: 12V ±10%
- Minimum payload output power per channel: 80W
- Optional: Minimum output power per channel in non-redundant mode: 100W (over the entire output voltage range)
- Output voltage stability (over dynamic load variations and including output voltage drift): ± 200mV
- PP maximum output noise and ripple: 100mV peak to peak (30 MHz BW)
- PP Maximum fast trip current limit: 9.7A (redundant); Optionally: 19.4A (non-redundant mode)
- Output current monitoring for each output channel (readout accuracy of 5%)
- MP output voltage accuracy: 3.3V ±5%
- MP max output noise and ripple: 100mV peak to peak (30 MHz BW)
- MP current available per channel: minimum 150mA
- MP fast trip current limit: 225mA (in redundant mode)

Prototype shelves delivered by two suppliers under evaluation



Conclusions

Over the past years we evaluated several MicroTCA and AdvancedTCA components including power modules, shelves and MCHs. This allowed us to acquire not only knowledge about specifications but also know-how about systems and components. Furthermore, thanks to a close collaboration with the manufacturers, we were able to address several technical and interoperability issues. The overall result we obtained is a significant improvement of the components and system stability. This brought us to the definition of two custom MicroTCA and AdvancedTCA shelves meeting the requirements of the LHC Experiments. We defined detailed equipment specification and test procedures on which we will base the future procurement of MicroTCA and AdvancedTCA equipment.

Topical Workshop on Electronics for Particle Physics - Aix-en-Provence, 22-26 September 2014