Overview of DMCS Projects and MicroTCA.4 Developments

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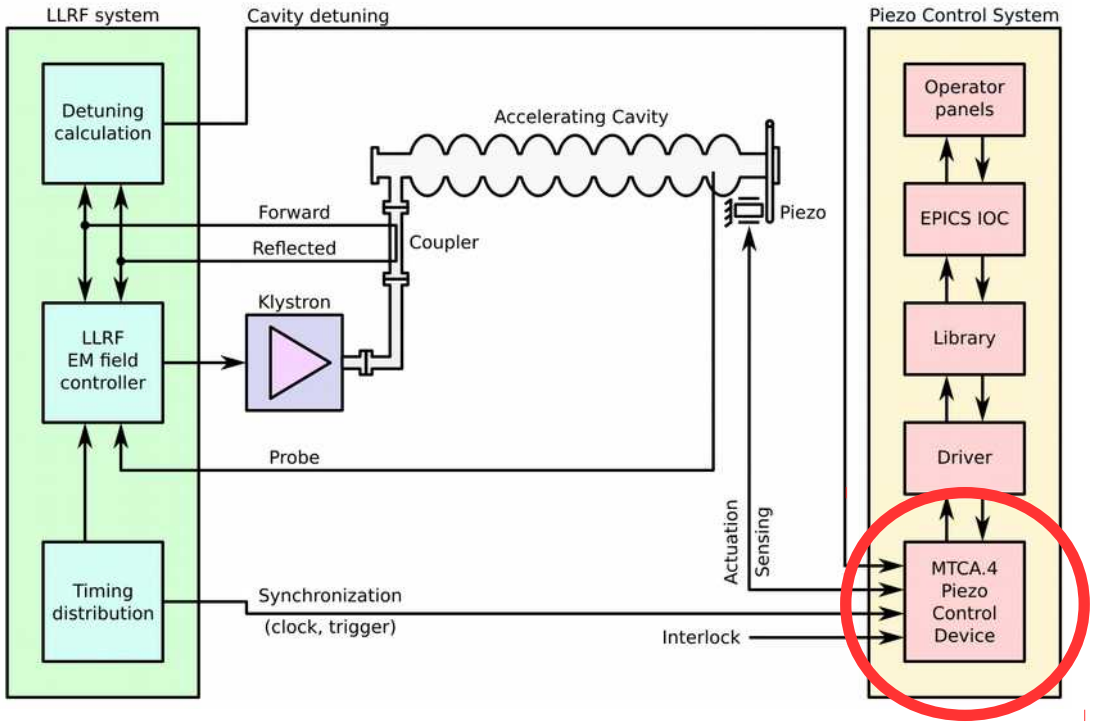
Agenda

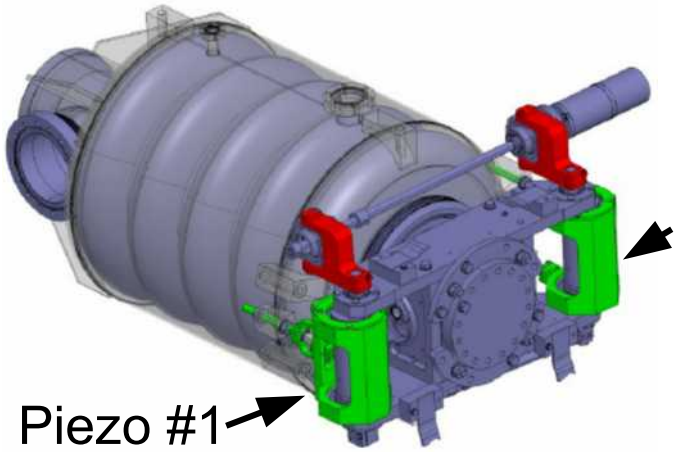
- Introduction
- High-Power Piezo Driver for Accelerator Applications
- Management Controller Developments for xTCA Systems
- Image Acquisition and Processing System in MicroTCA.4
- Conclusions

High-Power Piezo Driver for Accelerator Applications

High Power Piezo Driver - Motivation

- This work is being done in frame of the Polish in-kind delivered by the **Polish Electronic Group (PEG)** within in-kind agreement signed between PEG and ESS on 2016-11-08, (together with Schedule AIK 8.2, signed 09.2017, ESS-0060409)
- Department of Microelectronics and Computer Science, Lodz University of Technology as a member of PEG consortium is responsible for piezo driver system delivery for elliptical cavities of ESS linac.





ESS cavity with 2 piezo actuators

Piezo Actuators Planned for ESS Accelerator

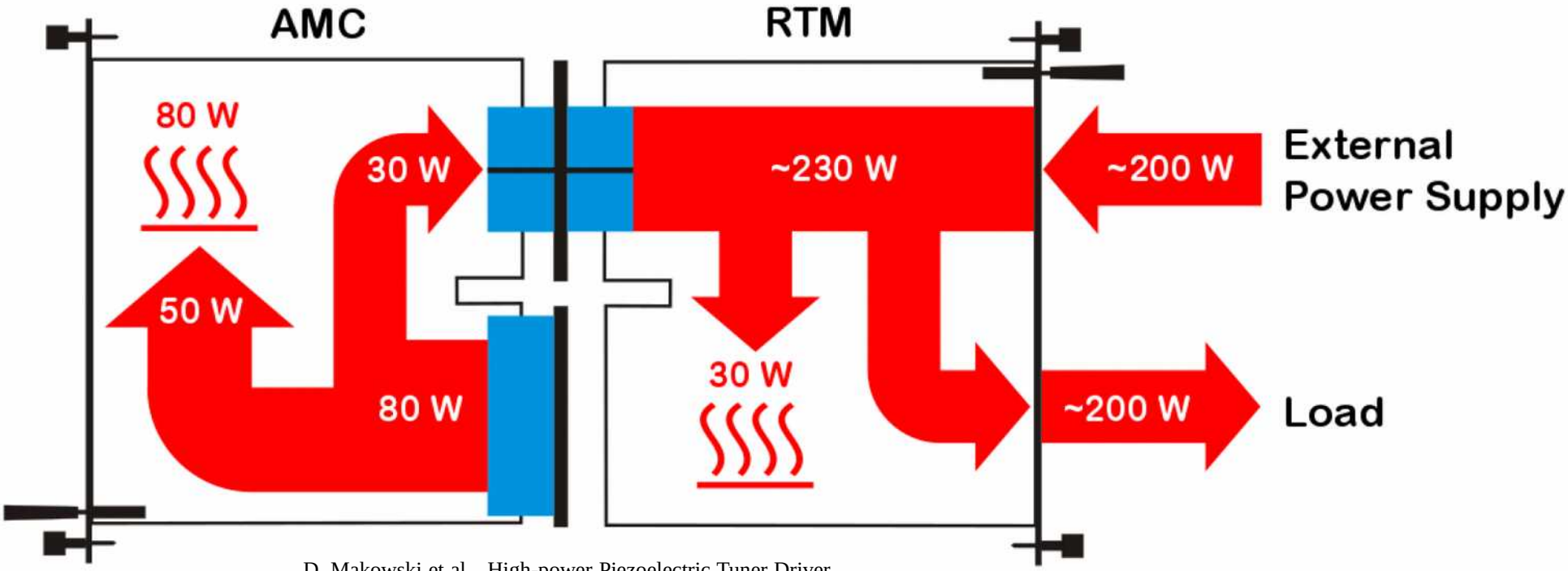
Cavity type	Piezo actuator type
Medium Beta cavities	Noliac NAC 2022 H30
High Beta cavities	Noliac NAC 2022 H30
Spoke cavities	Piezo #1: Noliac NAC2022-H90-A01 Piezo #2: PI PICMA P-888.91/51

Piezo type	Noliac NAC 2022 H30	Noliac NAC 2022 H90	PI Stack 2x P-888.90 + 1x P-888.50
Dimensions	10 x 10 x 30 mm	10 x 10 x 90 mm	10 x 10 x 90 mm
Cell material	NCE51F	NCE51F	PIC252
Number of cells	15	45	
Total capacitance (room temp.)	5.54 µF ±15%	17.4 µF ±15%	32 µF ±20%
Total capacitance (cryo, 20 K)	**~1.85 µF**	**~5.8 µF**	**~9.8 µF**
Max. free stroke	**46.2 µm**	**145.2 µm**	**94 µm**
Blocking force	4200 N	4200 N	3600 N
Max. operating voltage	200 V (±100 V)	200 V (±100 V)	-20 to 120 V
Max. operating temperature	200°C	200°C	150°C

Challenges of Piezo Driver Implementation in MicroTCA.4 Form Factor

Decided to use solution III AMC + RTM card + External PSM

1. 5-10 Watts for Payload (from AMC)
2. Untimed power for Piezo Driver from external power supply
3. **Limited piezo power by cooling capability to ~20-25 Watts**



D. Makowski et al. „High-power Piezoelectric Tuner Driver for Lorentz Force Compensation", *TNS, in print*

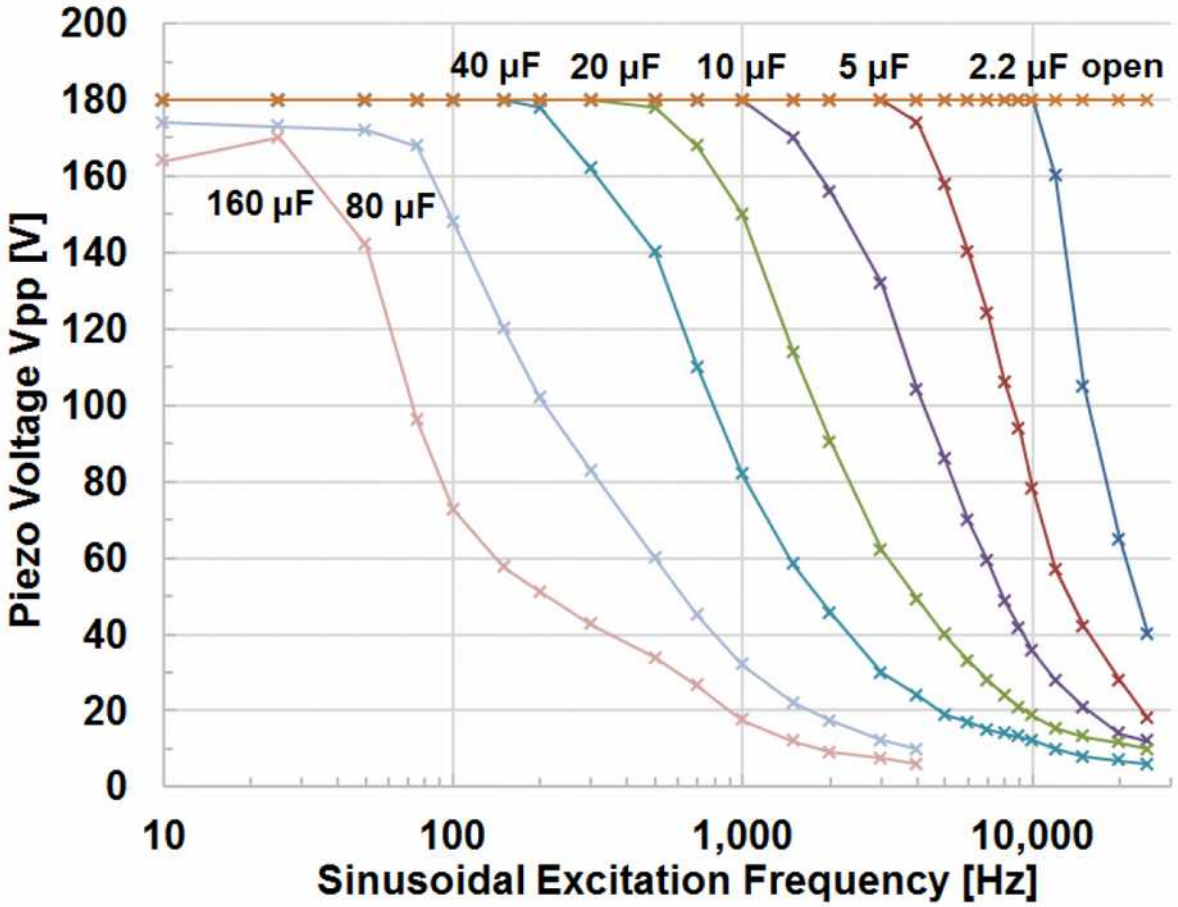
Piezo Driver RTM Module – Second Prototype

- Based on high efficiency Class-D amplifier (PWM)
- 2 channels available:
  - 2x 35 Watts (MTCA.4 power supply)
  - **2x 100 Watts (external power supply)**
- Piezo driver and piezo sensor mode
- Build-in diagnostics (advanced implementation of RMC)
- Various protection mechanisms for both Piezo channels to protect driver itself and piezo actuator

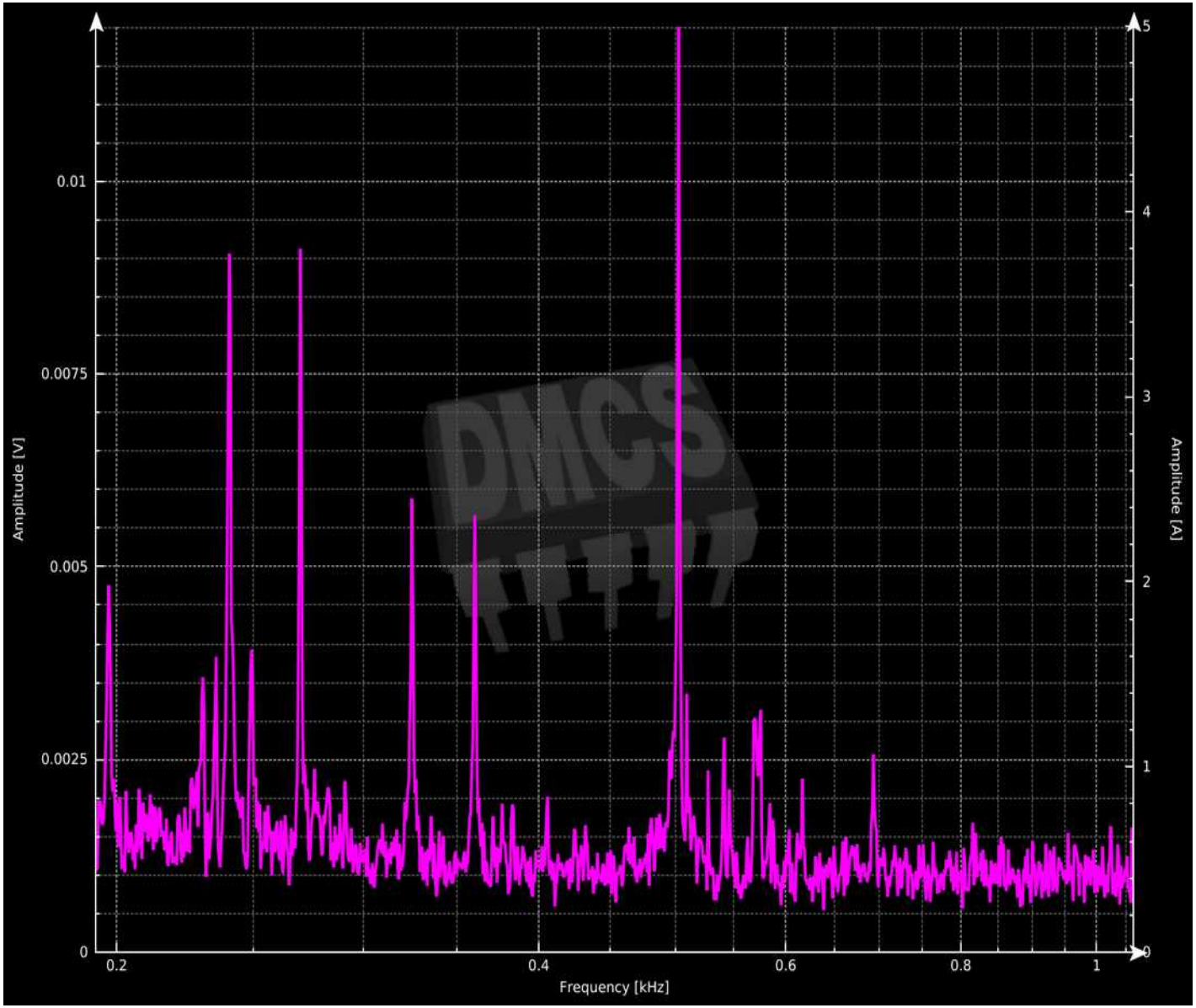
HDP-200 – Piezo Control Device

Piezo Control Device – SOA Characteristics

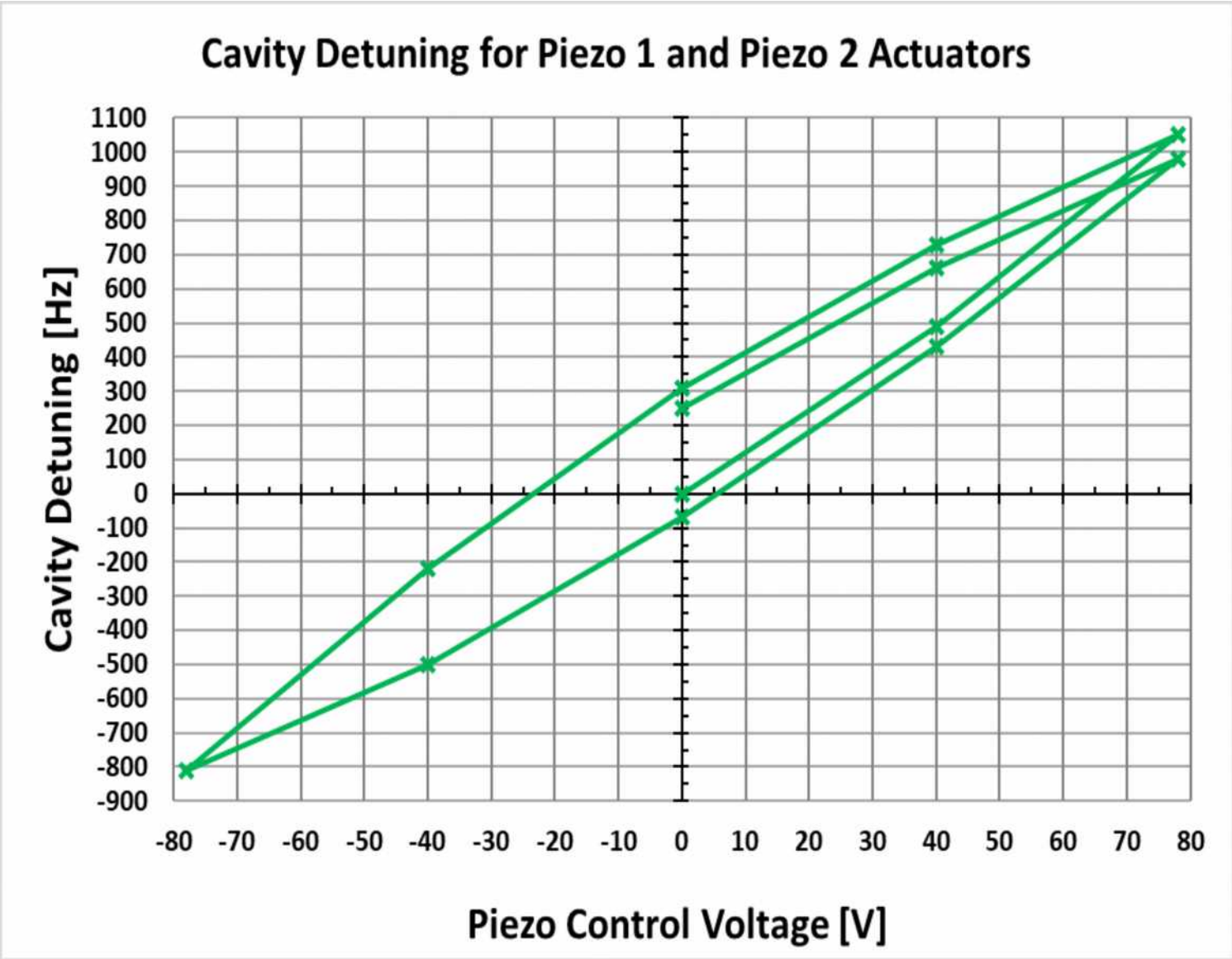
- Tested at laboratory conditions
- Single channel
  - Channel A as driver
  - Channel B as sensor
- 2.2 µF to 160 µF load
- Sinusoidal test signal
  - 10 pulses
  - 14 Hz repetition rate
- Various protections limit the maximum frequency of operation



Cavity Resonances [200 Hz – 1 kHz]



Cavity Detuning for Piezo 1 and Piezo 2 actuators



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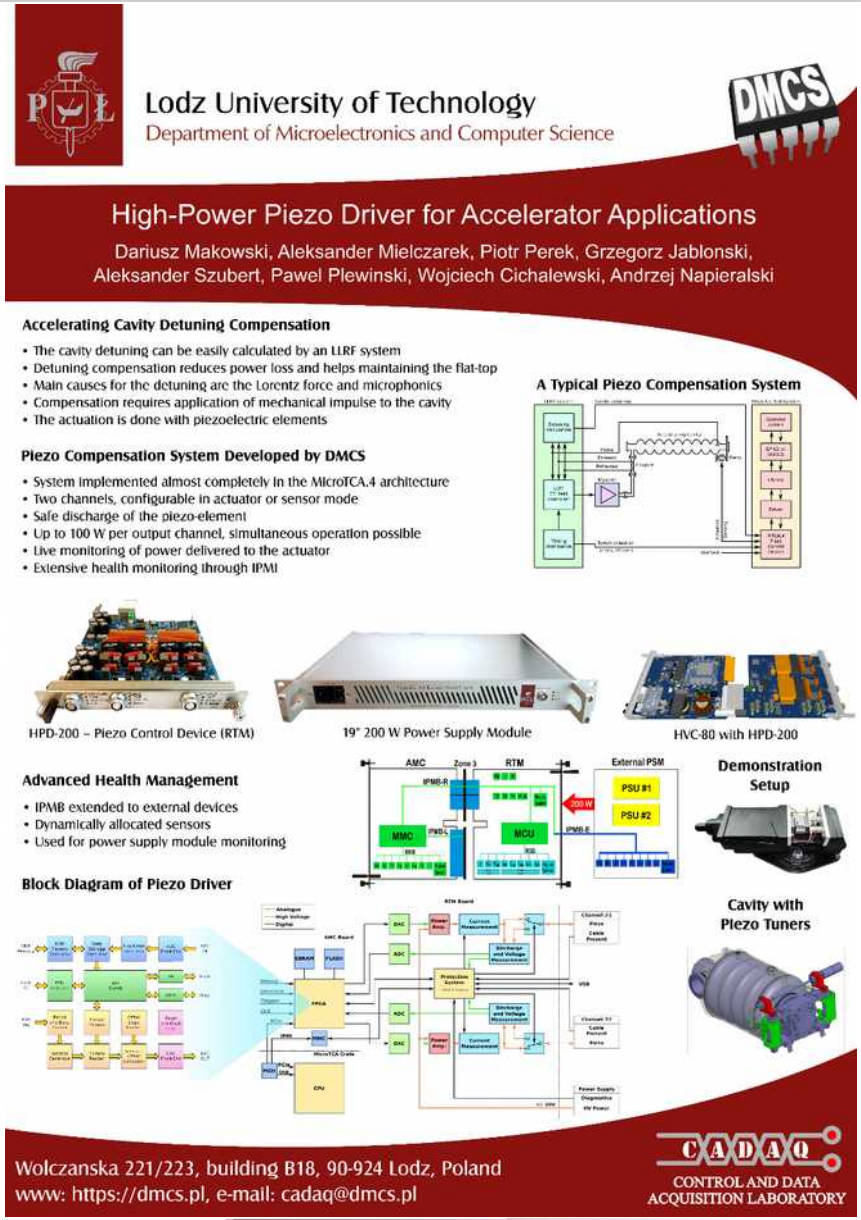
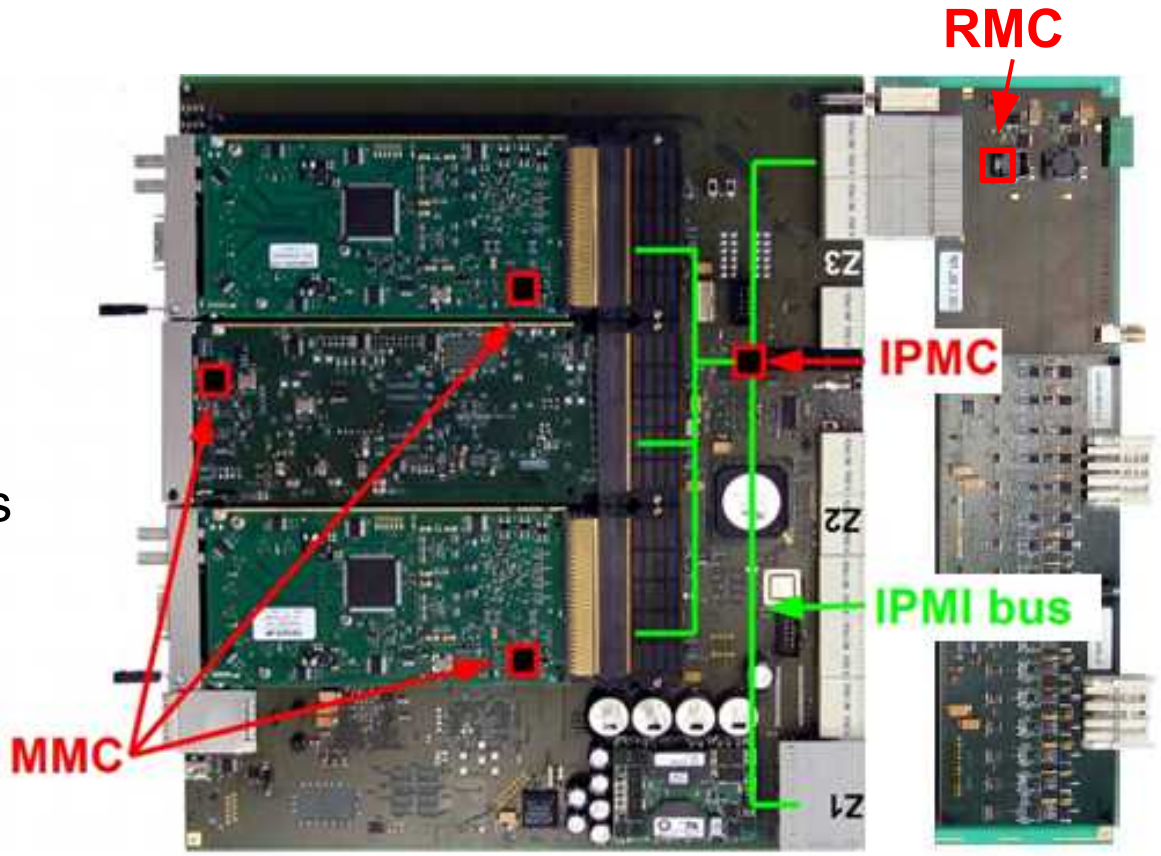
- Designed a two channel 2x 100 Watts PWM piezo driver prototype (HPD-200)
- Two solutions available:
  - Internal MicroTCA.4 and,
  - External power supply
- Suitable for driving large piezo actuators (room temperature capacitance <160 µF)
- Prototype successfully tested in laboratory and cryo-conditions
- Initial compensation of LFD for elliptical cavity of ESS accelerator
- Starting pre-production and mass production next year



Management Controller Developments for xTCA Systems

Intelligent Platform Management Controller for AdvancedTCA

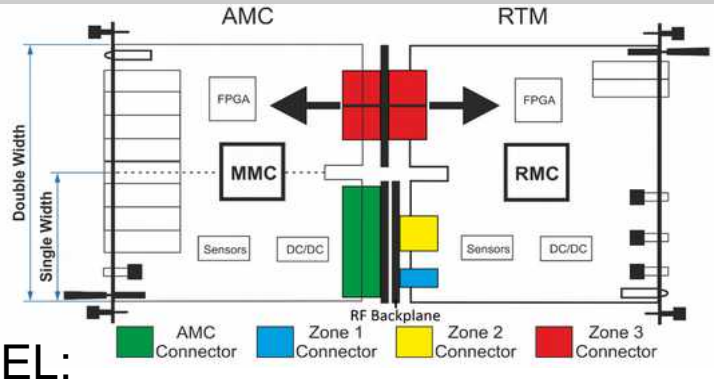
- AdvancedTCA board requires:
  - IPMC – IPMI controller implemented on ATCA carrier
  - MMC – controller needed on each AMC card
  - RTC – controller on RTM card
- Various microcontrollers tests:
  - Atmel, NXP, Renesas
- IPMC - final solution available with Renesas that offer 6 I2C controllers
  - Complex solution that requires a lot of work
- MMC – mainly based on Atmel ATxmega
  - Much simpler than IPMC
- Time consuming and challenging task, but we learned a lot during this exercise



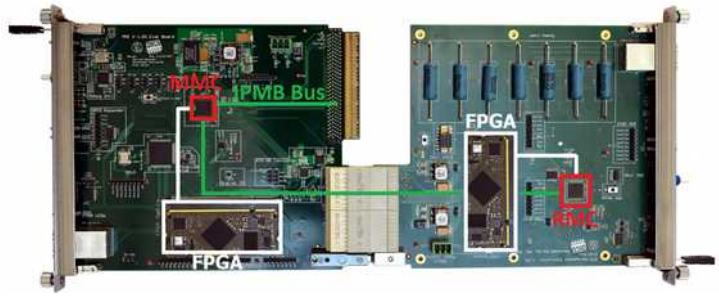
ATCA carrier with 3 AMC slots and RTM (before MTCA.4, <2007)

Development of MMC 1.0 solution for DESY

- **Unified solution for AMC and RTM cards**
  - Basic and Advanced versions available
  - Includes hardware (schematics) and firmware
    - Microcontroller and CPLD
  - Implemented on various AMC-RTM modules of E-XFEL:
    - TCK7, DAMC2, SIS8325, DS-800,...
    - VM2LF, DWC10, CLKFT, uLOG,...
  - Available evaluation kits
- Based on previous work (AdvancedTCA)
- **Many new ideas implemented**
  - New RTM solution – part of MicroTCA.4.1
  - Monitoring and diagnostics
  - RTM currents and voltages monitoring
  - Support of PMBus DC/DC converters
  - Payload management and monitoring



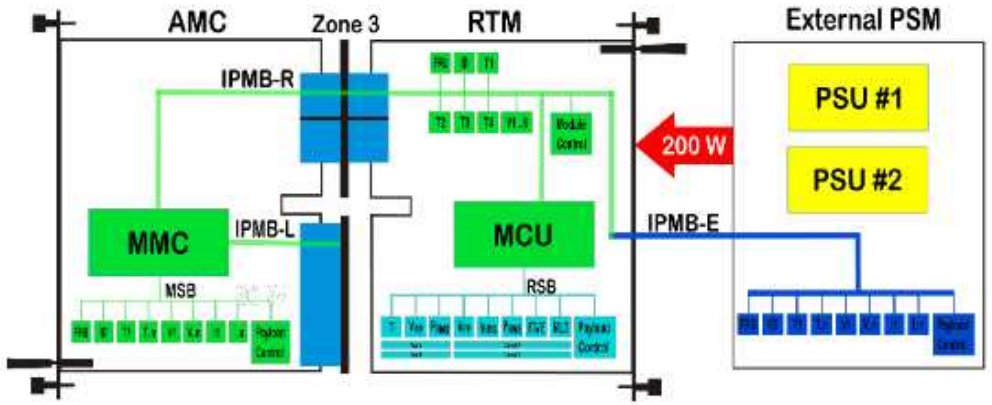
TCK7 and VM2 Devices

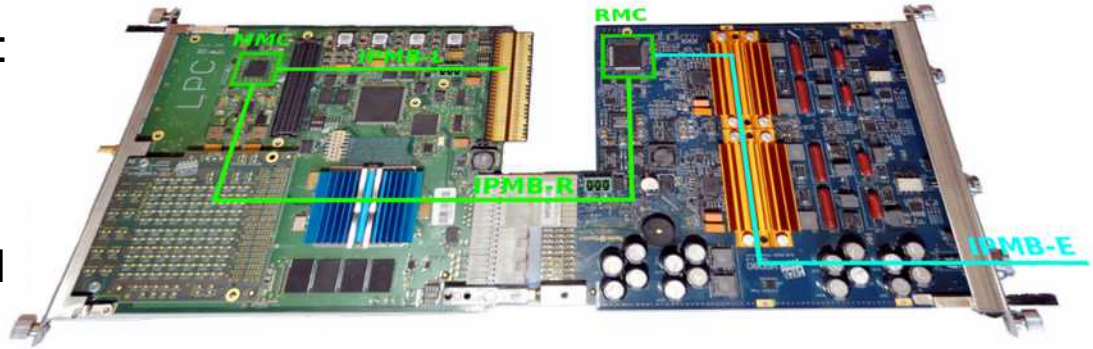


AMC and RTM Evaluation kits

Extension of IPMI Management for MicrtoTCA.4

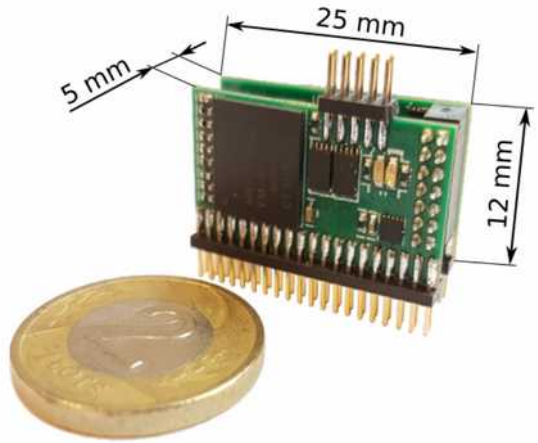
- Developing and testing new solutions
- Dynamic IPMI sensors for RTM
  - Available via IPMB-R
  - Requires RTM Management Controller
  - Implemented on Piezo Driver Module
- Management and control of External Piezo Power Supply
  - Diagnostics of external PPSM
    - Monitor temperatures
    - Monitor voltages
    - Monitor fans
  - Disable ±50 V voltage during hotplug:
    - AMC or RTM deactivated
    - AMC or RTM removed
    - Power supply cable removed
- FMC FRU support with unique ID





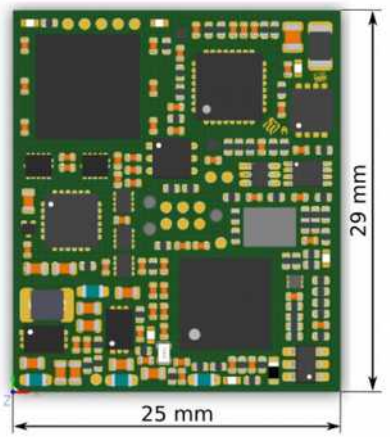
MMC Integrated Module – TUL-DMCS Solution

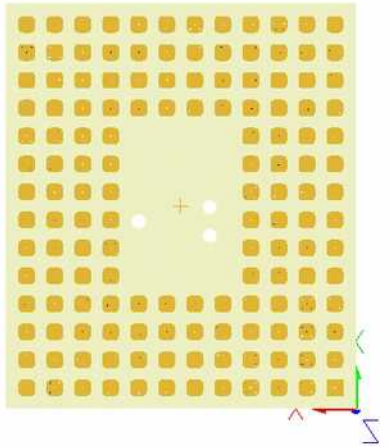
- Easy solution for MTCA.4 beginners
- Ready to use module with universal and customisable firmware
- Available two versions:
  - Basic – only AMC support
  - Advanced – extended RTM manager with diagnostics
- Based on ARM microcontroller and real-time OS
- Programmable unit for more advanced customisation
- Under testing on HVC-50 AMC module



MMC-Stamp Module – DESY Solution

- Project developed by TUL-DMCS for DESY
  - See M. Fenner presentation:
    "DESY MMC System on a Module and its Applications"
    for more details
- Smart solution:
  - Module Management Controller dedicated for AMC modules
  - Extended solution supporting RTM
  - Atmel ARM microcontroller
  - Programmable FPGA logic
  - Available 4x I2C controllers
  - Small size





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- We developed solutions for:
  - AdvancedTCA
  - MicroTCA
- A few versions available
- Working on small-size but still powerful solution for xTCA applications

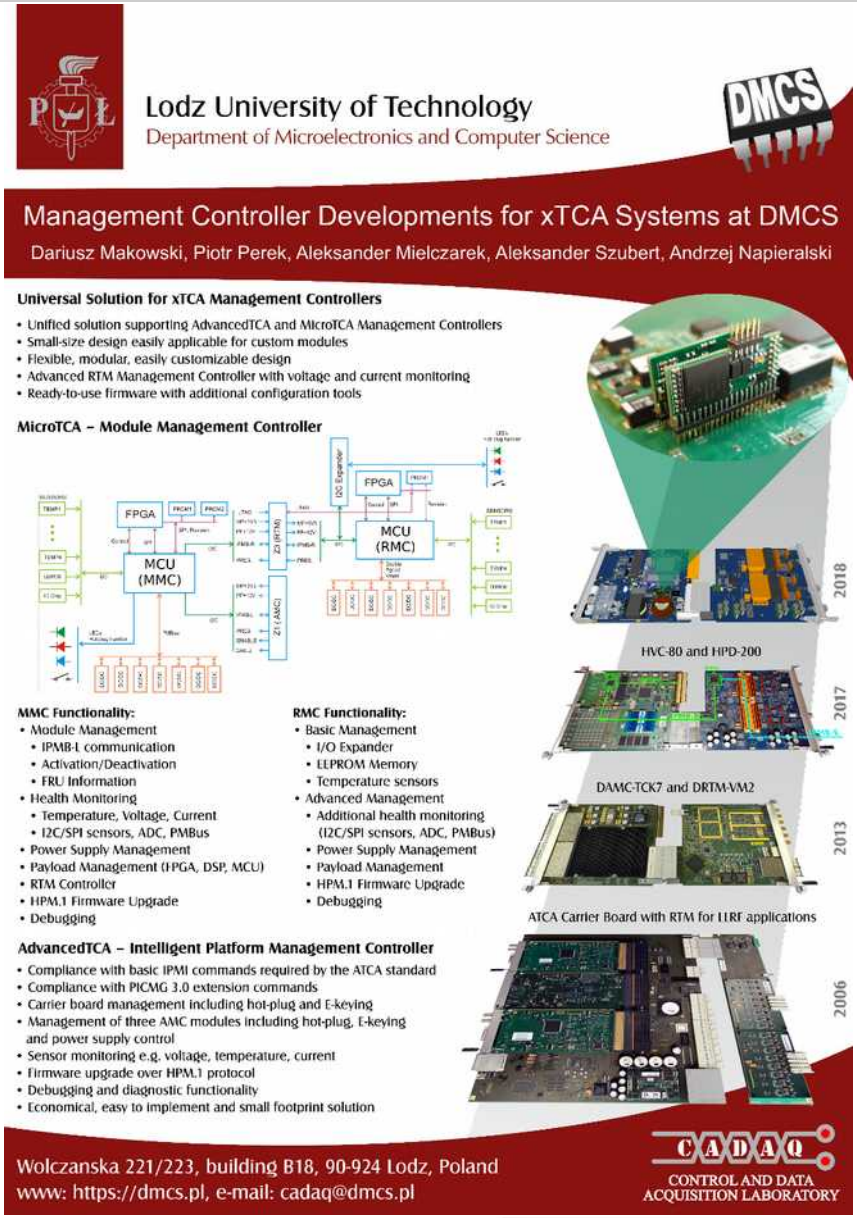


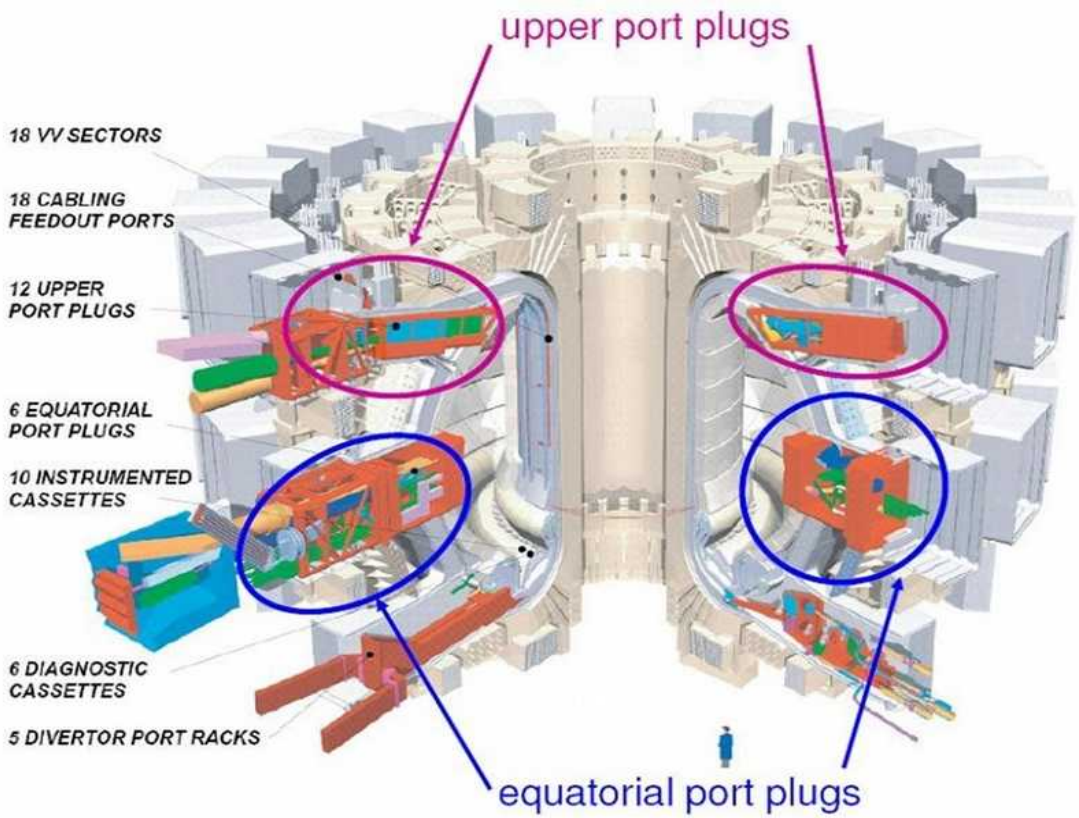
Image Acquisition and Processing System in MicroTCA.4

ITER Project

Challenges in design of imaging systems for plasma diagnostics:

- Plasma diagnostics - monitor plasma temperature, density, radiative properties, first-wall resilience
- 200 cameras:

  1-8 Mpx @ 50-50000 FPS
- Throughput can easily exceed 8 Gb/s per camera
- Scalability and high reliability
- 50 ns synchronization accuracy



ITER Diagnostic Port Plugs

Image Acquisition and Processing with MTCA.4 – Our Solution



8-32 Gbps

Frame Grabber

32 Gbps

MTCA.4 12-slot Chassis

128 Gbps – 1 Tbps

High Performance CPU

Timing module

Frame Grabber Card for MTCA.4

- Cost-effective solution for high-performance image acquisition systems
- Designed as FMC carrier module (HPC and LPC) with FMC extension modules:
  - Camera Link (Base, Full, Ext-Full)
  - Camera Link HS
  - CoaXPress
  - Universal IO module
  - Firmware support for selected protocols
- Provides all resources for data acquisition and control systems (FPGA processing power, SDRAM, clocks distribution, trigger and interlock signals)
- Based on Xilinx Artix 7 (XC7A200T) FPGA
- RTM Zone 3 connector (D1.2 Digital Class)

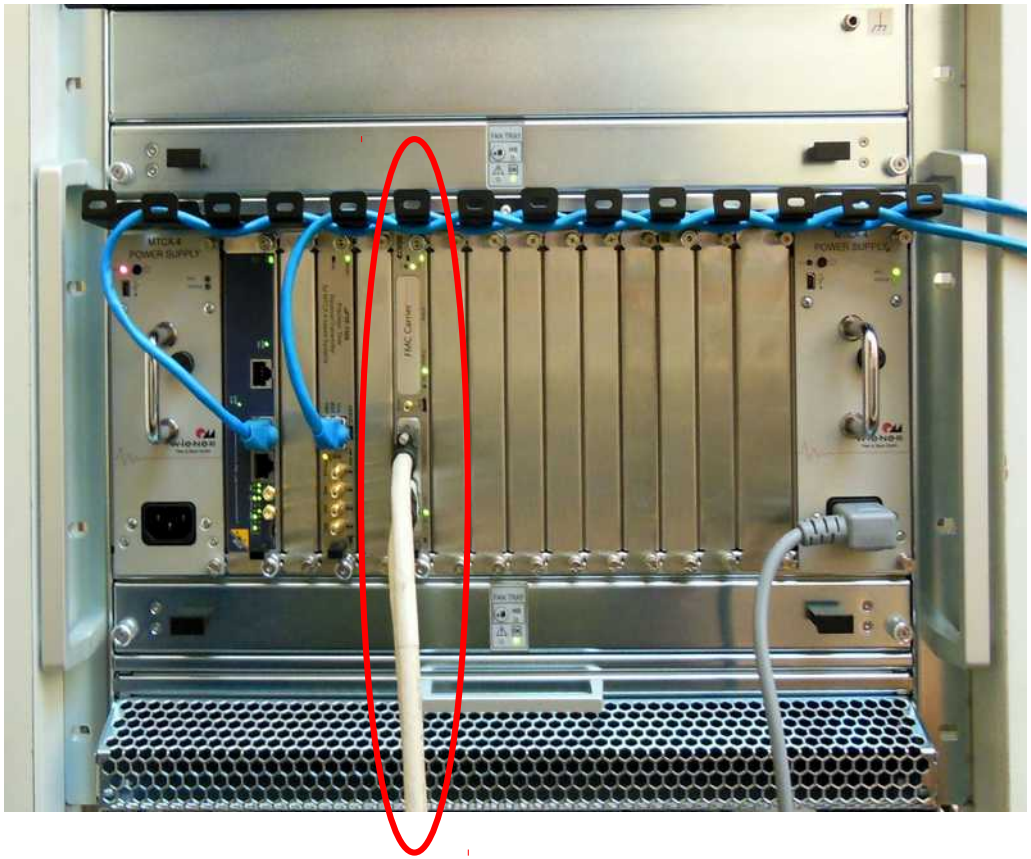
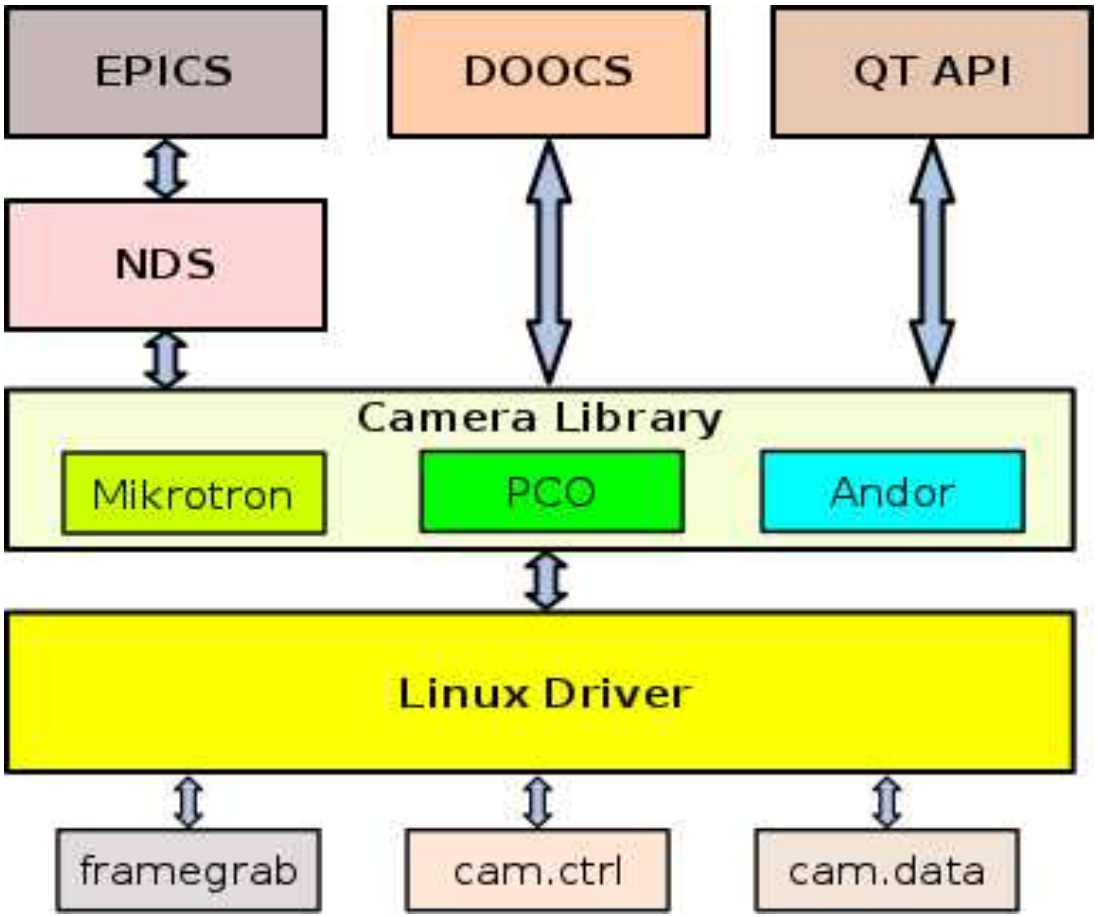


Image Acquisition System with Full-Extended Camera Link

Image Acquisition System – Software Framework

- API for EPICS, DOOCS and QT
- Library for 3 cameras:
  - Microtron
  - PCO
  - Andor
- Available nodes:
  - Frame Grabber
  - Camera control
  - Camera image
- Linux driver and NDS library
- HMI panels



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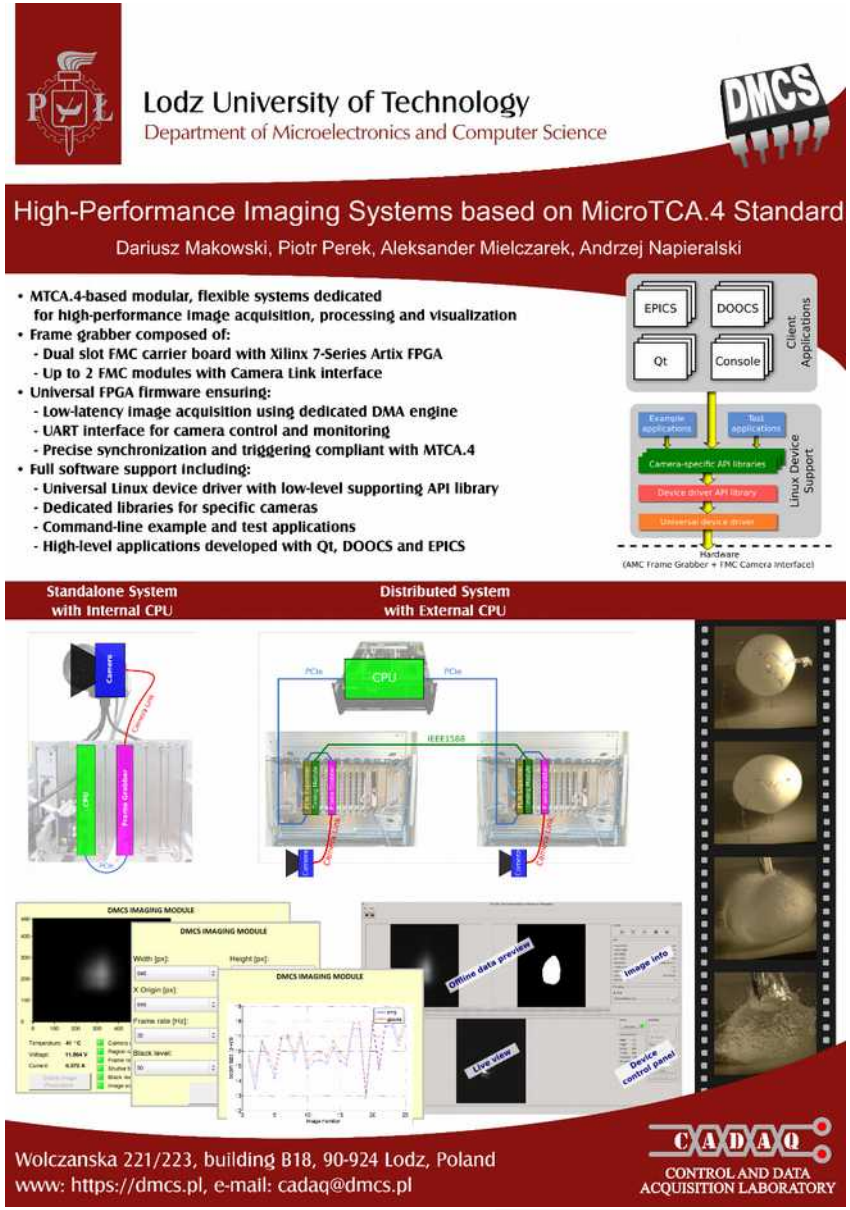
- Developed a complete Image Acquisition System for MicroTCA.4
- Various cameras supported
- Scalable and configurable software framework
- Support for new cameras could be easily added
- We are open for collaboration



Live Demo at TUL-DMCS Booth

Thank you for your attention