

Introduction to the MicroTCA.4 Standard Dr. Patrick Nonn 04/07/2019



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AGENDA

- 1. MicroTCA.4 in a nutshell
 - Motivation
 - Main Components
- 2. Use Cases
 - LLRF Systems
 - European XFEL
 - LILAC (NICA)
 - GigE Vision
- 3. What is MicroTCA Technology Lab?
 - Where we come from
 - Services





Introduction to the Micror CA.4 Standa	Introd	luction to	the Micro	oTCA.4	Standa
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What is ...

uTE!®



- European XFEL systems need high availability
 - More Uptime → Redundancy
 - Less Downtime → Remote Management
- Also important:
 - Low-noise signal transport
 - Precision timing
 - Compact form factor
- VME-crates provide none of the above
- Where else are requirements similar? Telecommunication





What is MicroTCA?

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Micro Telecommunications Computing Architecture

- An open, modular standard for high performance computing system, based on PCI Express
 - Evolved from Advanced Telecommunications Computing Architecture (ATCA)
- AdvancedTCA and MicroTCA both use Advanced Mezzanine Card (AMC) standard
 - Hot-swappable cards
 - Fully managed infrastructure
- Supports redundant power supplies and shelf controller





ATCA Crate

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MicroTCA lacks...

- High precision timing
- Rear input/output

New MicroTCA standard was developed:

- MicroTCA.4
- Specifically for science and similar industry application

From VME (FLASH) → MicroTCA (XFEL)

UTCA®

VME is 35 years old!!!





- Redundant fans & power supplies
- Internal clock & trigger distribution
- Modular: reusable components
- Complete remote management
- Modern high-speed data transfer
- Highest signal quality
- I/O cables from rear side



Composition of the MicroTCA Standard

- MicroTCA.0
 - originates in telecommunication
 - base for subsequent standards
- MicroTCA.1 to MicroTCA.3 are various levels of ruggedized variants
- MicroTCA.4 was developed with scientific application in mind



MICZOICA

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Essential Parts for MTCA.4 System

- Crate with Backplane
- Power Supply Module (PM)
- Cooling Unit (CU)
- MicroTCA Carrier Hub (MCH)
- Advanced Mezzanine Card (AMC)
- Rear Transition Module (RTM)



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MicroTCA.4 Hardware: MCH

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DESY

GEMEINSCHAFT

MicroTCA.4 Hardware: AMC Backplane

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Backplane Contents

- GigabitEthernet ٠
- SATA
- PCIe x4 and/or RapidIO
- Clocks
- Interlocks
- Triggers
- JTAG .
- **IPMI** .
- Point-to-point • Connections





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MicroTCA.4 Management: IPMI Bus

- Intelligent Platform Management
 Interface
 - Management and monitoring capabilities independent from the host system's CPU
- Led by Intel in Sept. 1998
- I2C based serial bus
- Identify hardware (FRU)
- Hardware diagnostics (tempature, expected current consuption etc.)
- Initiate boot up and shutdown
- Logging of events





MicroTCA.4.1: RF Backplane



Additional Backplane for RTMs

- Three extra slots for RF/clock signal generation and distribution modules
- RF signal distribution over backplane, thus reduced RF coaxial cabling usage
- Supports up to 3 extended RTMs (RTMs without AMC)
- Shielding from digital noise from AMCs
- Up to 2 power supply RTMs with low-noise, separated, analog, bipolar power distribution
- MCH-RTM for system management of RTMs



MicroTCA in Comparison to Competing Standards

Introduction to the MicroTCA.4 Standard

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DESY

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	ATCA	VME (VXS)	cPCI (serial)	VPX	MicroTCA.4
Board size (mm)	very large 280x320	medium 230x160	small 100x160	medium 230x160	medium 150x180
Rear Extension	small	small	(no)	small	large
Typical power per slot	450W+	200W+	120W	150W	80W
Managed	YES	no	no	(no)	YES
Lane speed	10-25Gbps	parallel/6Gbps	10Gbps	10Gbps	10Gbps
Application area	Telecom/ Physics	Industry	Industry	Military/ Industry	Physics/ Industry



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Use Cases of

uTE!®



MicroTCA in European XFEL



- Biggest success story of MicroTCA
- 800 Superconducting Cavities
- Over 200 MicroTCA Crates (> 2000 components)
 - LLRF
 - Synchronization
 - Timing
 - Beam Diagnostics





European XFEL: Precision RF Controls

Introduction to the MicroTCA.4 Standard

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Specification for RF Field Control $\Delta A/A < 0.01$ % and $\Delta \phi < 10$ mdeg.



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- In order to access the data from the MicroTCA.4 crate bidirectionally over PCIe bus, the ChimeraTK framework was developed at DESY.
- The scope of this toolkit focuses on abstracting specifics of the underlying system, as well as giving the user the ability to create a portable user applications across different control system choices
- One application (e.g. LLRF Server) can be adapted for various hardware and control systems



https://github.com/ChimeraTK



Upgrade of LU-20 to Light Ion Linear Accelerator (LILAC)



Nuclotron-based Ion Collider Facility Dubna/ Russia







NICA LILAC LLRF Overview



- 1 MicroTCA-Crate
- 2 External CPU
- 3 Signal-/Clock Generator (Master Oscillator)



In cooperation with **BEVATECH**





DIPC-7050 GigE Vision Stack

System architecture for operating GigE Vision standard compliant cameras in a FPGA/SoC based environment.

Features

- Support for Xilinx 7-Series, Zynq, Ultrascale and Ultrascale+ devices
- AXI4 compliant interfaces
- Synchronization between camera devices using IEEE 1588 or external trigger
- Support for x86 and ARM architectures



MicroTCA.4 GigE Vision: Applications

Camera-based diagnostics for beamlines at PETRA III (DESY)

Typical applications: Scintillator screens for diagnostics of X-ray beams,

- Beam center and its distribution can be calculated from the image
- GigE Vision cameras are a popular choice for such applications





beamline center position calculation

Quick setup with Xilinx Vivado IP Integrator



Quality Assurance

Automated, optical product testing









Introduction to the MicroTCA.4 S	Standard

Introduction



A HELMHOLTZ INNOVATION LAB



- Transfer MicroTCA.4 Technology from Science to Industry
- Promote and provide support for the science community in regards of MicroTCA.4
- Foster the community and support future development
- Enabling space for innovative ideas and new business models





MicroTCA Technology Lab: A Helmholtz Innovation Lab

GEMEINSCH

- Part of Helmholtz Innovation Labs (HGF) Validation Fund)
 - Finance instrument to support the spinoff and technology transfer from scientific and technical inventions or developments from HGF centers to the industry and society
- 5M € over 5 years
- Started renovation for office space + Hiring around Oct. 2016, official opening April 2018



- ~ 10 FTE for MicroTCA Technology Lab
 - Hardware, Firmware and Software Developer
- Close collabration with Machine Beam Control Group of DESY (MSK)
 - >60 FTE (~25 FTE for LLRF)
- MSK Responsibilities:
 - LLRF Control Systems for Accelerator Structures
 - Special Diagnostic Devices
 - Beam Stabilization Systems
 (transversal/longitudinal) in storage rings & linacs
 - Timing for accelerator infrastructure (e.g. Klystron)





Module Management Controller (MMC) Stamp: Compact solution to realize IPMI controller on the AMC card.

Speed-up your board design + Prevents reinventing the wheel

We also provide Altium Design Templates







Solving high speed signal integrity issues on PCB design, FPGA design etc. using High-end digital measurement equipment (e.g. 80 GSPS LeCroy)

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	Packet Packet<
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	(2) [] 214 PM / 9/6/2018



Together with N.A.T. we provide training on MicroTCA

- Basic Course (2 days):
 - Introduction to the Hardware
 - Hands-on exercise: Setting up MCH
- Advanced Course (2 days):
 - PCI Express and IPMI
 - Hands-on exercise: Maintenance tasks

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Example: LLRF and Tuning Control

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RF Backplane

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MicroTCA.4 Management: Interface

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, ,	
MCH global parameter	Configuration
remote interfaces:	
Management interface at GbE port	disabled T
RMCP access	enabled T
telnet access	enabled T
ssh access	disabled T
WEB access	enabled T
IP address source for management port	DHCP
IP address source for GbE port	DHCP
RMCP session activity timeout minutes	o min
RMCP session activity timeout seconds	60 Sec
Telnet session activity timeout seconds	0 sec
default fan level	30 percent
MCH configuration flags:	P=====
enable watch dog timer	no 🔻
Enable alternative cooling scheme	no T
PM Assignment strategy	strict •
Use BM (MCH-RTM) as PM for eRTM15	no T
IPMI Compatibility Mode	enabled T
,	, , , , , , , , , , , , , , , , , , , ,
Shelf manager parameter	Configuration
configuration flags:	
allow shelt FRU Invalid	уеѕ ▼
temperature management	enabled T
	disablad
emergency shutdown	disabled
	tab201/index.asp gie Translate YouTube YouTub

Web Interface

				gue	mues(@msk	pcx19263: ~		-	۰	×
File	Edit Vie	ew	Searcl	h Term	ninal	Help					
<mark>guem</mark> Tryir Conne Escap	ues@msk ng 192. ected to be chara	pcx1 168. o ms acte	115. skmch	:~\$ te 233 techla '^]'.	lnet b201	mski .des	mchtechlab2 y.de.	01			
Wel(:14)		N./		MCH V2			nal (r15180) (Dec			14
Curi 13	rent op 31.169.3	en 1 132.	elne 253:	t sess 45276	ions (thi						
Type nat>	to show_f	see ru				ilab	le commands				
FRU I	Enforma	tior									
				e Nam							
===== 0	 MCH	====	===== M4	NMC	==== H - CM	====					
						-MCM					- 1
	AMC1					902/	411				- 1
	AMC2		M4	X2T	IMER						- 1
	AMC3		M4	SIS	8300	KU A	ИС				- 1
8	AMC4		M4	DAM	C - FM	25	D				- 1
40	CIII		M4	Sch	roff						- 1
50	PM1		M4	PM1	GW	V20					- 1
60	Clock	1		MCH	-Clo	ck					- 1
	HubMo			MCH	-PCI						- 1
	AMC6-I	RTM			8300	L2 R	тм				- 1
===== nat>	show 1	ink	stat	====== م	====	====					- 1
AMC	1 Port		is E	- therne		1000	Base-BX				- 1
AMC	1 Port		is P	CIe -		8,0	GT/s				- 1
AMC				CIe -		8,0					- 1
AMC	1 Port		is P	CIe -	x4 -	8,0	GT/s				- 1
AMC	1 Port		is P	CIe -	×4 -	8,0	GT/s				- 1
AMC	2 POFt		15 P	cie -	X1 -	2,5	GT/S				- 1
AMC	3 Port	+ 5	ic D	CIE -	×4 -	8,0	GT/S				- 1
AMC	3 Port		is P	CIe -	x4 -	8.0	GT/S				- 1
AMC	3 Port		is P	CIe -	x4 -	8,0					- 1
AMC	4 Port			CIe -							
AMC	4 Port		is P	CIe -							- 1
AMC	4 Port		is P	cie -	x4 -	2,5	GT/s				
AMC	4 Port		IS P	cle -	x4 -	2,5	GT/S				
AMC	6 Port		15 P	CIE -	×4 -	2,5	GT/s				
AMC	6 Port		is P	CIe -	×4 -	2,5	GT/S				
AMC	6 Port		is P	CIe -	x4 -	2.5	GT/s				
nat>											- 1

Telnet (Terminal)

BEVATECH	Bevatech GmbH	Gear For Science	CAEN ELS s.r.l.
elspec group	el-spec GmbH		EMCOMO Solutions AG
N. A. P.	N.A.T. GmbH	Schroff	nVent Schroff
powerBridge Computer	powerBridge GmbH	ROHDE&SCHWARZ	Rohde & Schwarz
TELEDYNE SP DEVICES Everywhereyoulook	Teledyne SP Devices	struck innovative systeme	Struck Innovative Systeme GmbH
	VadaTech	A Phoenix Mecano Company	WIENER Power Electronics GmbH

MicroTCA Technology Lab: The Team

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Michael Hardware Dev.

Simone Hardware Dev.

Johannes

Sven FPGA Firmware Dev. PhD. / Hardware Design

ທແລບໄ

Jan FPGA Firmware Dev.

Çağıl LLRF Expert/ FPGA Firmware Dev.

Patrick LLRF Expert

Christoph

Software Dev.

Aaron Software Dev.

- The ChimeraTK software toolkit has control system adapters to EPICS, DOOCS and OPC-UA
- Adapters for other control systems can be added by everyone
- Control System Studio (CSS) LLRF Panels available for free on Techlab Gitlab

