PCIe Gen4/5 and
100G-Ethernet on mTCA platform

nVent/Schroff GmbH

Sergej Dizel,

Principal Engineer Backplanes & Signal Integrity

mTCA applications / mTCA-NG working group motivation

Industry

Telecommunication

Medicine

Physics

Defence

The most of these applications have one thing in common:

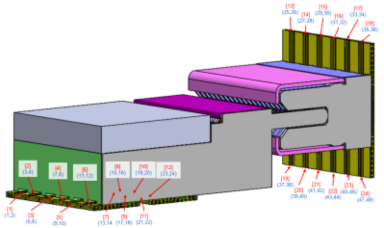
need for higher data rates

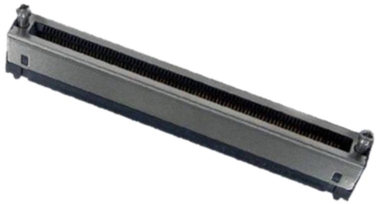
SI goal of the PICMG mTCA-NG working group:

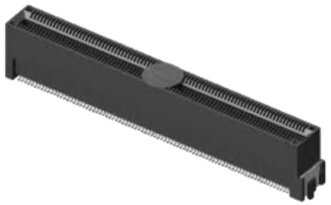
implementation of the latest bus generations PCIe Gen4/5 and 100Gbps ethernet

mTCA, new connectors

SI improved connectors from Yamaichi and Amphenol (backplane and MCH-plug tongue 2)

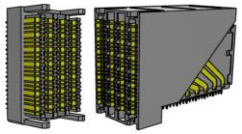


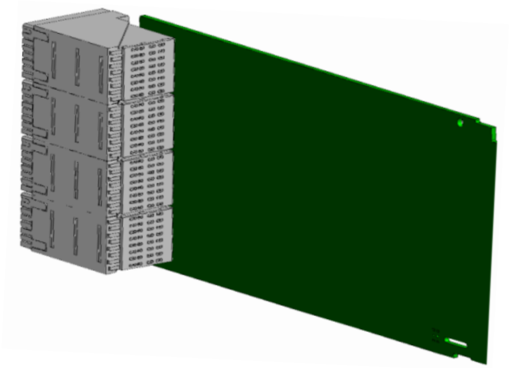




AMC-card second tongue (more power and wider data planes for AMC)

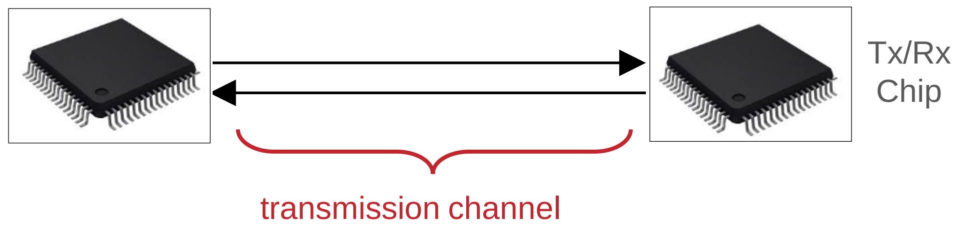
New HUB connector, ExaMAX from Amphenol and Samtec

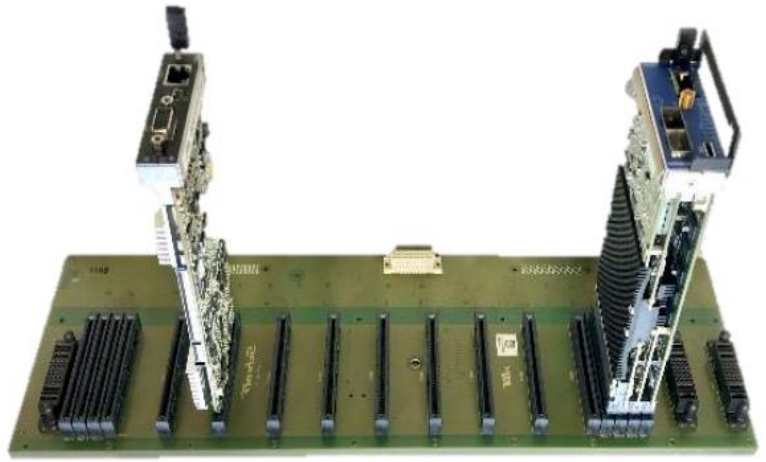


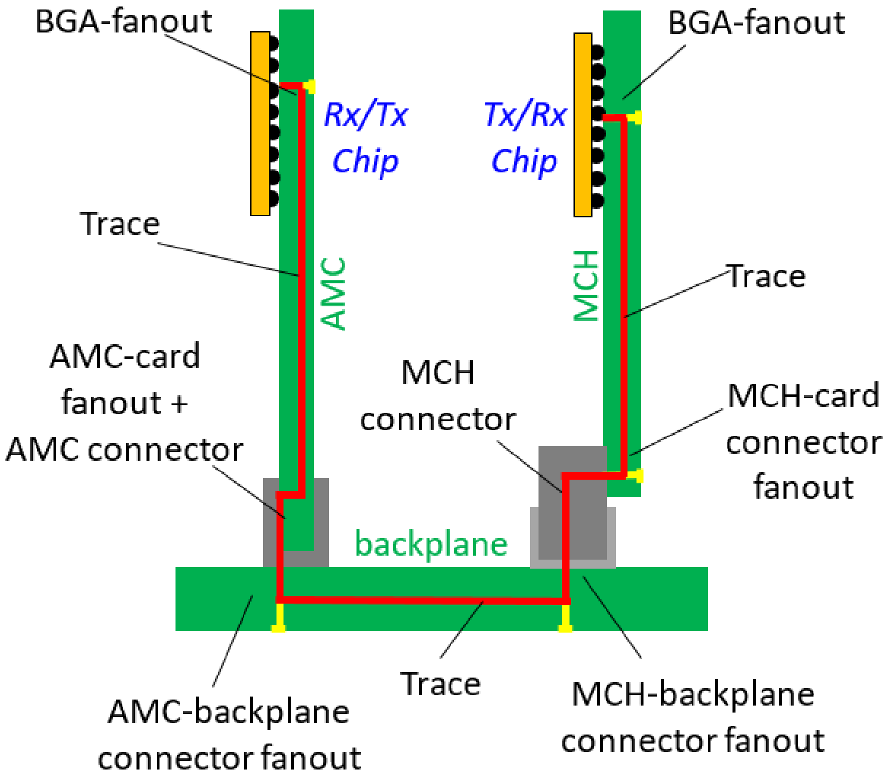


- PCIe Gen4/5 and 100Gbps Ethernet capable
- with 4 connectors up to 192 pin pairs on MCH realizable (current MCH has <170 pairs)
- new, x-talk optimized signal assignment (Rx/Tx allocation)
- MCH-card pn: not finally decided (e.g. Samtec EBTF-6-08-2.0-S-RA-1 or Amphenol 10131762-101LF)
- Backplane pn: not finally decided (e.g. Samtec EBTM-6-08-2.0-S-VT-1 or Amphenol 10124752-101LF)

mTCA transmission channel (PCIe or Ethernet)





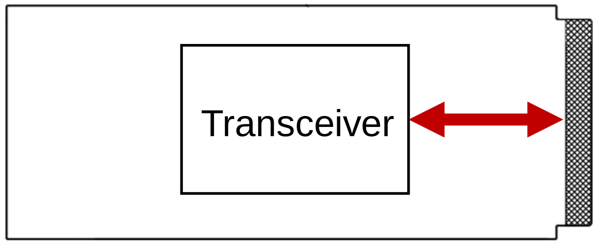


nVent

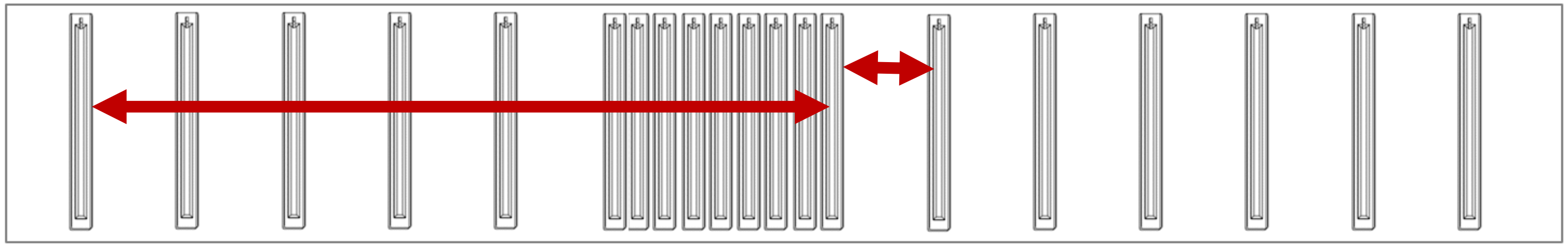
mTCA, 3D-model parameters

Min and max trace length:

AMC/MCH card



Backplane



min trace length: 25mm (1 inch)
max trace length: 127mm (5 inch)

min trace length: 50mm (2 inch)
max trace length: 250mm (9.8 inch)

PCB material:

For all cards: Isola Tachyon100G (typ. Dk 3.02 Df 0.0021 @10GHz)

For backplane: Elite Material EM-891K (typ. Dk 3.1 Df 0.0024 @10GHz)

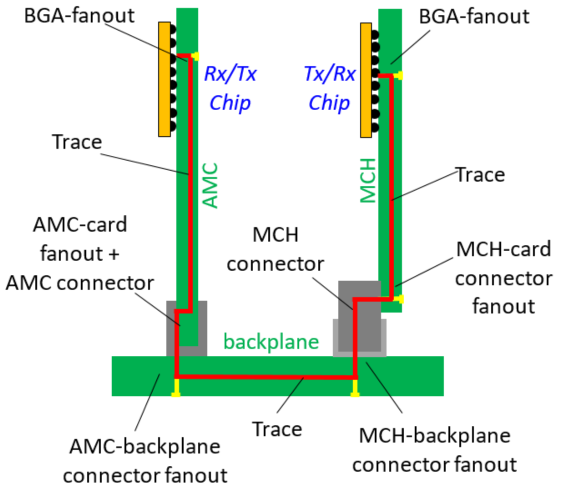
Diff pair impedance:

For PCIe and Ethernet busses: 90Ω

mTCA, 3D-model parameters

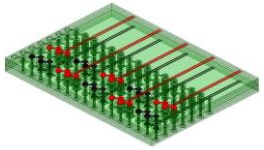
Channel segment parameter were defined in the group and base on realistic dimensions and routing strategies for AMC/MCH-cards and mTCA-backplanes:

- PCB stack-ups
- Routing layers
- differential trace dimensions
- BGA and connector fanouts
- Signal assignment/pinout
- Via, pad, anti-pad, backdrill … geometries
- allocation of x-talk aggressors
- …

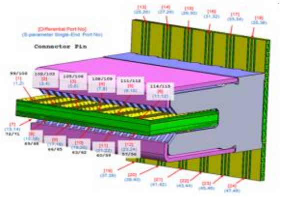


3D Models (simulated with CST and HFSS software):

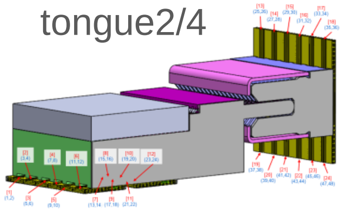
BGA-fanout



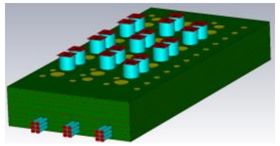
tongue1/3

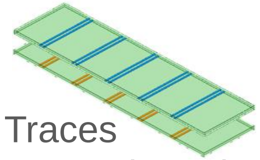


tongue2/4



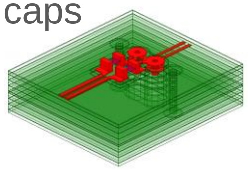
ExaMAX fanout

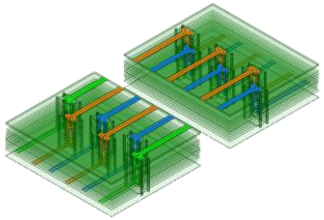




Traces
Cards and BPL

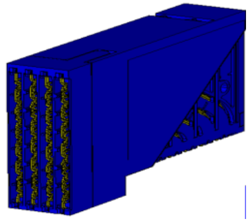
Decoupling caps





AMC BPL fanout

ExaMAX connector

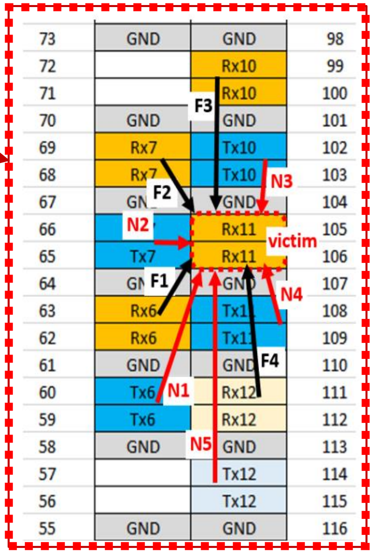


nVent

mTCA, 3D-model parameters

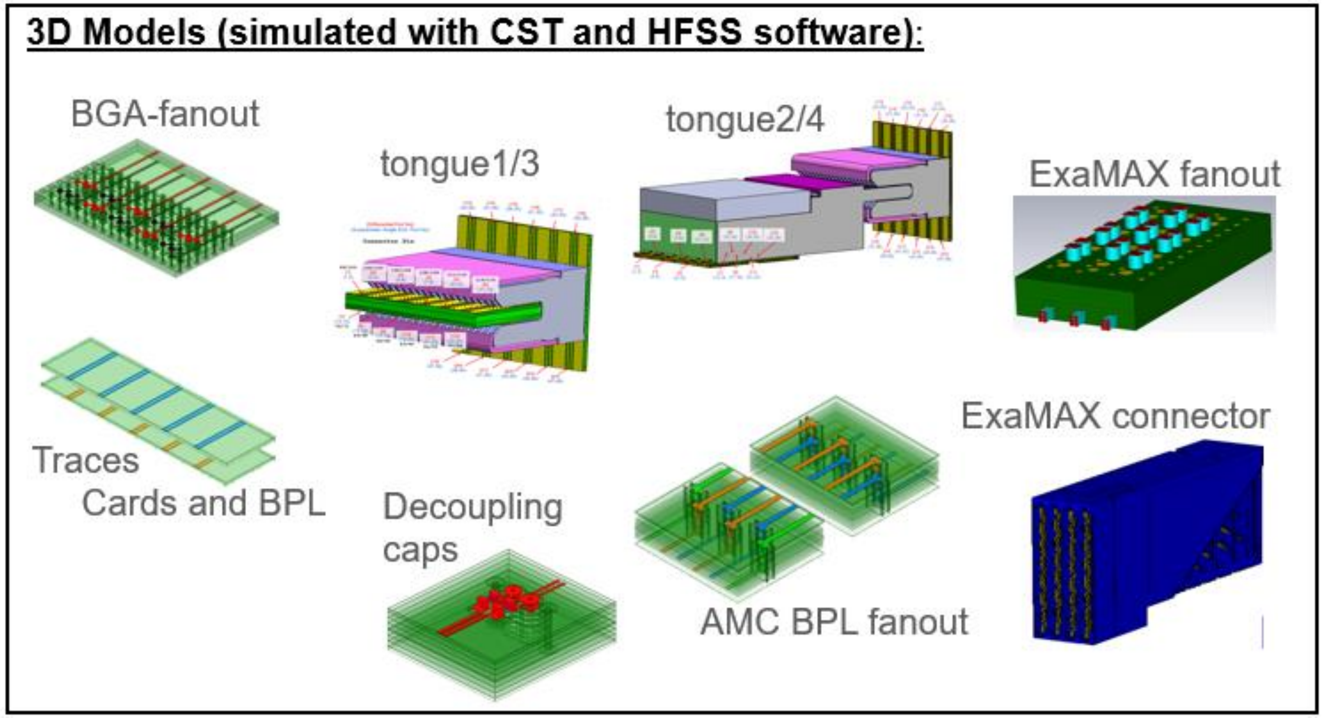
Numbers of x-talk aggressors in the connector determines the 3D-model size

highest x-talk in the channel is caused by the connectors.



Model size
(number of diff pairs)

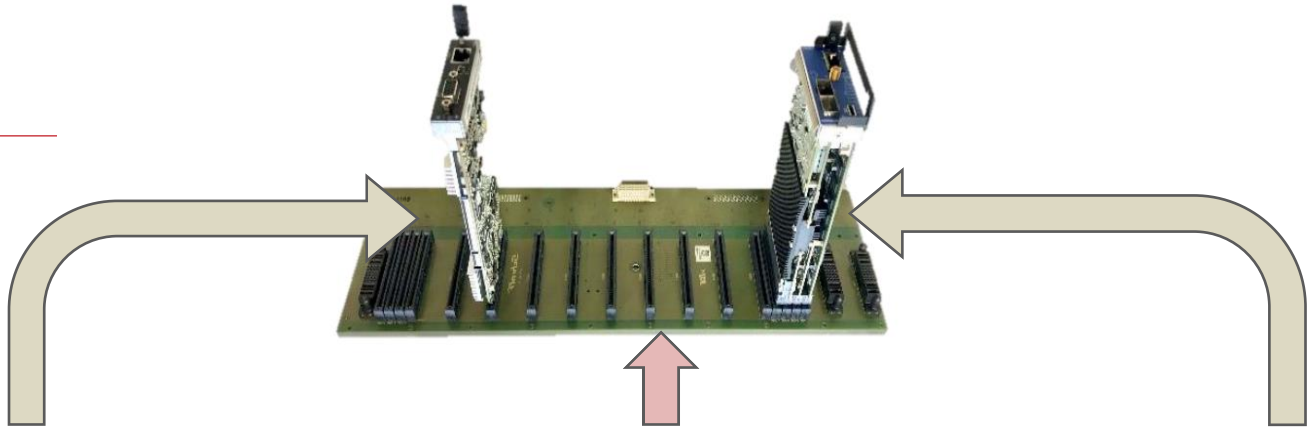
For example 10 diff pairs
for AMC tongue 1



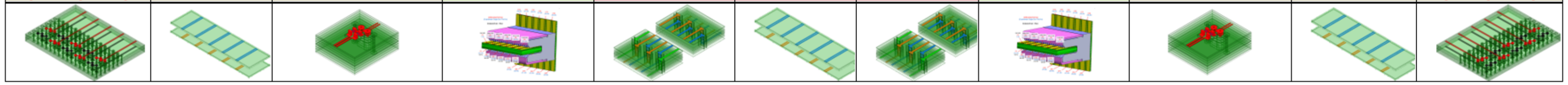
Description and S-parameter of all 3D-models can be downloaded from PICMG mTCA-NG working group area

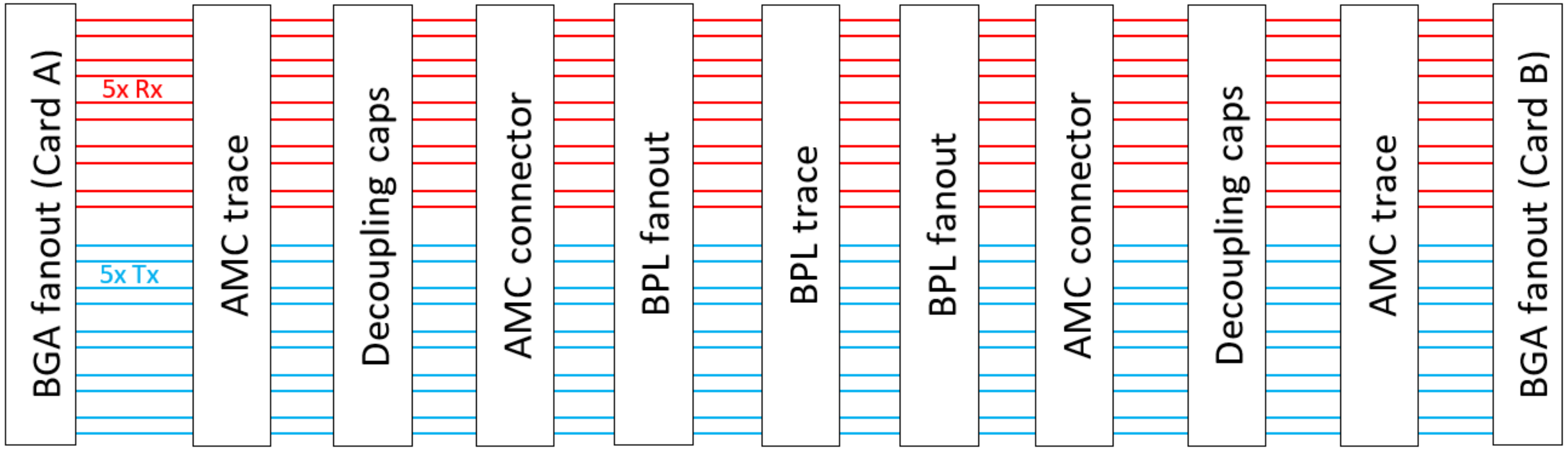
nVent

mTCA channel composition



AMC A card			AMC connector Tongue 1	Backplane			AMC connector Tongue 1	AMC B card		
BGA fanout (start point)	AMC trace	Decoupling caps		BPL fanout	BPL Trace	BPL fanout		Decoupling caps	AMC trace	BGA Fanout (end point)



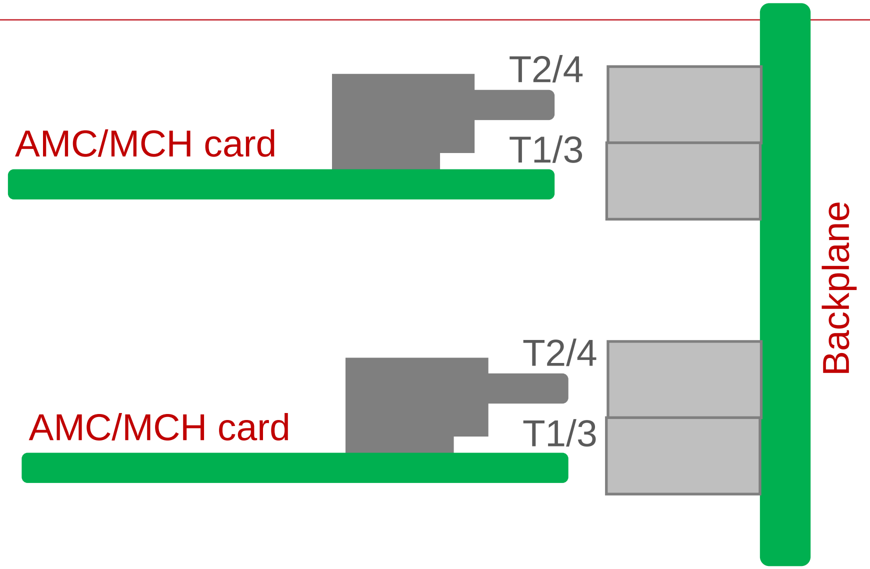


nVent

mTCA, simulation cases

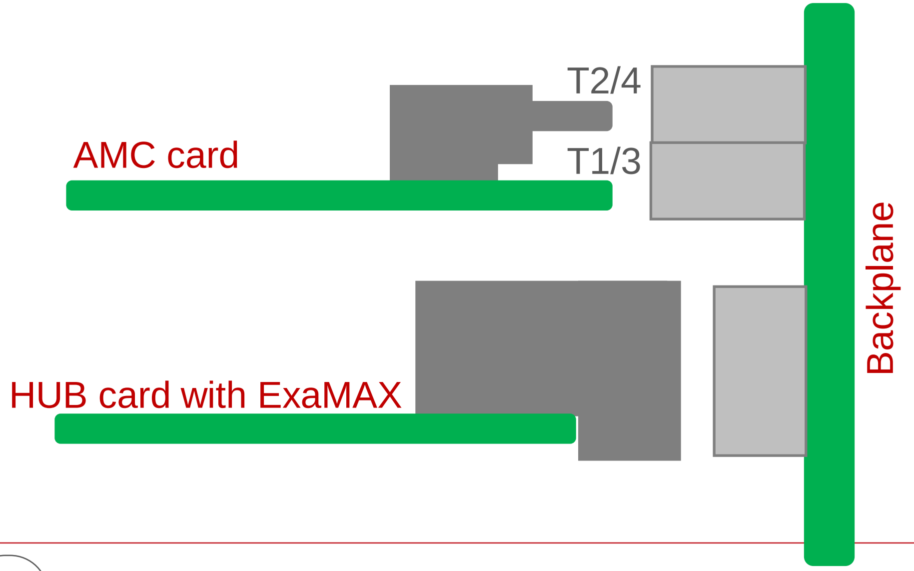
Interconnection groups with existing connectors:

1. AMC_T1 to AMC_T1
2. AMC_T1 to AMC_T2 (AMC_T1 to MCH_T4)
3. AMC_T2 to AMC_T2 (MCH_T4 to MCH_T4)



Interconnection groups with ExaMAX connector:

4. AMC_T1 to HUB
5. AMC_T2 to HUB



nVent

mTCA, simulation cases

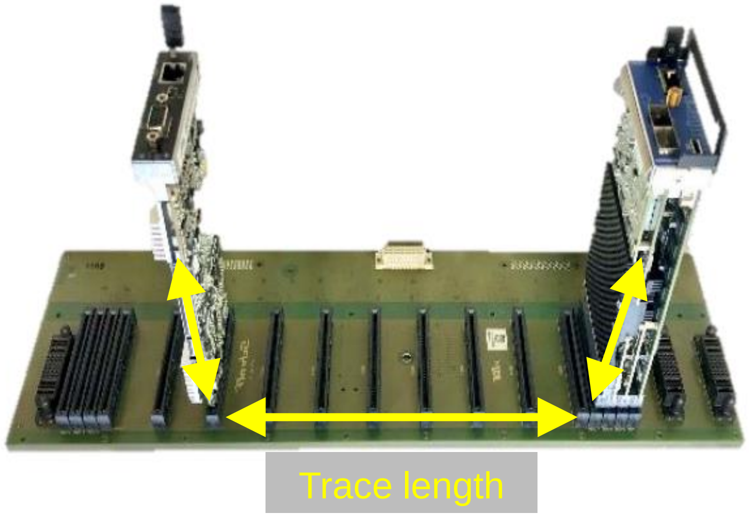
Corner cases (channels with the most critical parameters)

min trace length -> maximal Re-Reflections

max trace length -> worst case ICR (Insertion loss to Cross talk Ratio)

Cases for AMC_T1 to AMC_T1 interconnection group:

Case	card A (trace length / impedance)	Tongue 1 connector	BPL (trace length / impedance)	Tongue 1 connector	card B (trace length / impedance)
AMC_T1_AMC_T1_Case 1	25mm / 90Ω	Yamaichi	50mm / 90Ω	Yamaichi	25mm / 90Ω
AMC_T1_AMC_T1_Case 2	25mm / 90Ω	Yamaichi	50mm / 90Ω	Yamaichi	127mm / 90Ω
AMC_T1_AMC_T1_Case 3	25mm / 90Ω	Yamaichi	250mm / 90Ω	Yamaichi	25mm / 90Ω
AMC_T1_AMC_T1_Case 4	25mm / 90Ω	Yamaichi	250mm / 90Ω	Yamaichi	127mm / 90Ω
AMC_T1_AMC_T1_Case 5	127mm / 90Ω	Yamaichi	50mm / 90Ω	Yamaichi	25mm / 90Ω
AMC_T1_AMC_T1_Case 6	127mm / 90Ω	Yamaichi	50mm / 90Ω	Yamaichi	127mm / 90Ω
AMC_T1_AMC_T1_Case 7	127mm / 90Ω	Yamaichi	250mm / 90Ω	Yamaichi	25mm / 90Ω
AMC_T1_AMC_T1_Case 8	127mm / 90Ω	Yamaichi	250mm / 90Ω	Yamaichi	127mm / 90Ω



In total 88 channel cases for all 5 interconnection groups

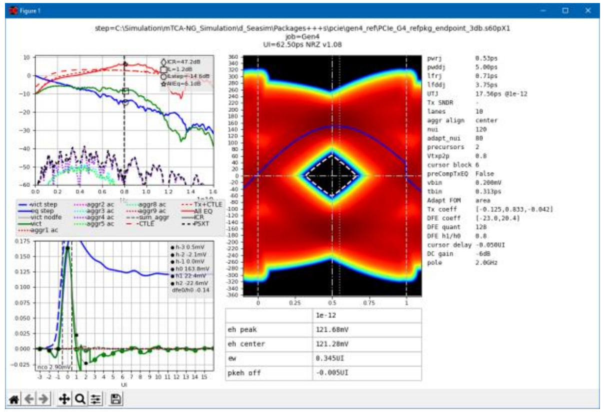
(AMC connector vendors: Yamaichi and Amphenol)

mTCA, channel verification

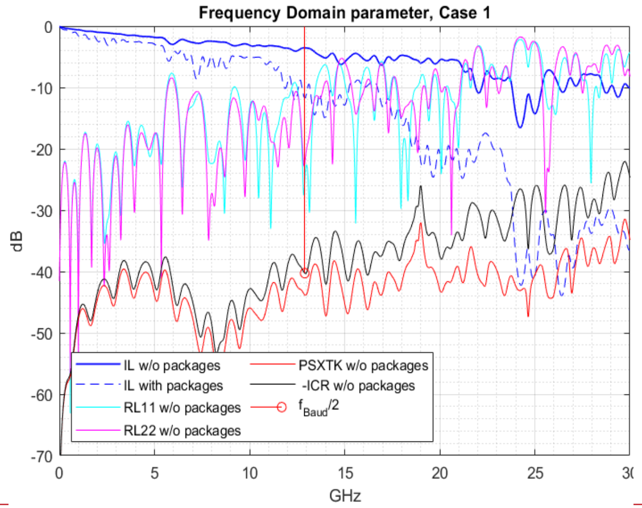
In all 88 channel cases it was checked whether their parameter were complied with specification requirements:

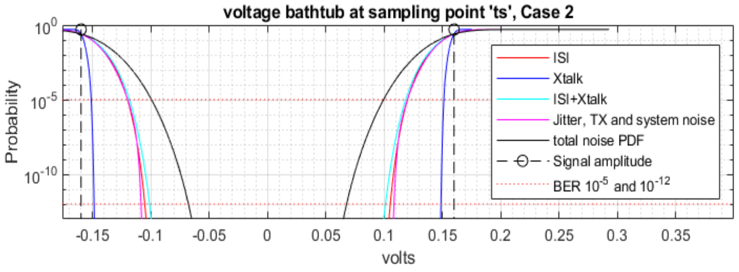
For PCIe Gen4/5, the Seasim tool from PCI-SIG was used (seasim-release_1.08)

(transceiver reference packages from PCI-SIG were used for eye simulation)



For 100GBASE-KR4, MATLAB tool from IEEE was used (ran_com_3bj_3bm_01_1114)





Transmitter and Receiver equalizer settings, Case 2	
FFE taps:	[-0.12,0.86,-0.02]
CTLR gain:	0 dB
DFE taps [1:7]:	[0.3187, 0.1072, 0.0560, 0.0254, 0.0183, 0.0224, 0.0153]
DFE taps [8:14]:	[0.0161, 0.0046, -0.0282, 0.0474, 0.0193, 0.0246, 0.0046

Channel Operating Margin (COM) @ DER0=1e-05, Case 2 [dB]:	8.17

nVent

mTCA, simulation results

Trace length were updated:

AMC/MCH card:	Backplane:
min trace length: ~~25mm~~ 35mm	min trace length: ~~50mm~~ 60mm (100mm for HUB channels)
max trace length: 127mm	max trace length: 250mm

All 88 channel cases fulfils PCIe Gen4/5 and 100GBASE-KR4 requirements

- Worst case PCIe Gen4/5 eye opening: ≥20.7mV / ≥0.301UI (Pass criteria: 15mV / 0.3UI)
- Worst case 100GBASE-KR4 COM Value: ≥3.47dB (Pass criteria: 3dB)

Conclusion:

- **PCIe Gen4/5 and 100GBASE-KR4, are realizable on mTCA platform**
- **100% backward compatibility can be insured with the improved AMC connectors from Yamaichi and Amphenol**
- **All Channels with the ExaMAX connector meet the requirements**

Evaluation concept

(compliance testing)

nVent

mTCA, evaluation

current situation:

- SI-parameter/limits and test procedures for AMC/MCH cards and mTCA backplane are defined for 10/40Gbps Ethernet only (MTCA.0 R2.0 Annex B)

- For PCIe Gen3 no limits and test procedures are defined -> interoperability problems

=> the goal is to insure the interoperability between different card and backplane vendors

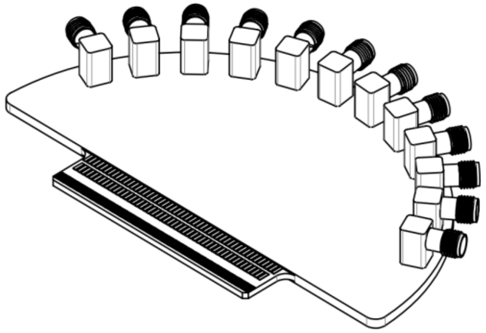
mTCA, evaluation

test adapters for measurements

- test cards replicates worst case cards (with longest and shortest traces)
- test backplane replicates worst case backplanes (with longest and shortest traces)

test cards

(with parameters of AMC/MCH cards with min and max trace length)



test backplanes

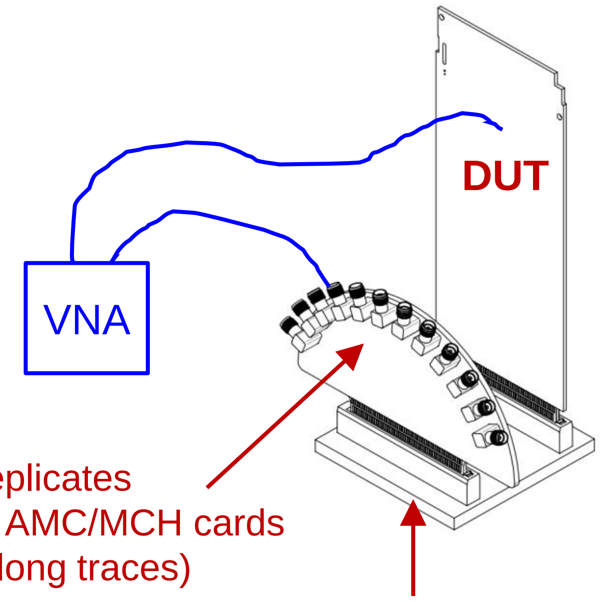
(with parameters of backplanes with min and max trace length)

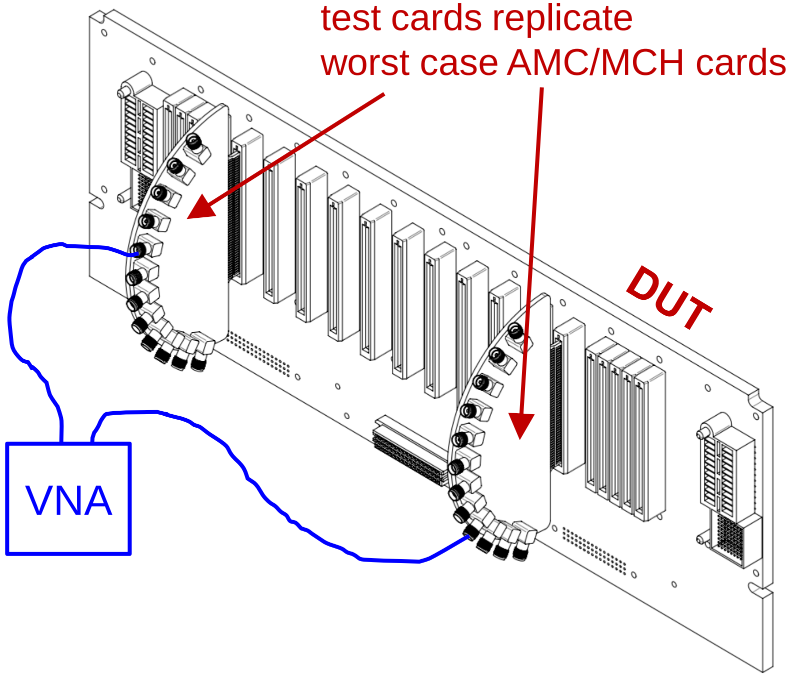
nVent

mTCA, evaluation

100GBASE-KR4 evaluation:

- same approach as defined in PICMG ATCA specification (PICMG 3.1 R3.0)
- measurement of DUT parameters in frequency domain in combination with worst case paddle cards and test backplanes
- calculation of COM value (Channel Operating Margin), shall be >3dB





nVent

mTCA, evaluation

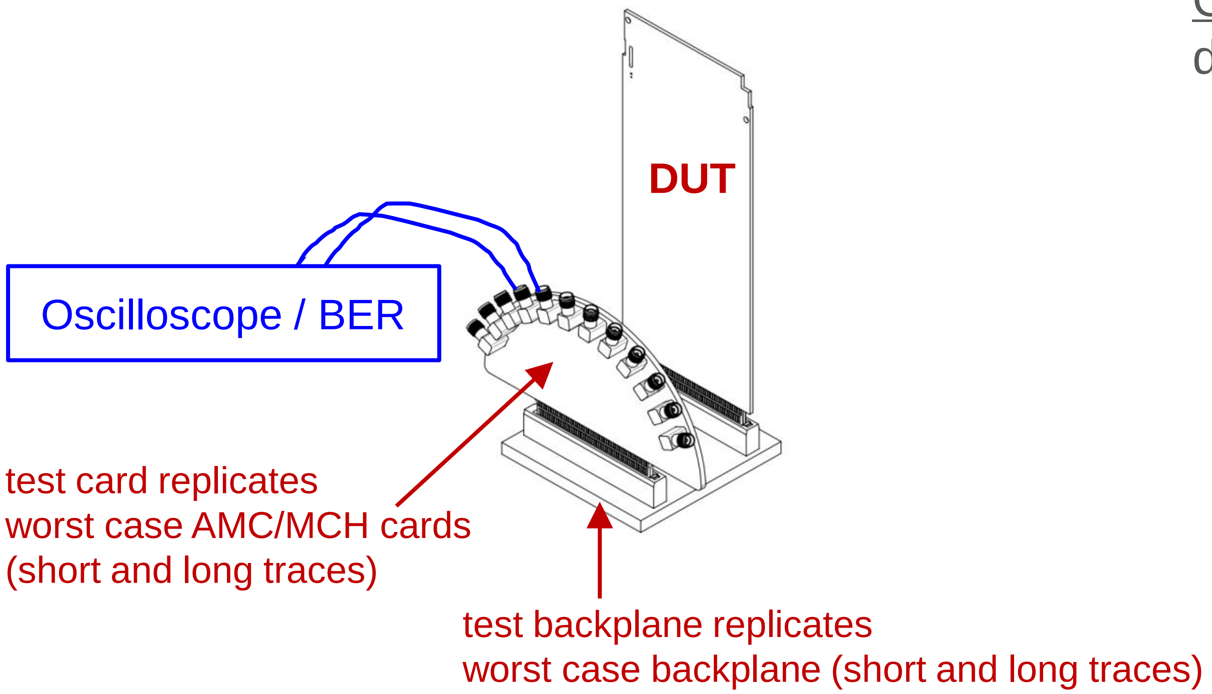
PCIe Gen4/5 evaluation:

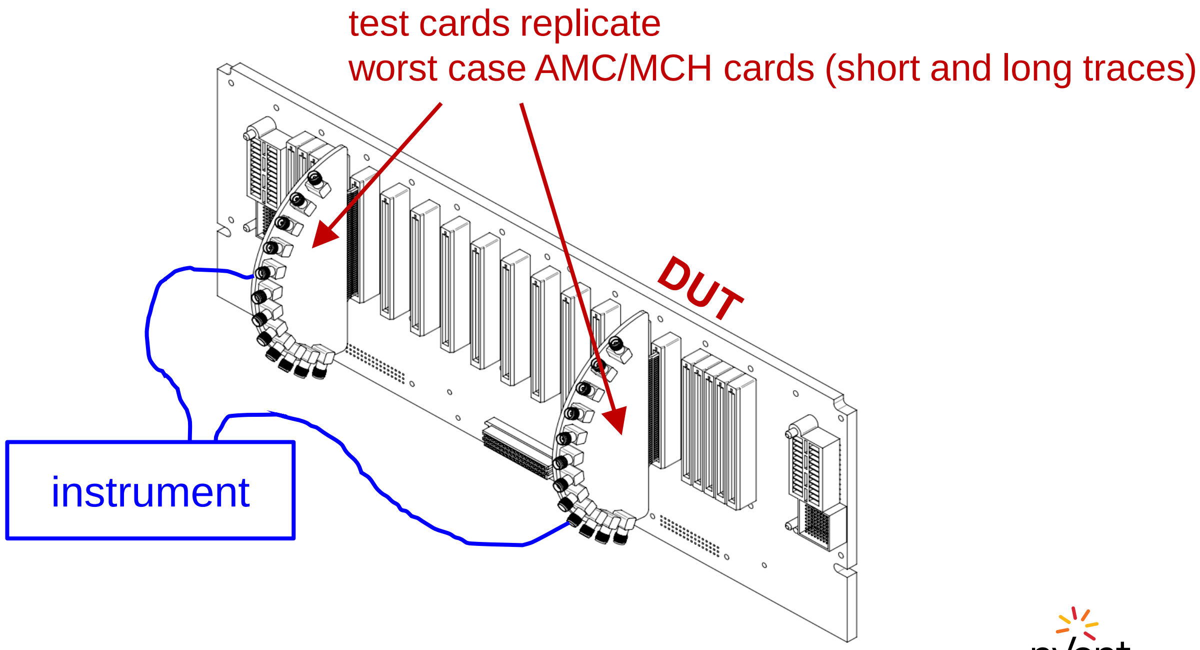
- Approach as defined in PCIe specification
- For cards:
  measurement of eye opening in combination with worst case paddle cards and test backplanes

- For backplane (TBD):

Option 1: measurement of eye opening in combination with worst case paddle cards by using BER + Oscilloscope

Option 2: measurement of DUT parameters in frequency domain and calculation of the eye opening (e.g. in Seasim)





Thank you