Extension of MMC for Diagnostics and Management of High Power Piezo Driver

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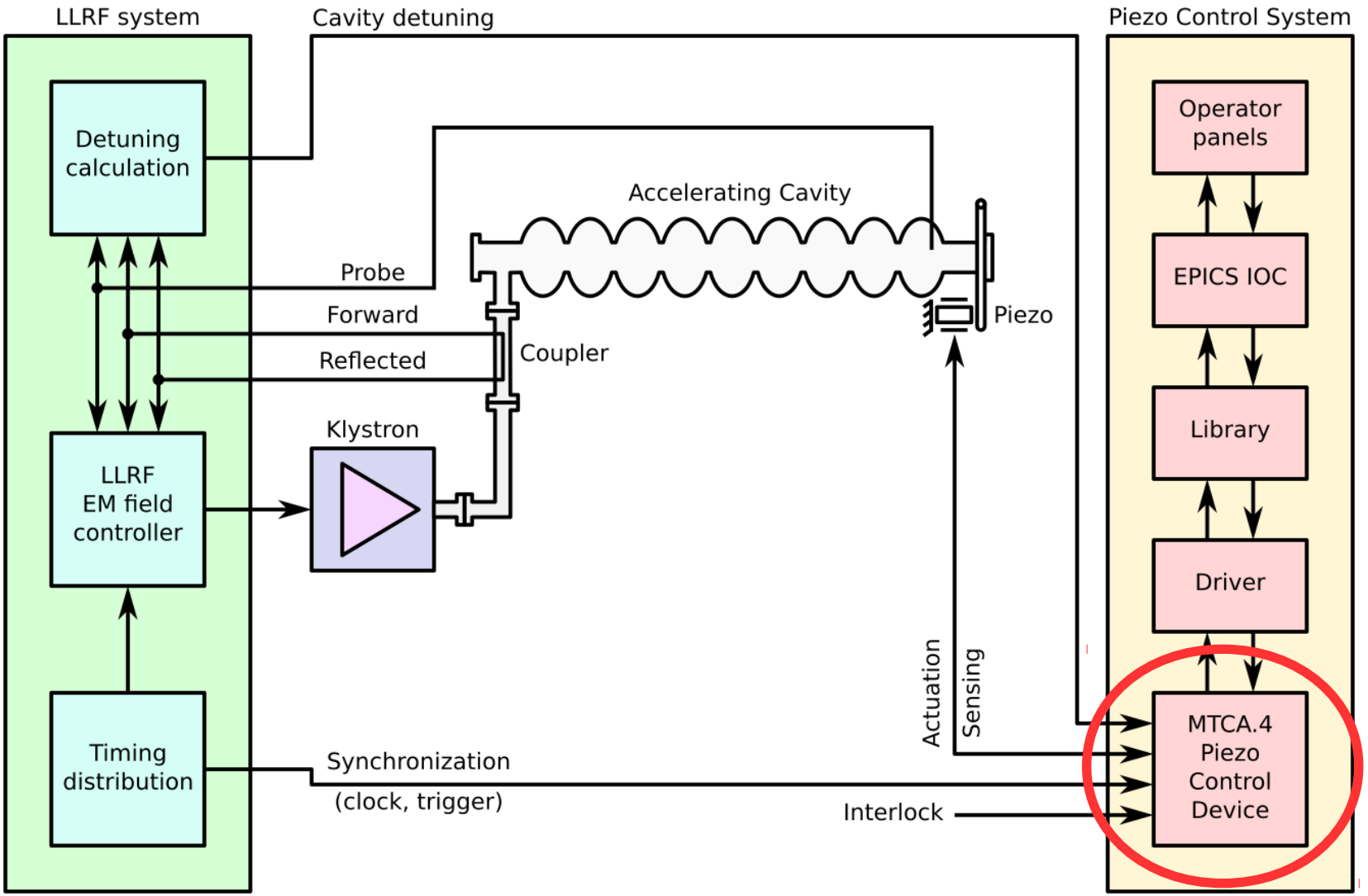
- Responsible for MicroTCA.4 LLRF system for medium- and high-beta cavities
- TUL-DMCS provides hardware and software for Piezo Control System
- High Power Piezo Driver - Short Specification
  - Provide a control signal for piezo actuators of medium-, high-beta and spoke cavities of ESS accelerator operating in cryogenic temperatures
  - Measure cavity deformation using piezo device as sensor element
  - Support two independent channels with configurable mode of operation:
    - Piezo actuator and/or
    - Piezo sensor
  - **Compatible with MicroTCA.4 and MicroTCA.4.1 standards**
  - Provide health monitoring and diagnostics
  - Assure safe operation of piezo actuator

Piezo Compensation System



Piezo Actuators Selected for ESS

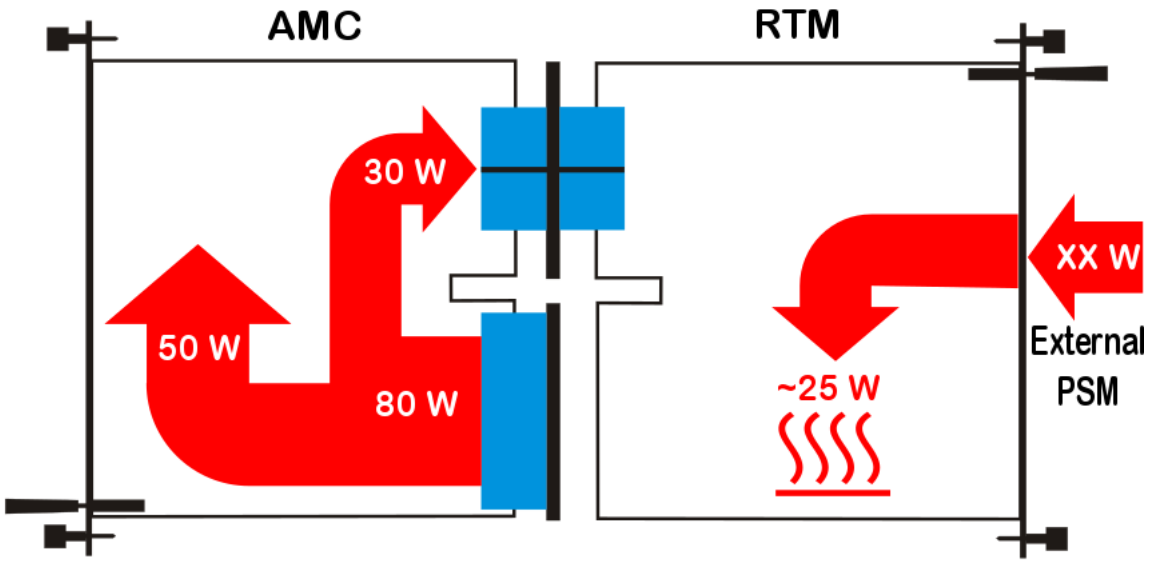
Cavity type	Piezo actuator type
Medium Beta cavities	Noliac NAC 2022 H30
High Beta cavities	Noliac NAC 2022 H30
Spoke cavities	Piezo #1: Noliac NAC2022-H90-A01 Piezo #2: PI PICMA P-888.91/51

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.)	6.6 µF ±15%	17.4 µF ±15%	32 µF ±20%
Total capacitance (cryo, 20 K)	**~2.2 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

Possible Solutions of Piezo Driver MicroTCA.4 Implementation #3

III. AMC + RTM card + External PSM

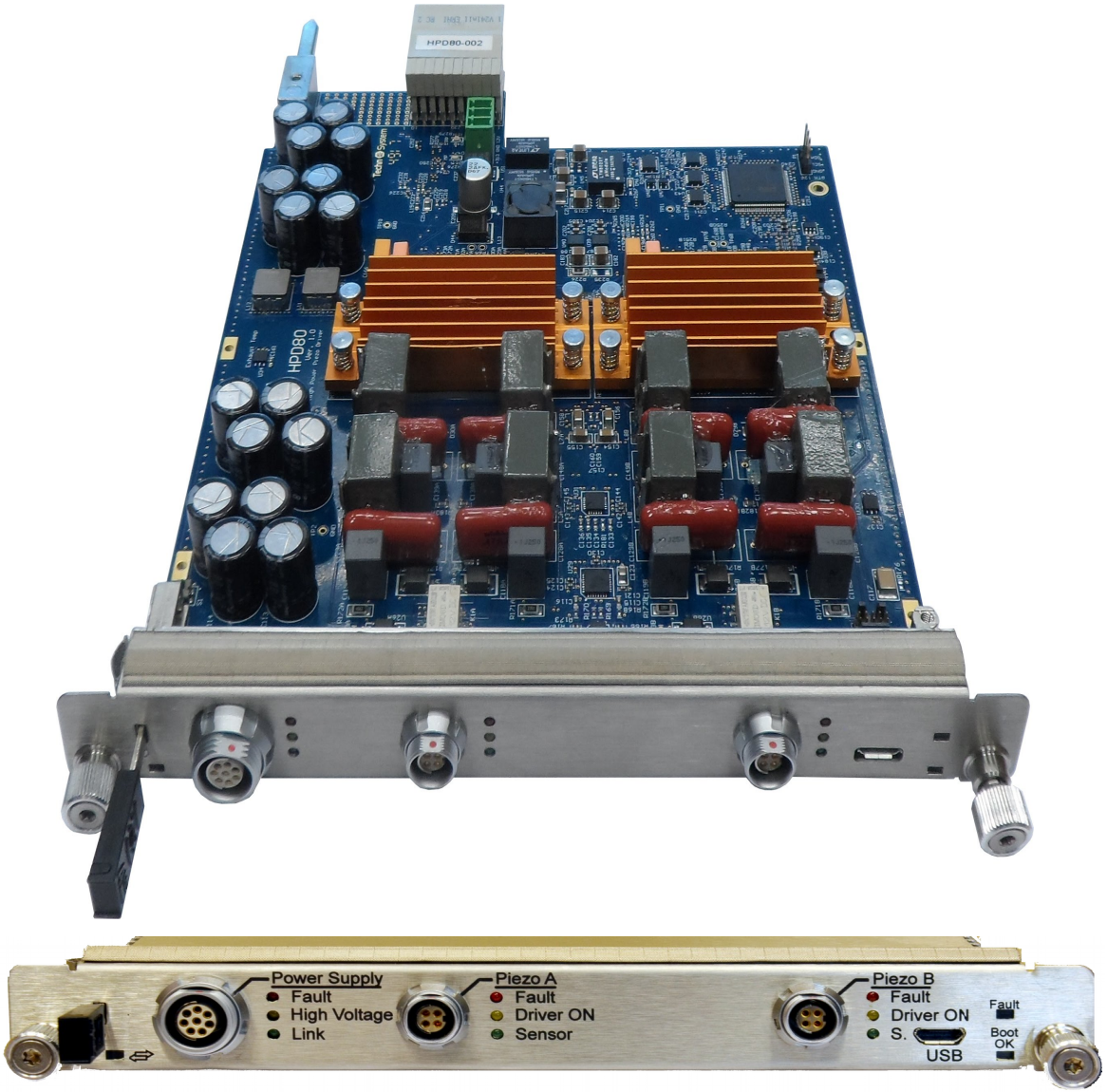
1. 5-10 Watts for Payload (from AMC)
2. Untimed power for Piezo Driver from external power supply
3. Limited piezo power by cooling capability to ~20-25 Watts



200 W Piezo Power Supply Module

Piezo Driver RTM Module – the final Device

- 2 channels of high power piezo driver
  - 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
- Working on a new digital high-voltage class D1.2-HV (±50 V) on Zone 3 (MTCA.4 power supply)



More about High Power Piezo Driver

High-power Piezoelectric Tuner Driver for Lorentz Force Compensation

12 Jun 2018, 14:40

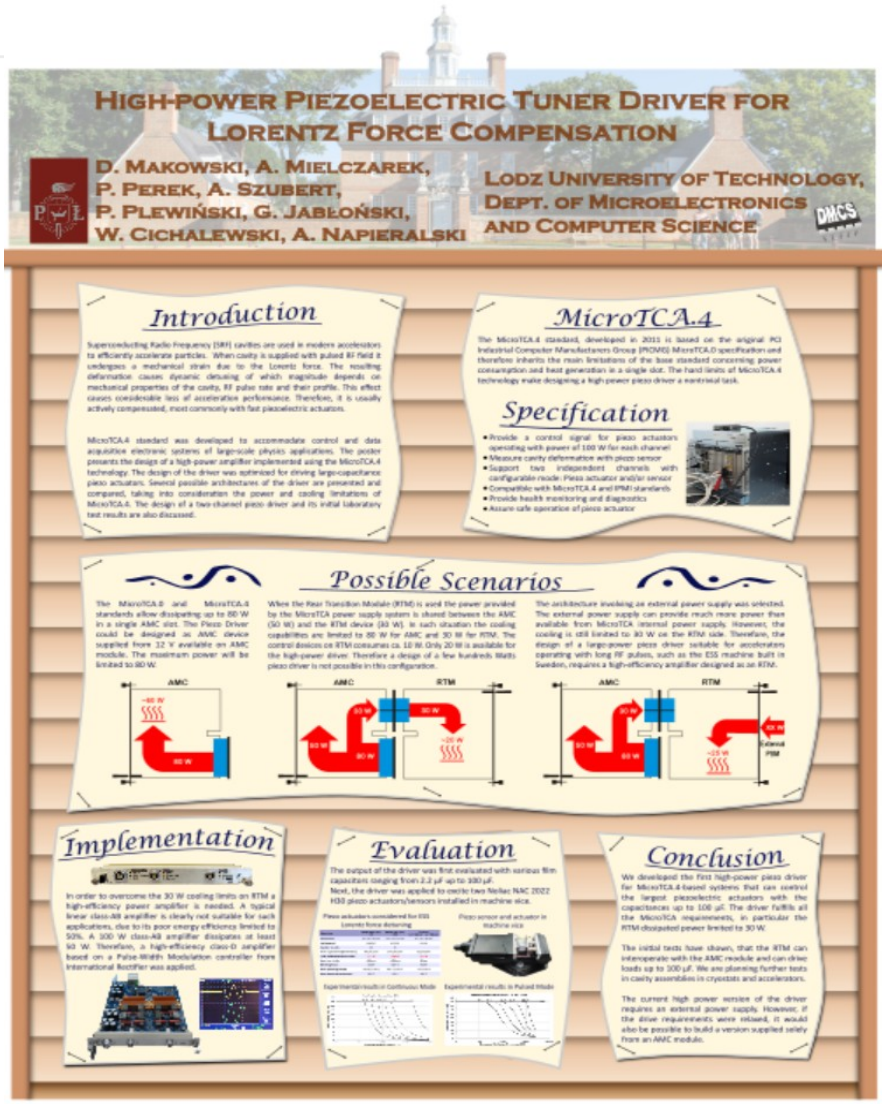
1h 30m

Woodlands Conference Center

Speaker

Dr Dariusz Makowski (Lodz University of Te...)

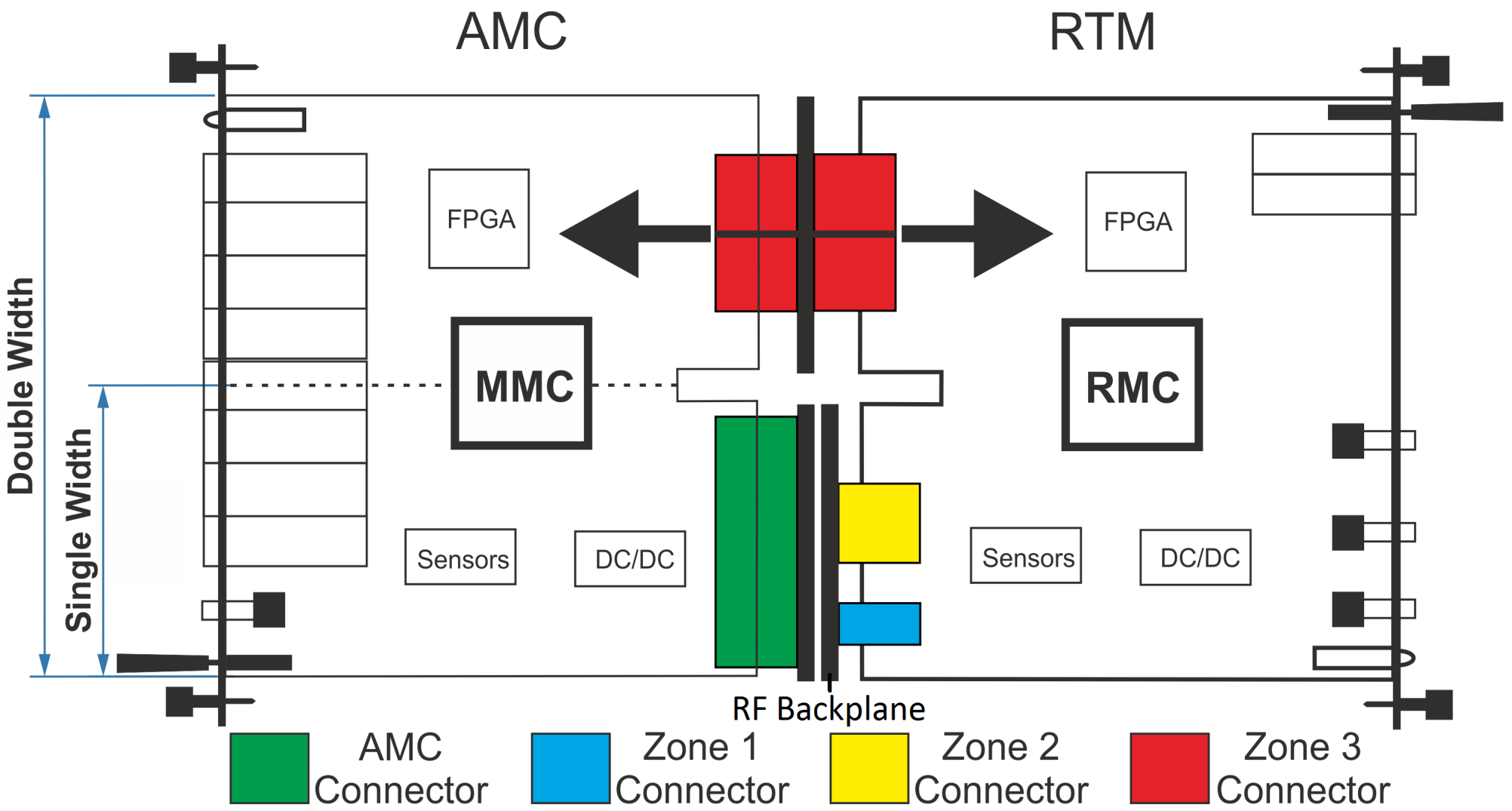
Poster presentation | New Standards | Poster 1



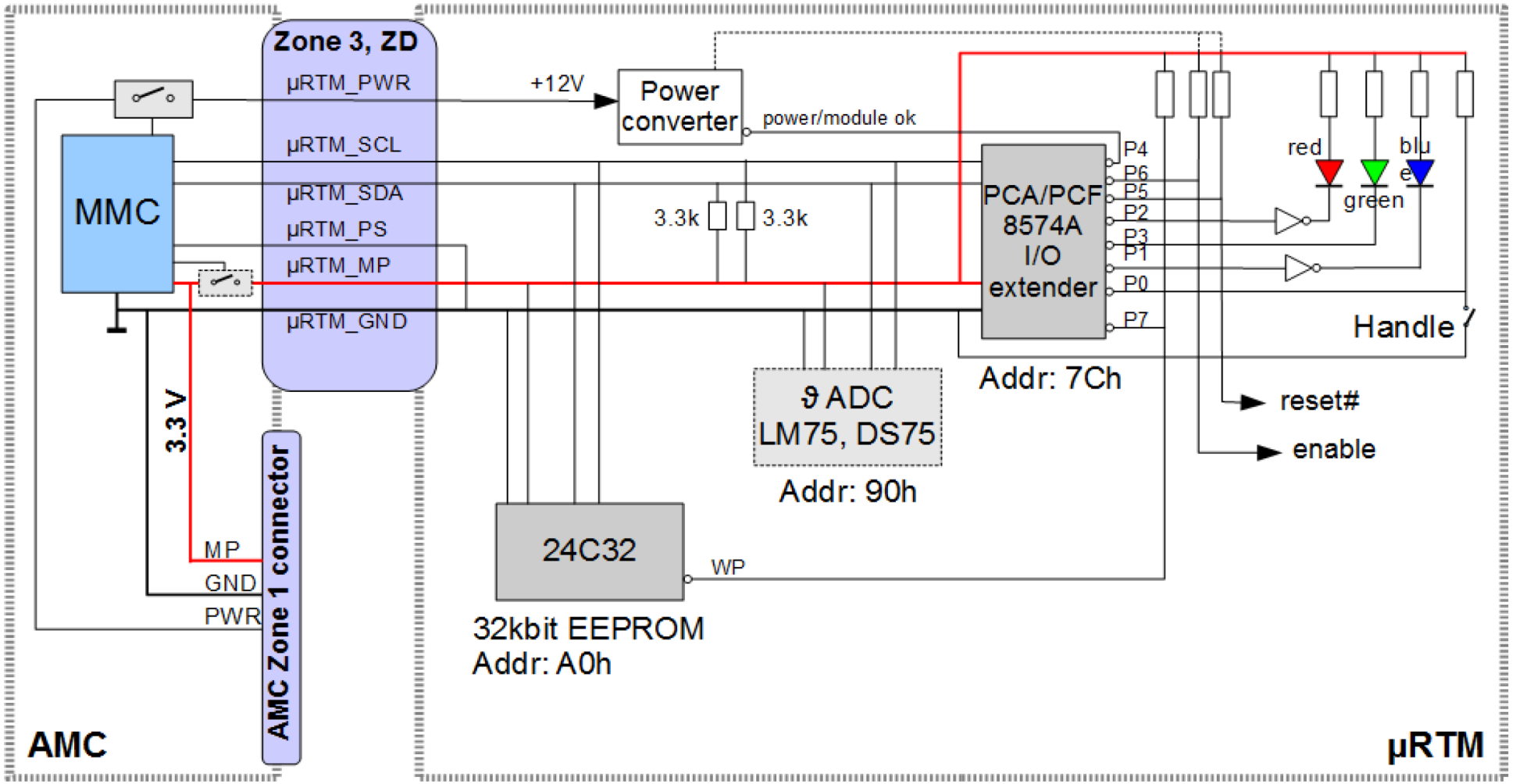
External Power Supply Health

- Condition of external PSM need to be monitored to assure high reliability (MTBF)
  - Avoid active cooling if possible (in other case monitor fan RPMs)
  - Monitor temperature of critical components (active components in AC/DC converters)
    - -50 V and +50 V
  - Monitor voltages:
    - -50 V and +50 V
- ID signature of PSM
- Communication with PSM
- Control External PSM
  - Disable in critical situation
  - Disable when cable disconnected
  - Provide power sequencer for high-voltage management

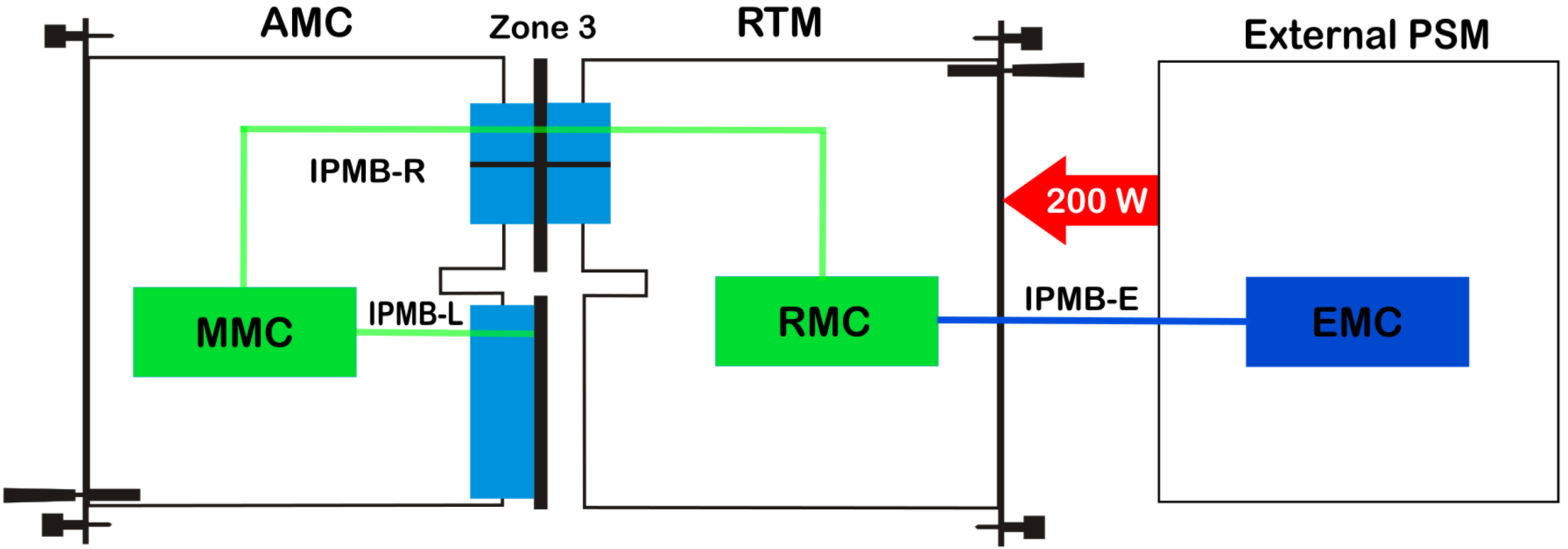
MicroTCA.4 – Intelligent Platform Management Interface



MTCA.4.1 – Basic RTM Management



Extended IPMI Diagnostics #1



Based on MTCA.0, MTCA.4 and MTCA.4.1 PICMG standards

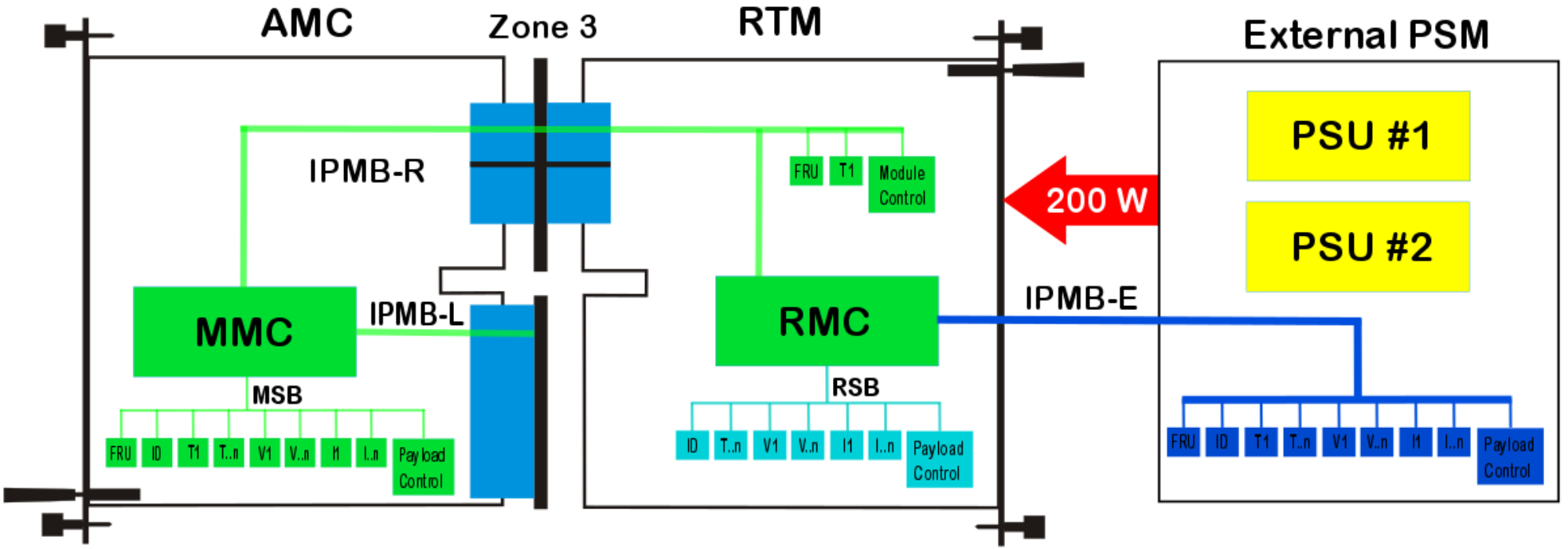
- MMC – Module Management Controller
- RMC – RTM Management Controller
- EMC – External Management Controller

IPMP-L – IPMI Local Bus

IPMP-R – IPMI RTM Bus

IPMP-E – External IPMI Bus

Extended IPMI Diagnostics #2

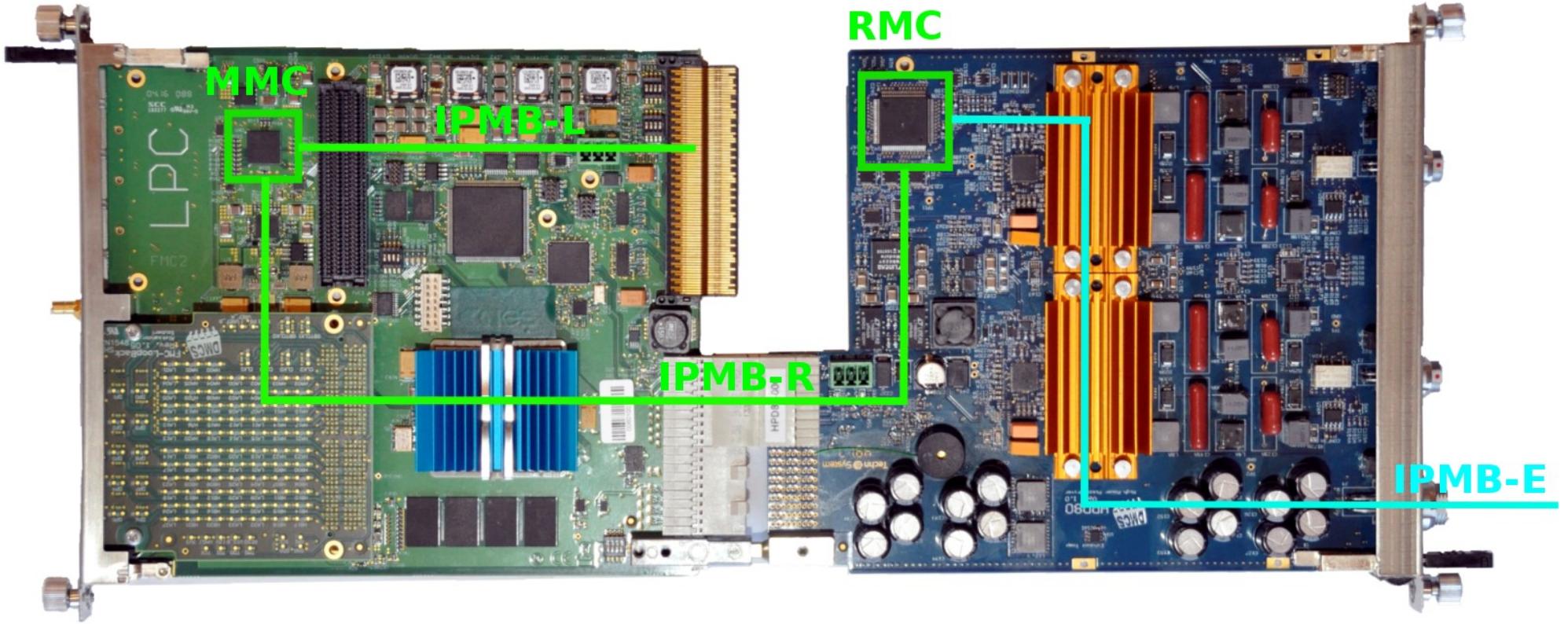


New architecture proposed for Extended IPMI Diagnostics

- MSB – MMC Sensors Bus
- RSB – RTM Sensors Bus

Hardware Setup for Extended IPMI Diagnostics Development

- Module Management Controller (MMC) designed by TUL-DMCS based on our 15-years experience in xTCA developments and standards (e.g. DESY MMC1.0).
- New project: Extended with RTM Module Management Controller (RMC)



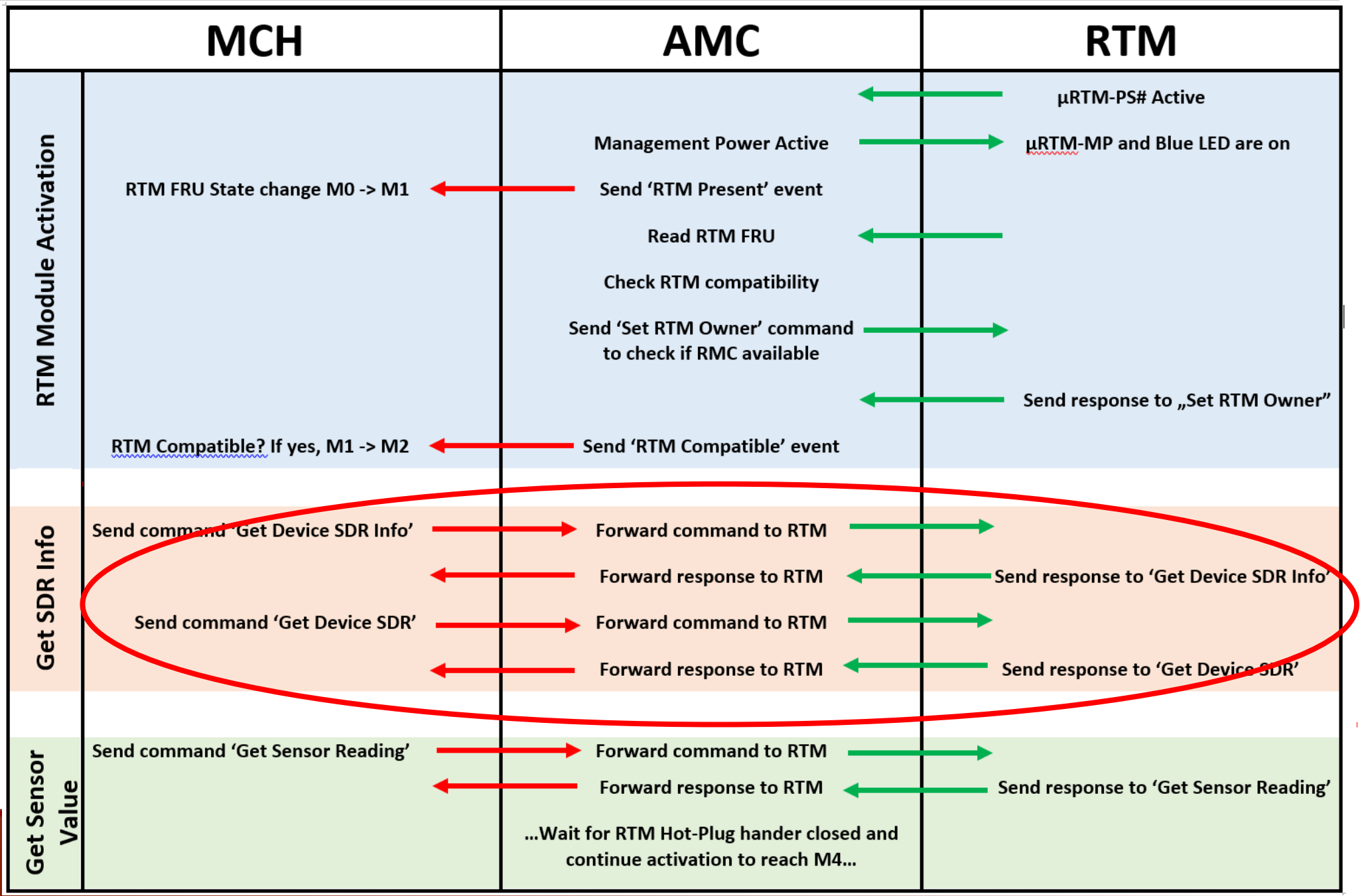
AMC module with MMC

High-power Piezo Driver RTM with RMC

High-Power Piezo Driver – IPMI Sensor Devices

- **Static IPMI Sensors:**
  - Module Hot Swap
  - Temperature
- **Dynamic IPMI Sensors:**
  - Temperature
    - Piezo Driver (Channel 1 and 2)
    - Inlet and Outlet
  - Voltage
    - High Voltage +/-50 V
    - Analogue and Digital supply (6 voltages)
  - Piezo Protection Circuit
    - Peak and Averaged Power (Channel 1 and 2)
  - Piezo Channel Status
    - Mode of operation: Driver or Sensor (Channel 1 and 2)
    - Piezo presence and ID signature (Channel 1 and 2)
  - External power supply
    - Device Presence (communication)
    - Temperature (ambient, negative and positive power supply)
    - Power Good signals (negative and positive power supply)
    - Device State

IPMI Protocol – Dynamic Sensors



Get Device SDR Info Command

Table 35-, Get Device SDR Info Command

Request Data	(1)	Operation (optional) [7:1] - reserved [0] - 1b = Get SDR count. This returns the total number of SDRs in the device. 0b = Get Sensor count. This returns the number of sensors implemented on LUN this command was addressed to.
Response Data	1	Completion Code
	2	For Operation = "Get Sensor Count" (or if byte 1 not present in request): Number of sensors in device for LUN this command was addressed to. For Operation = "Get SDR Count": Total Number of SDRs in the device.
	3	Flags: Dynamic population [7] - 0b = static sensor population. The number of sensors handled by this device is fixed, and a query shall return records for all sensors. 1b = dynamic sensor population. This device may have its sensor population vary during 'run time' (defined as any time other that when an install operation is in progress). Reserved [6:4] - reserved Device LUNs [3] - 1b = LUN 3 has sensors [2] - 1b = LUN 2 has sensors [1] - 1b = LUN 1 has sensors [0] - 1b = LUN 0 has sensors
	4:7	Sensor Population Change Indicator. LS byte first. Four byte timestamp, or counter. Updated or incremented each time the sensor population changes. This field is not provided if the flags indicate a static sensor population.

HPD80 RTM – Dynamic Sensors

show_sensorinfo 93

Sensor Information for FRU 93 / RTM4

#	SDRType	Sensor	Entity	Inst	Value	State	Name
128	FDevLoc		0xc0	0x64			DMCS-HDP80 RTM
32	Full	0xf2	0xc0	0x64	0xa1		RTM Hot Swap
33	**Compact**	**0x0b**	**0xc0**	**0x64**	**0x00**		**0x00 001EC0FEA37D**
34	Full	Temp	0xc0	0x64	27.3 C	ok	TEMP_CH_A
35	**Full**	**Temp**	**0xc0**	**0x64**	**49.2 C**	**ok**	**TEMP_CH_B**
36	**Full**	**Temp**	**0xc0**	**0x64**	**25.7 C**	**ok**	**TEMP_INTAKE**
37	**Full**	**Temp**	**0xc0**	**0x64**	**34.2 C**	**ok**	**TEMP_EXHAUST**
38	**Full**	**Voltage**	**0xc1**	**0x64**	**49.88 V**	**ok**	**VCC+50V_IN**
39	**Full**	**Voltage**	**0xc1**	**0x64**	**-49.98 V**	**ok**	**VCC-50V_IN**
40	**Full**	**Voltage**	**0xc1**	**0x64**	**5.050 V**	**ok**	**VCC+5V0A**
41	**Full**	**Voltage**	**0xc1**	**0x64**	**-5.025 V**	**ok**	**VCC-5V0A**
46	**Compact**	**0x0b**	**0xc1**	**0x67**	**0x01**		**0x00 RES_ID_CH_A**
47	**Compact**	**0x0b**	**0xc1**	**0x67**	**0x00**		**0x00 RES_ID_CH_B**
48	**Compact**	**0x0b**	**0xc1**	**0x67**	**0x01**		**0x00 CH_A_STATE**
49	**Compact**	**0x0b**	**0xc1**	**0x67**	**0x0**		**0x00 CH_B_STATE**

Summary

- 200 W Piezo Driver was designed as MicroTCA.4 RTM
- External Power Supply Module is required for high-power driver operation
- MicroTCA.4 and MicroTCA.4 RTM has a limited diagnostic capabilities
- We proposed an extended diagnostics based on IPMI Dynamic Sensor Devices
  - Real-time diagnostics of RTM Piezo Driver is possible (ca. 20 sensors)
  - Real-time diagnostics and basic control over external Power Supply (6 sensors)

- In case of questions or suggestions you can contact with me via email: dariusz.makowski@p.lodz.pl.

Thank you for your attention