Introductory Tutorial

MTCA - Hardware Platform Management Systems Basics

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Agenda

- Introduction and Overview

- Shelf Management in xTCA Systems

- xTCA for Physics Extension

- Examples of IPMI Implementation
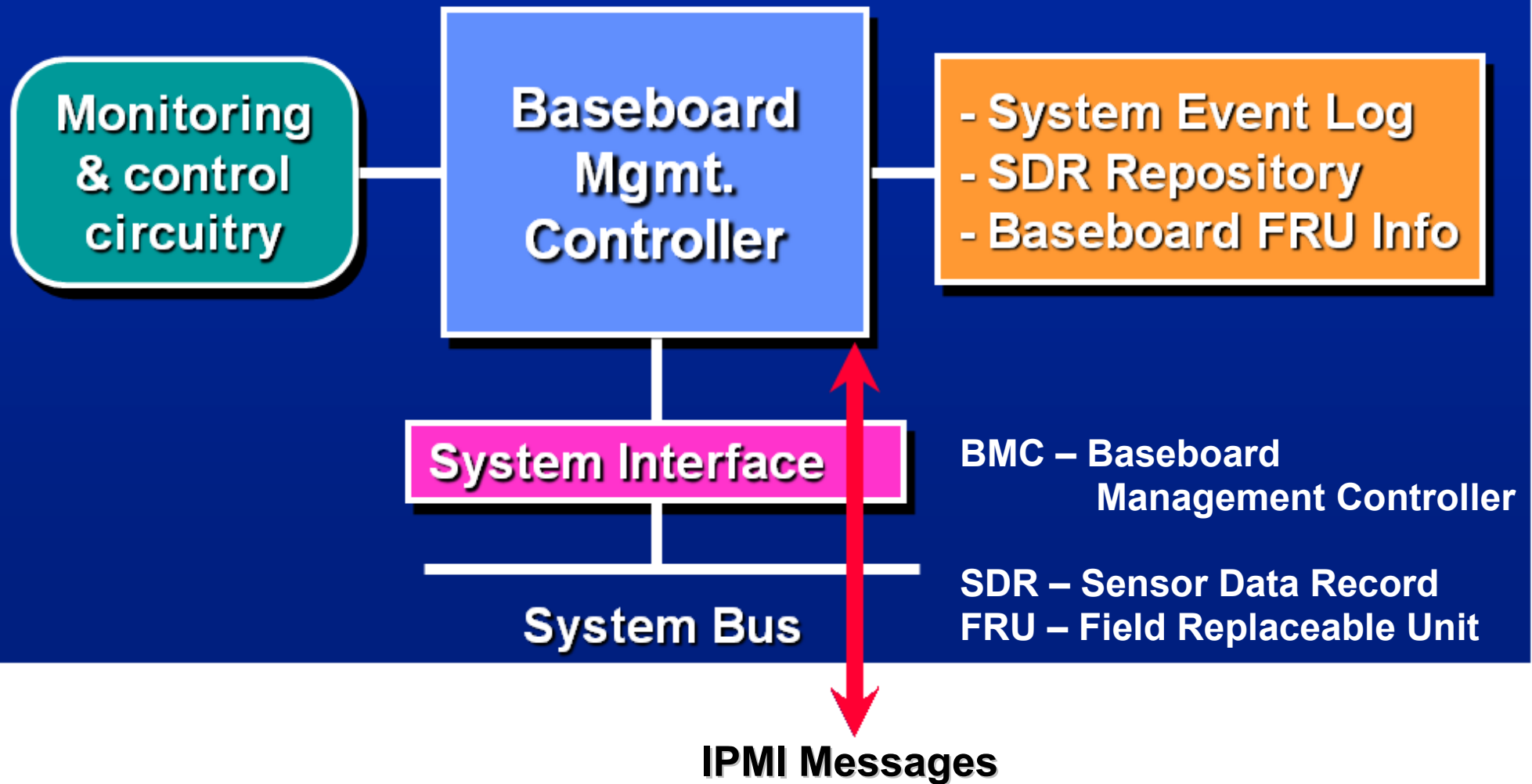
Introduction and Overview

Keep it Running...

◆ **Intelligent Platform Management Interface** – protocol initially developed by Intel, Hewlett-Packard, NEC and DELL consortium

◆ Used by system administrators for out-of-band management of computer systems and monitoring of their operation

◆ First draft available in Spring '98 (IPMI v0.9)

◆ **RAS** Features Focus:

   ◆ **R**eliability

   ◆ **A**vailability

   ◆ **S**erviceability

◆ Server oriented:

   ◆ Remote administration

   ◆ Expensive hardware

   ◆ High costs of downtime and repair

◆ Plug and Play, Hot-swap
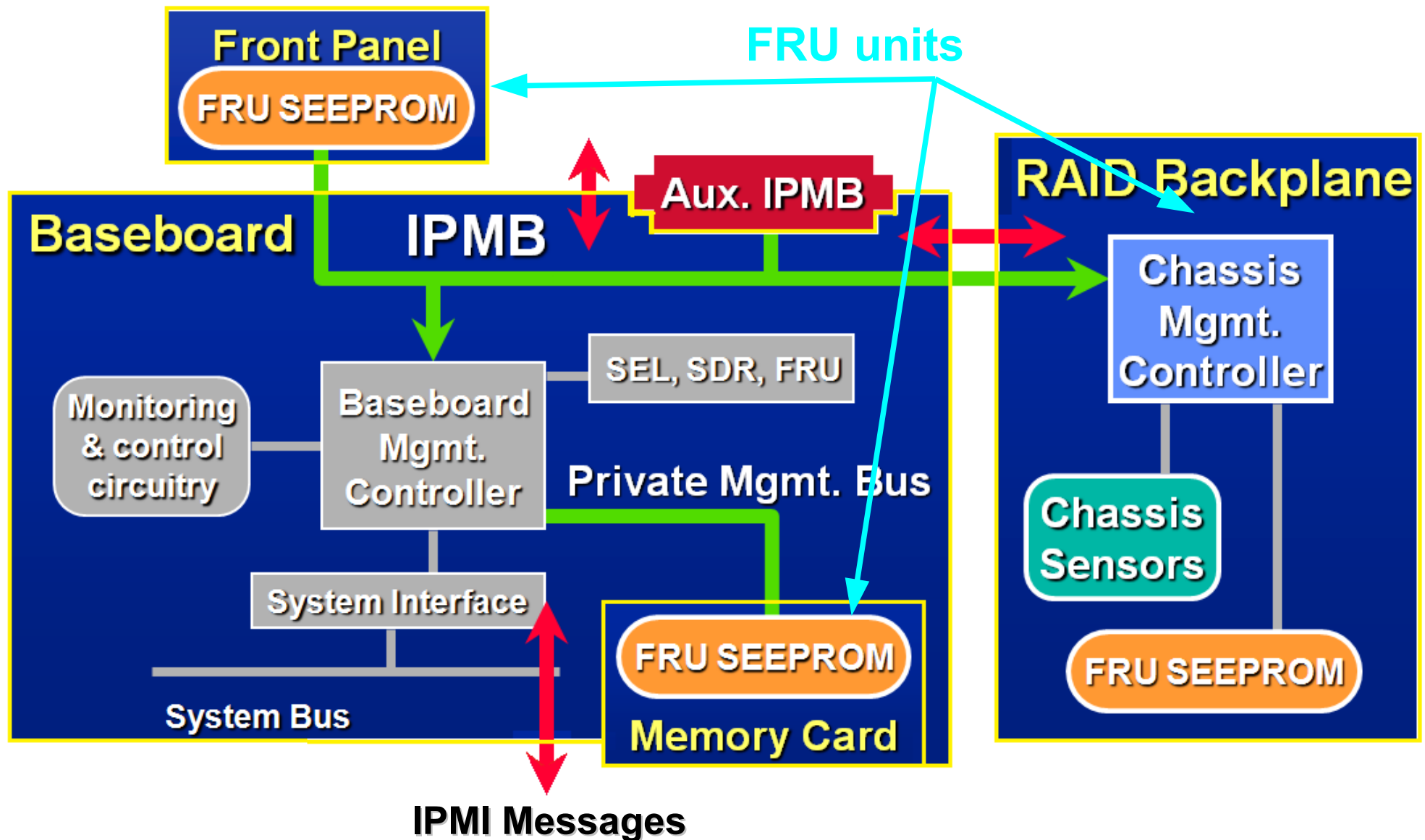
SuperBlade supercomputer
source: www.supermicro.com

IPMI Components

Baseboard

| Monitoring & control circuitry | Baseboard Mgmt. Controller | - System Event Log
- SDR Repository
- Baseboard FRU Info |

System Interface

System Bus

IPMI Messages

BMC – Baseboard
              Management Controller

SDR – Sensor Data Record
FRU – Field Replaceable Unit

Computer Node - IPMI Implementation

Chassis Implementation

Remote Mgmt Console System

IPMB **I**ntelligent **P**latform **M**anagement **B**us

BMC Baseboard Management Controller

SC Satellite Controller

MMP Management Module Processor

BP/I/F Backplane Management Interconnect

LAN, Serial, SOL

Management Module

MMP

BP/I/F

FAN Unit #1 — **SC**

FAN Unit #2 — **SC**

Power Supply Module #1 — **SC**

Power Supply Module #2 — **SC**

Power Supply Module #N — **SC**

Out Of Band

In Band

BP/I/F
BMC
IPMB
Computation node A

BP/I/F
BMC
IPMB
Computation node B

BP/I/F
BMC
IPMB
Computation node N

SC
Storage Device

IPMI Elements (1)

- **Baseboard Management Micro-Controller provides intelligence for IPMI**

  - Out Of Band (OOB) access to computer

  - Autonomous monitoring and logging

  - System interface to internal IPMB (I2C)

  - Interface to IPMI Storage

  - Receives and logs events messages

  - Power control functions

  - BIOS access

 - OEM defined functions

  - System Watch-dog Timer

IPMI Elements (2)

- **Field Replaceable Unit (FRU)**
Field replaceable components of the system such as a board, module, fan unit, power supply module, raid matrix, etc.
FRU records are stored in a non-volatile memory.

- **Sensor Data Record (SDR)**
Provide information about available on FRU sensors, events, management controllers, e.g. temperatures, voltages, sensors, etc.
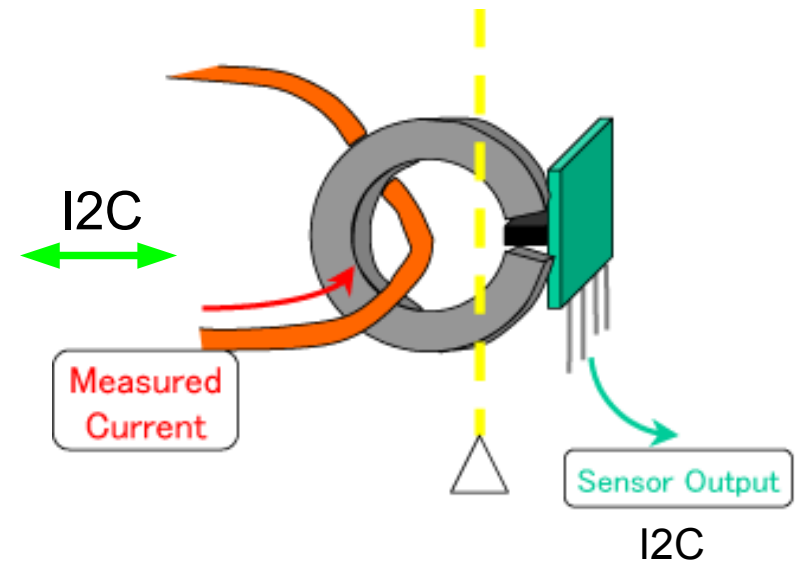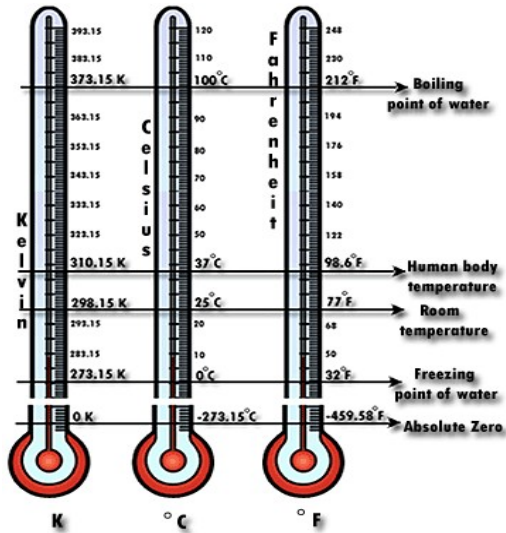
I2C Interface – IPMI Backbone (1)

- I2C – **I**nter-**I**ntegrated **C**ircuit bus

- Standard developed by Philips on early 80s

- Two wire synchronous, half-duplex interface (SDA – data line, SCL – clock line)

- Bidirectional multi master-slave transfers, 8-bit frames

- Transmission speed: 100 kbps, 400 kbps, 3.4 Mbps

- 7-bit or 10-bits device address

- Arbitration used for multi-master transmission

I2C bus
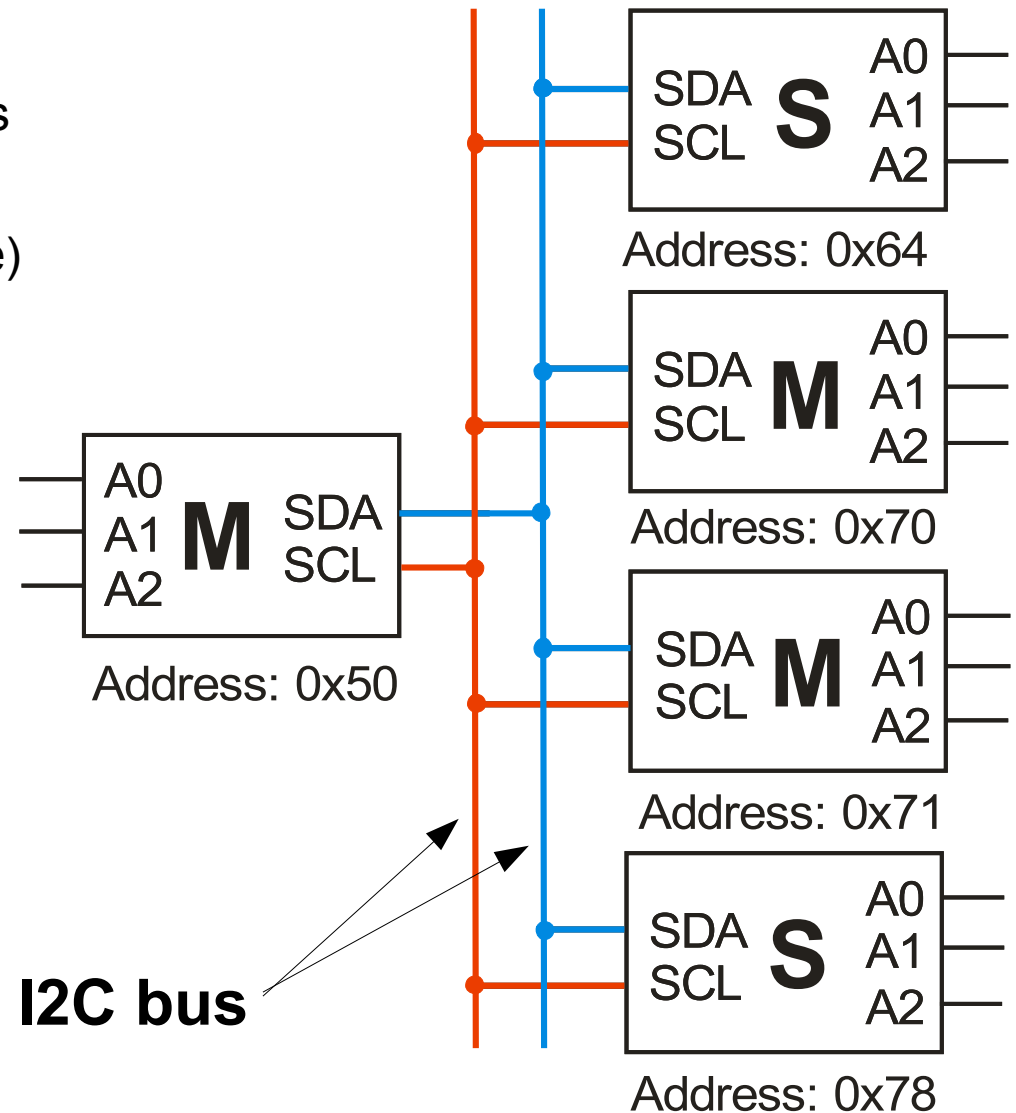
I2C Interface – IPMI Backbone (2)
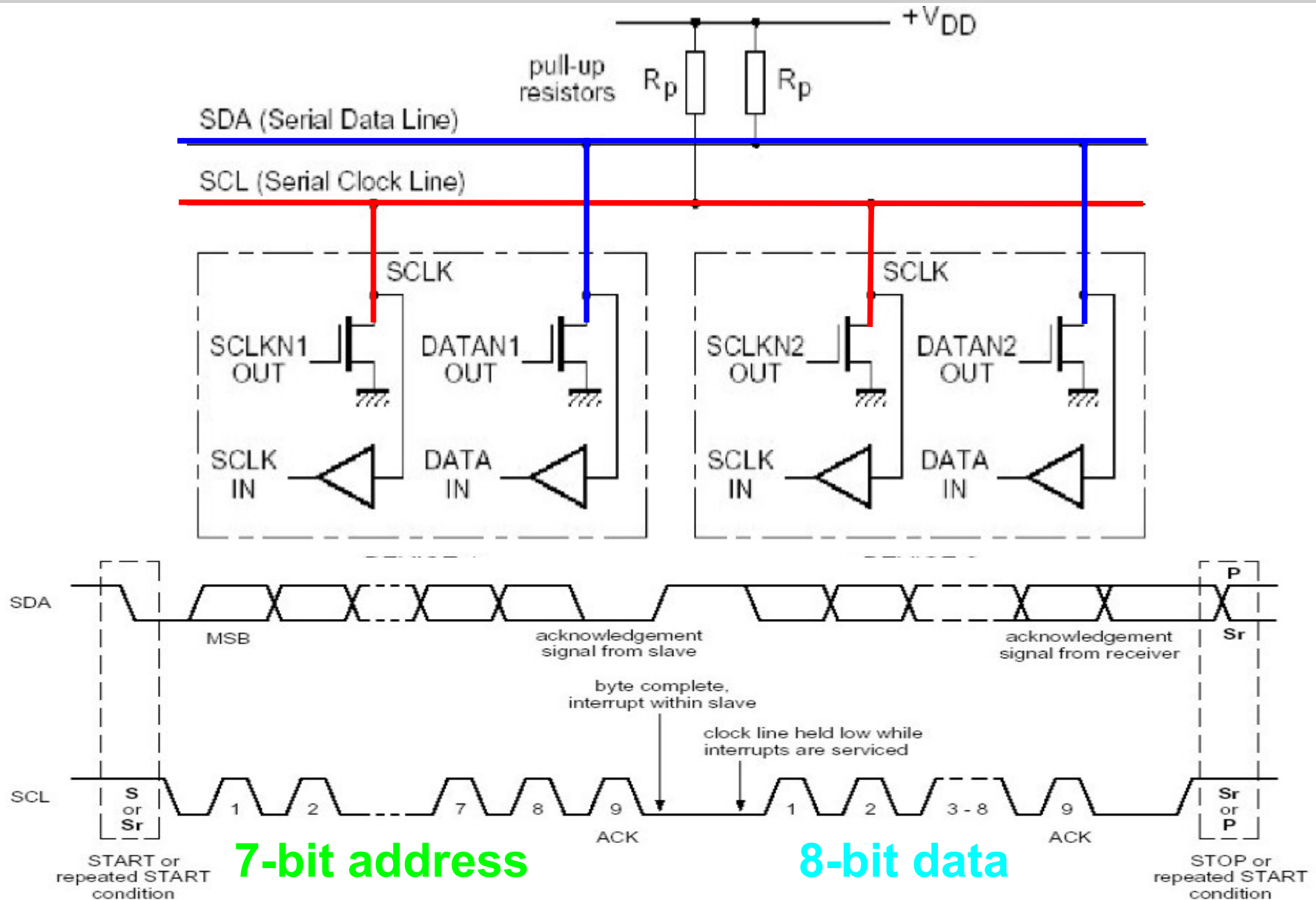
Shelf Management in xTCA Systems

xTCA and IPMI

➤ IPMI introduced in PICMG 2.16 backplanes (CompactPCI systems) and later in AMC, ATCA and MTCA standards

➤ IPMI enables "diagnose-before-dispatch" automation

➤ Required for 99.999 percent high availability (HA) mark

➤ IPMI controller (shelf manager) is responsible for:

  ➤ Monitoring overall shelf health

  ➤ Communicating with remote System Management Software (SMS)

  ➤ Hot-swap events (e.g. hardware component entry-removal events)

  ➤ Latch/lock management

  ➤ Power budgeting

  ➤ In-rush current sequencing

  ➤ Electronic keying (E-keying)

➤ PICMG 3.0 extension commands

➤ HPM.1 management firmware upgrade capability

ATCA Shelf Management System

AMC **A**dvanced **M**ezzanine **C**ard

ShMC Shelf Manager

IPMC Intelligent Platform Management Controller

MMC Module Management Controller

Serial-over-LAN

System Manager

Intelligent Platform Management Controller

Shelf Manager — ShMC

Shelf Manager — ShMC

Fan Tray — IPMC

Power Module — MMC

Power Module — MMC

Redundant IPMB-0

ATCA Board — IPMC

ATCA Board — IPMC

AMC MMC / AMC MMC — IPMC

IPMB-L

ATCA Board — IPMC

RTM RMC
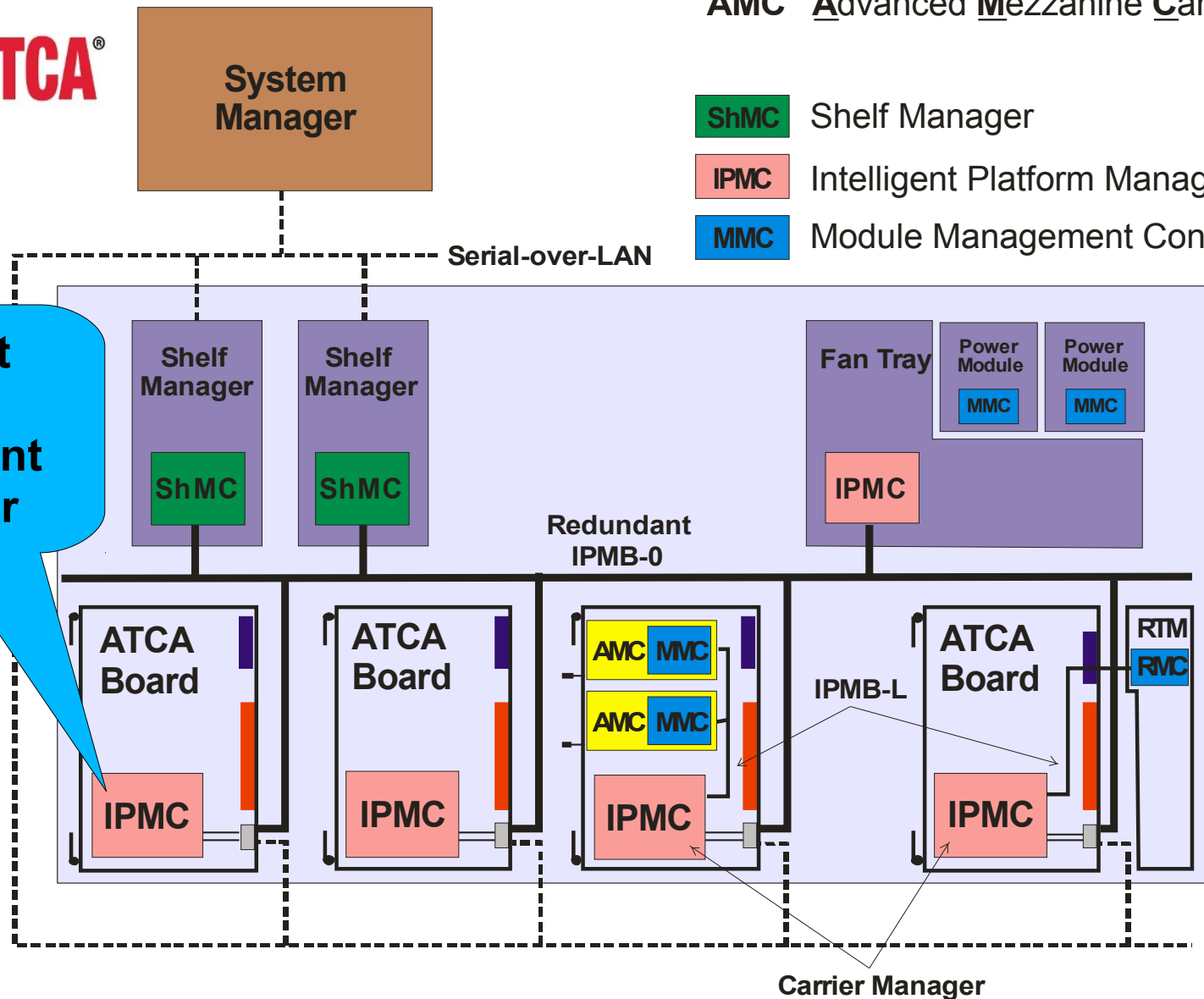
Carrier Manager

MTCA Shelf Management System

μTCA®

System Manager
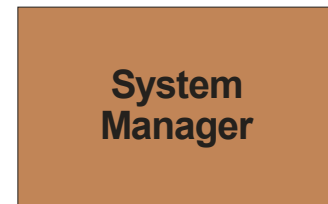
MCH	**M**TCA **C**arrier **H**ub
AMC	**A**dvanced **M**ezzanine **C**ard
RTM	**R**ear **T**ransition **M**odule
MMC	Module Management Controller
EMMC	Enhanced MMC
MCMC	MTCA Carrier Management Controller
RMC	RTM Management Controller

LAN, Serial, SOL

Module Management Controller

MTCA Carrier Hub — Carrier Manager — MCMC

MTCA Carrier Hub — MCMC

Cooling Unit #1 — EMMC

Cooling Unit #2 — EMMC

Power Module #1 — EMMC

Power Module #2 — EMMC

Power Module #N — EMMC

Redundant IPMB-0

IPMB-L

MMC — AMC #1

MMC — AMC #2

MMC — AMC #3

MMC — AMC #4

MMC — AMC #...

MMC — AMC #12

RMC — RTM #12

DMCS | DESY | PICMG
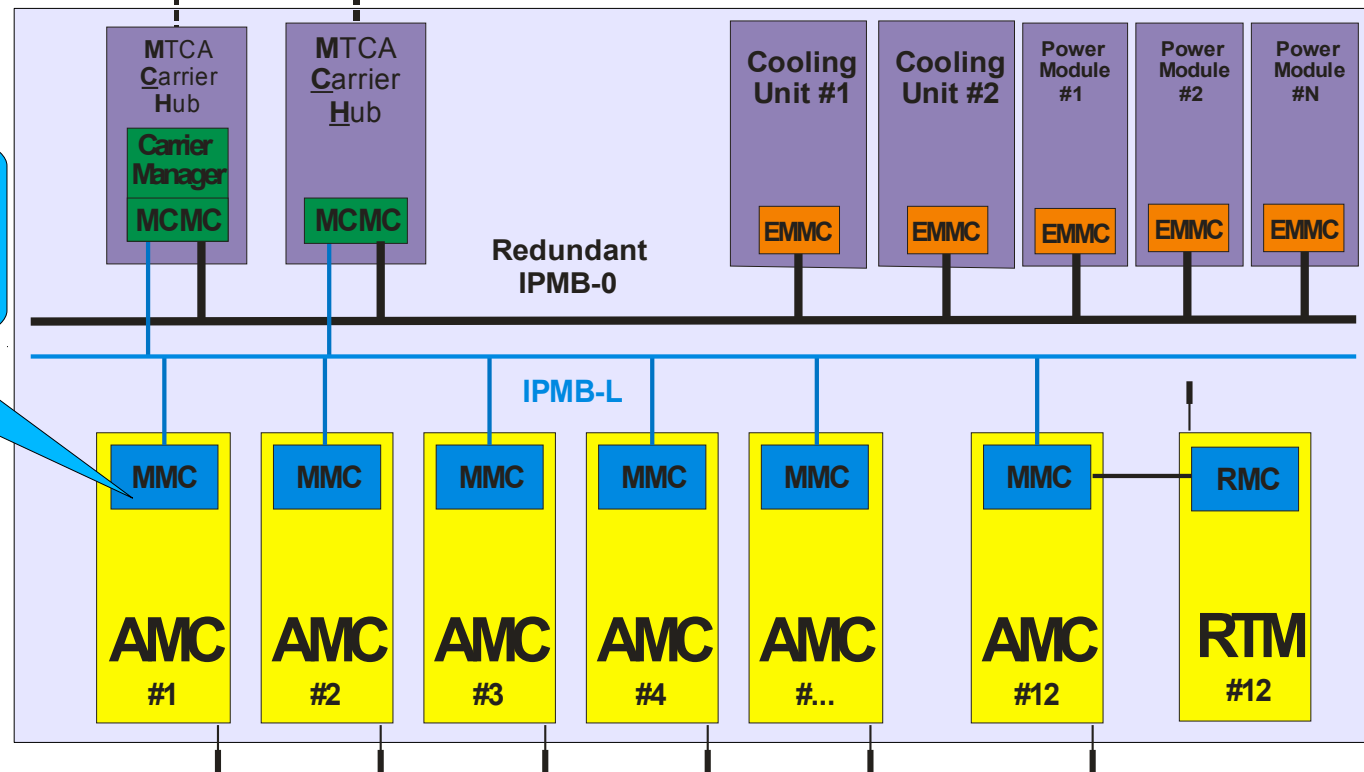
uTCA-based LLRF Control System of Accelerator
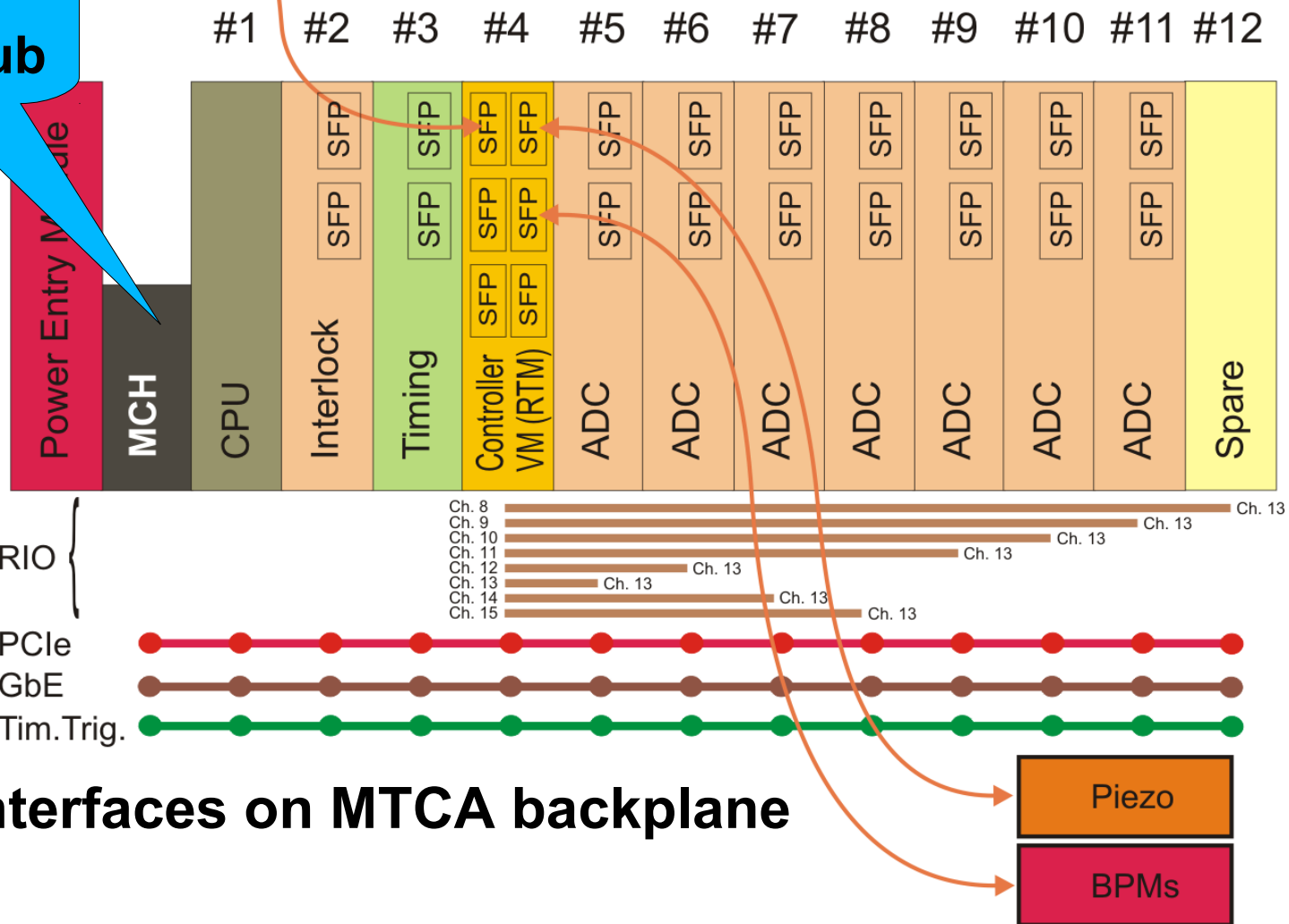
AMC Module Hot-plug

- What really happens when you plug AMC card into MTCA chassis?

- Module Activation procedure?

- Module Deactivation?

- How IPMI automates this process?

- What if something goes wrong?

Hot-plug handle

Blue LED
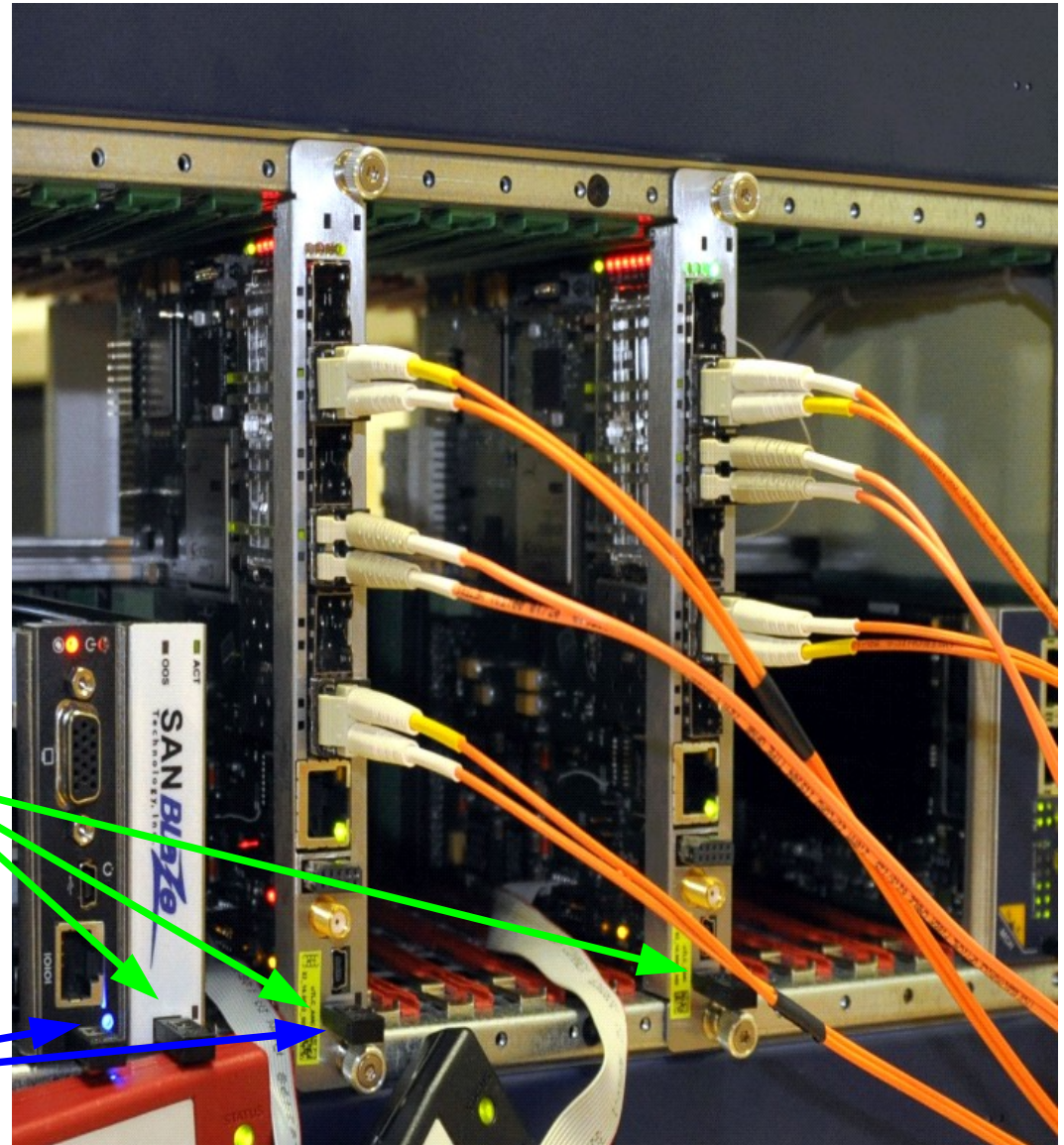
Module Activation/Deactivation

- PICMG 3.0 and AMC specifications define FRU states

- Activation pushes FRU into M4 state

- Deactivation moves FRU into M1 state

- If something wrong happen module goes into M7 state

- MCH decides if and when module can reach M4

- MMC uses a state machine to control hot-plug procedure

AMC Module Insertion

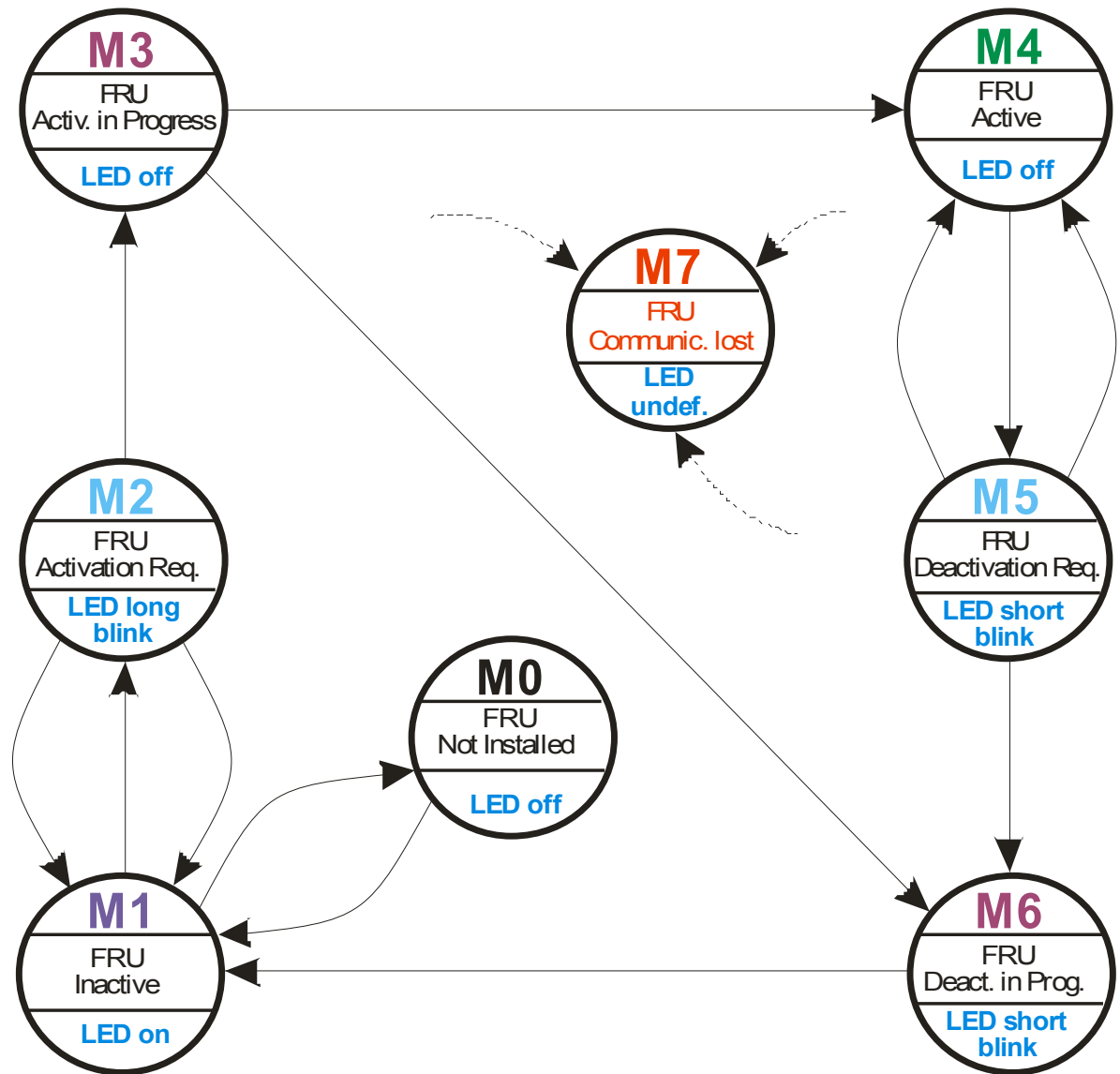| MTCA Carrier HUB		AMC Module
Shelf Manager	Carrier Manager	

PS1# Asserted

Management Power → Blue LED on

ENABLE # Active → MMC starting

M0 -> M1

Read FRU data
(E-keying, power)

Hot-plug handle closed (User)
(Module Handle Closed)

M1 -> M2

Blue LED long blink
(Set FRU LED State)

Set FRU Activation
(Activate)

M2 -> M3

Blue LED off
(Set FRU LED State)

(Get Power Level)
(Set Power Level) → Power Negotiation

Enable PP and E-keying
(Set AMC Port State)

M3 -> M4

Legend:
→ Hardware signal
→ IPMI message
← Hot Swap Event

AMC Module Extraction

MTCA Carrier HUB		AMC Module
Shelf Manager	Carrier Manager	

Hot-plug handle opened
(Module Handle Open)

M4 -> M5

Blue LED short blink
(Set FRU LED State)

Set FRU Activation
(Deactivate)

M5 -> M6

Disable Module
(Set AMC Port State)

Remove Payload Power

M6 -> M1

Blue LED on
(Set FRU LED State)

Module Extracted (User)

PS1# Deasserted

M1 -> M0

Remove
Management Power

Hardware signal

IPMI message

Hot Swap Event

MTCA.4 – Hardware Management
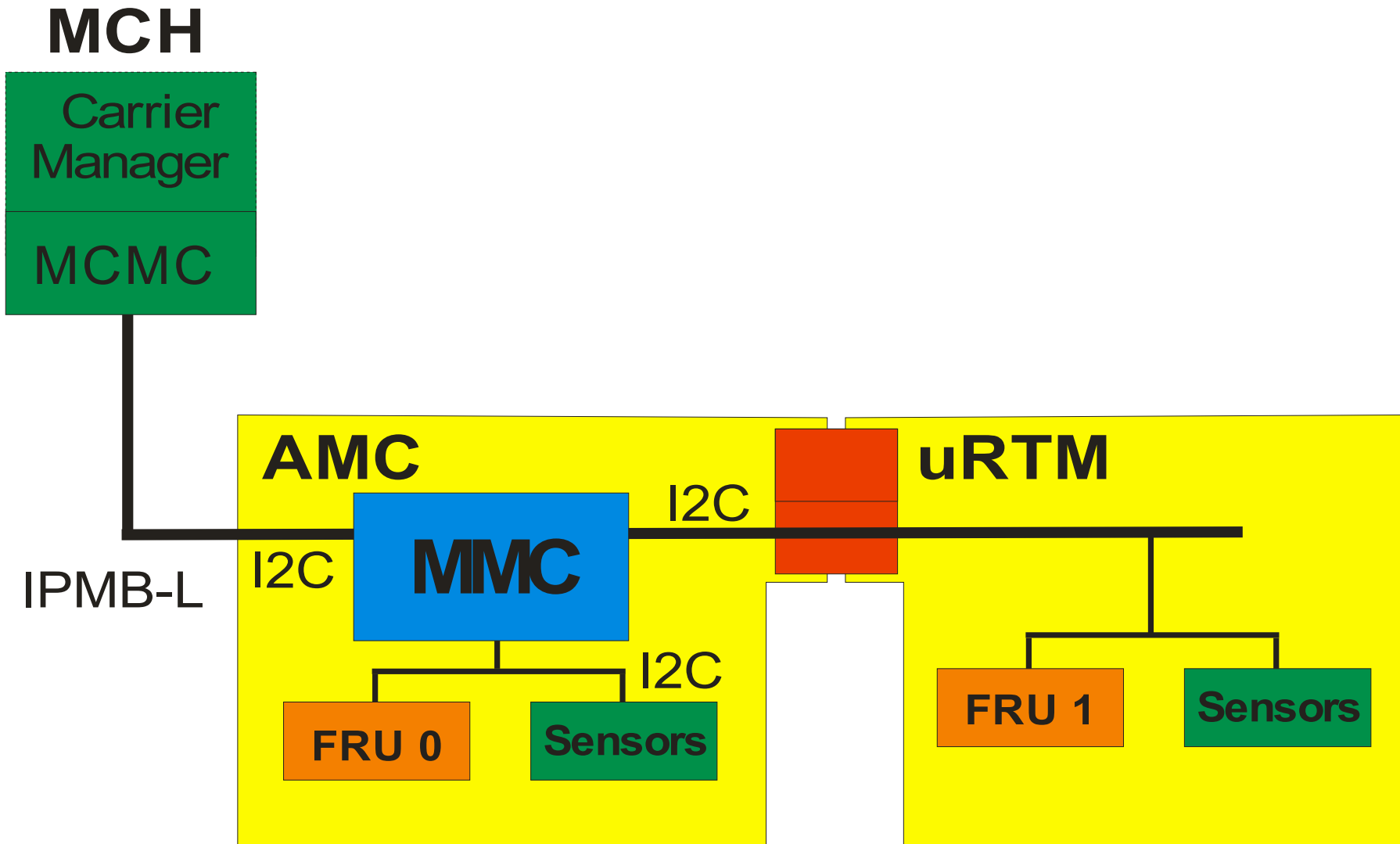
RTM Module Insertion

RTM Module Extraction

MTCA Carrier HUB		AMC Module FRU ID=0	uRTM Module FRU ID=1
Shelf Manager	Carrier Manager		

Hot-plug handle opened (Module Handle Open) ← Handle opened (User)

M4 -> M5

Blue LED short blink (Set FRU LED State) → Set Blue LED short blink ····> Blue LED blinking

Set FRU Activation (Deactivate) →

M5 -> M6

FRU Control (Quiesce) → Disable Zone3 Interfaces ····>

Module Hot Swap (Quiesced) ←

Disable Payload Power (Set Power Level = 0) → Disable Payload Power →

M6 -> M1

Blue LED on (Set FRU LED State) → Set Blue LED on ····> Blue LED on

Module extracted (user)

PS1# Deasserted ←

Disable sensors, MP →

Module Hot Swap (RTM Absent) ←

M1 -> M0

Delete sensors

Legend:
- → Hardware signal
- ····> Signal via I2C
- → IPMI message
- ← Hot Swap Event
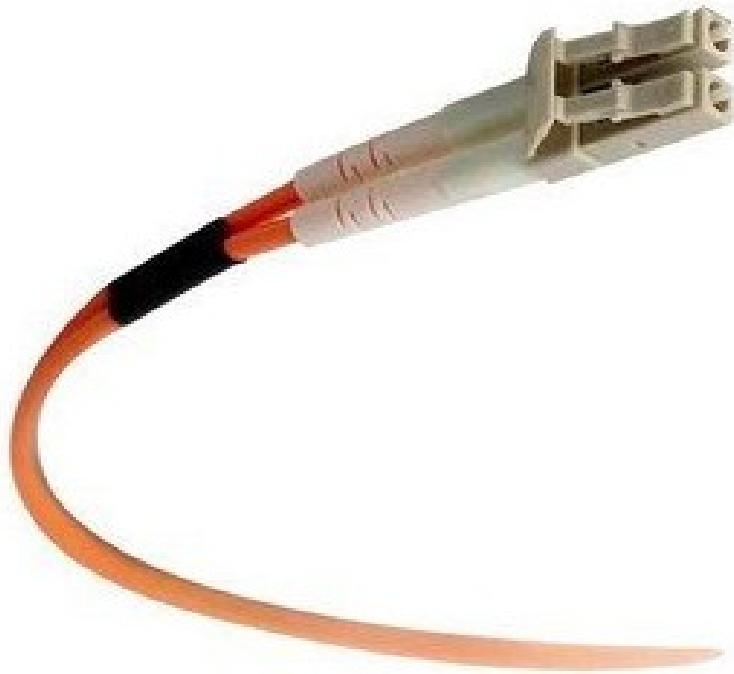
# Electronic-keying – Connection Compatibility Management

- Allow using different standards (1/10 GbE, PCIe, SRapidIO, Inifiniband, Custom links)

- Provide connections compatibility

- Protect hardware

E-keying for MTCA Zone 1 Connector

MTCA Zone 1 connector divided into zones:

- Each module can receive or drive clock signals

- Star connection on ports 0 and 1

- P2P (Peer-to-Peer) connection on ports 2 and 3

- Star connection via switch on ports 4-7

- Star connection or P2P on ports 8-11

- P2P connection on ports 12-15

- Bus connection on ports 17-20
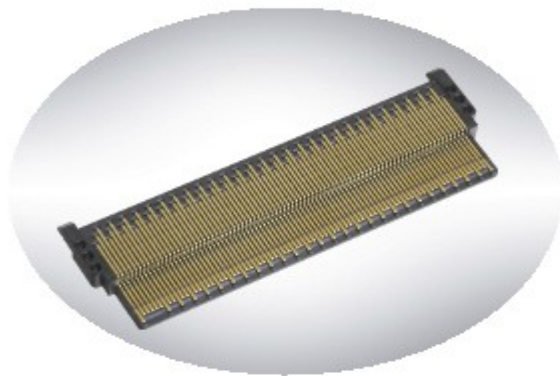
AMC 170 pin connector

Region	Interface	Port
Clocks	CLK1	TCLKA
	CLK2	TCLKB
	PCIe Clock	FCLKA
Common Option	1 GbE	0
		1
	SAS/SATA	2
		3
Fat Pipe	PCIE 10 GbE SRIO	4
		5
		6
		7
Ext. Fat Pipe	PCIE 10 GbE SRIO P2P	8
		9
		10
		11
Extended Options	P2P	12
		13
		14
		15
	CLK	TCLKC/D
	Triggers Interlocks Clocks	17
		18
		19
		20

E-keying in MTCA

- MCH will read FRU records from both modules

- Compare E-keying records of MCH and AMC3/AMC4

- Compare E-keying records of AMC3 and AMC4

- Activate interfaces with compatible protocols

| AMC in slot 3			Decision		AMC in slot 4		
Region	Interface	Port	AMC 3	AMC 4	Region	Interface	Port
Clocks	CLK1	TCLKA	☑	☑	Clocks	CLK1	TCLKA
Clocks	CLK2	TCLKB	☑	☑	Clocks	CLK2	TCLKB
Clocks	PCIe Clock	FCLKA	☑	☑	Clocks	PCIe Clock	FCLKA
Common Option	1 GbE	0	☑	☑	Common Option	1 GbE	0
Common Option	1 GbE	1	☑	☑	Common Option	1 GbE	1
Common Option	SATA	2	☒	☑	Common Option	SAS	2
Common Option	SATA	3	☑	☑	Common Option	SATA	3
Fat Pipe	PCIE 1	4	☑	☑	Fat Pipe	PCIE 1	4
Fat Pipe	PCIE 2	5	☑	☒	Fat Pipe		5
Fat Pipe	PCIE 3	6	☑	☒	Fat Pipe		6
Fat Pipe	PCIE 4	7	☑	☒	Fat Pipe		7
Ext. Fat Pipe	10 GbE	8	☒	☑	Ext. Fat Pipe	SRIO	8
Ext. Fat Pipe	10 GbE	9	☒	☑	Ext. Fat Pipe	SRIO	9
Ext. Fat Pipe	10 GbE	10	☒	☑	Ext. Fat Pipe	SRIO	10
Ext. Fat Pipe	10 GbE	11	☒	☑	Ext. Fat Pipe	SRIO	11
Extended Options	GTX	12	☒	☒	Extended Options	P2P - LVDS	12
Extended Options		13	☒	☒	Extended Options		13
Extended Options	P2P - LVDS	14	☑	☑	Extended Options	P2P - LVDS	14
Extended Options	P2P - LVDS	15	☑	☑	Extended Options	P2P - LVDS	15
Extended Options	CLK	TCLKC/D			Extended Options		
Extended Options	Triggers Interlocks Clocks	17	☑	☑	Extended Options	Triggers Interlocks Clocks	17
Extended Options	Triggers Interlocks Clocks	18	☑	☑	Extended Options	Triggers Interlocks Clocks	18
Extended Options	Triggers Interlocks Clocks	19	☑	☑	Extended Options	Triggers Interlocks Clocks	19
Extended Options	Triggers Interlocks Clocks	20	☑	☑	Extended Options	Triggers Interlocks Clocks	20

Module Management Controller

Tasks of MMC

- Required for each **Advanced Mezzanine Card**

- Communication with the Carrier Manager

- Module management:

  - Module activation and deactivation

  - Warm and cold module reset

  - Power supply management

- Monitoring of module crucial parameters

  - Temperature

  - Supply voltages

  - Currents

  - Clocks, etc.

- E-keying mechanism (PCIe, GbE, sRIO, clocks, etc.)

- Supervision of RTM module (MTCA.4)
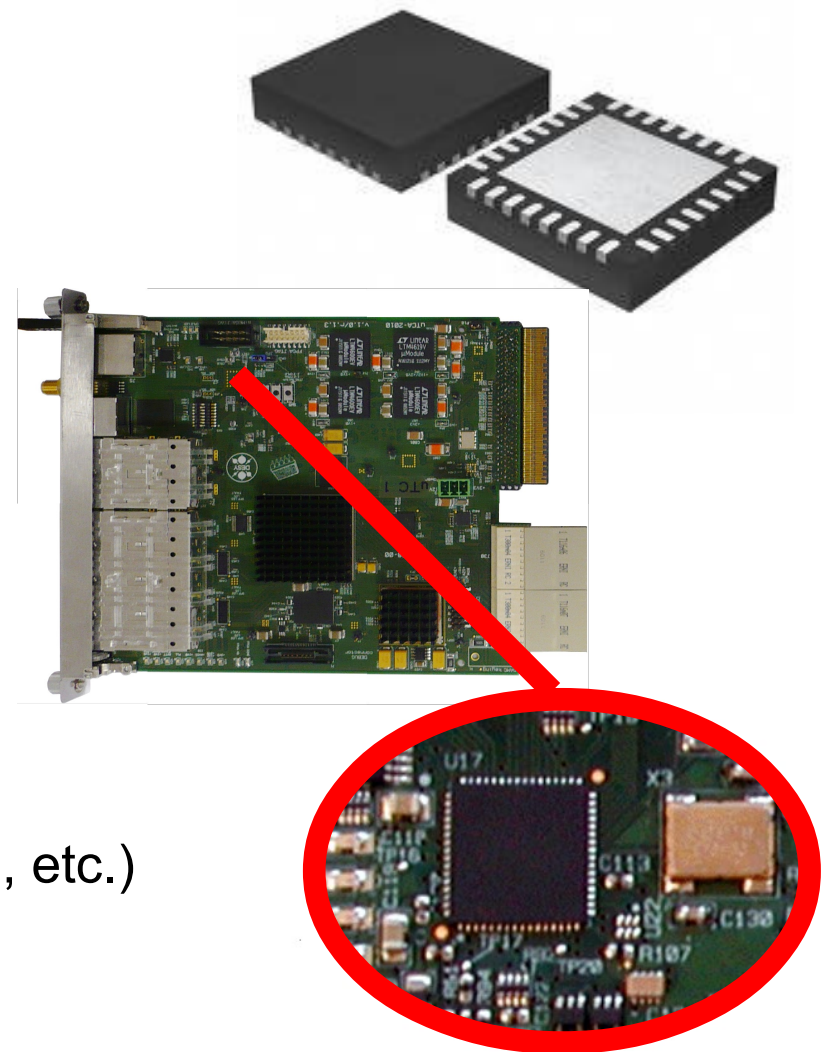
uTCA - based LLRF Controller (1)
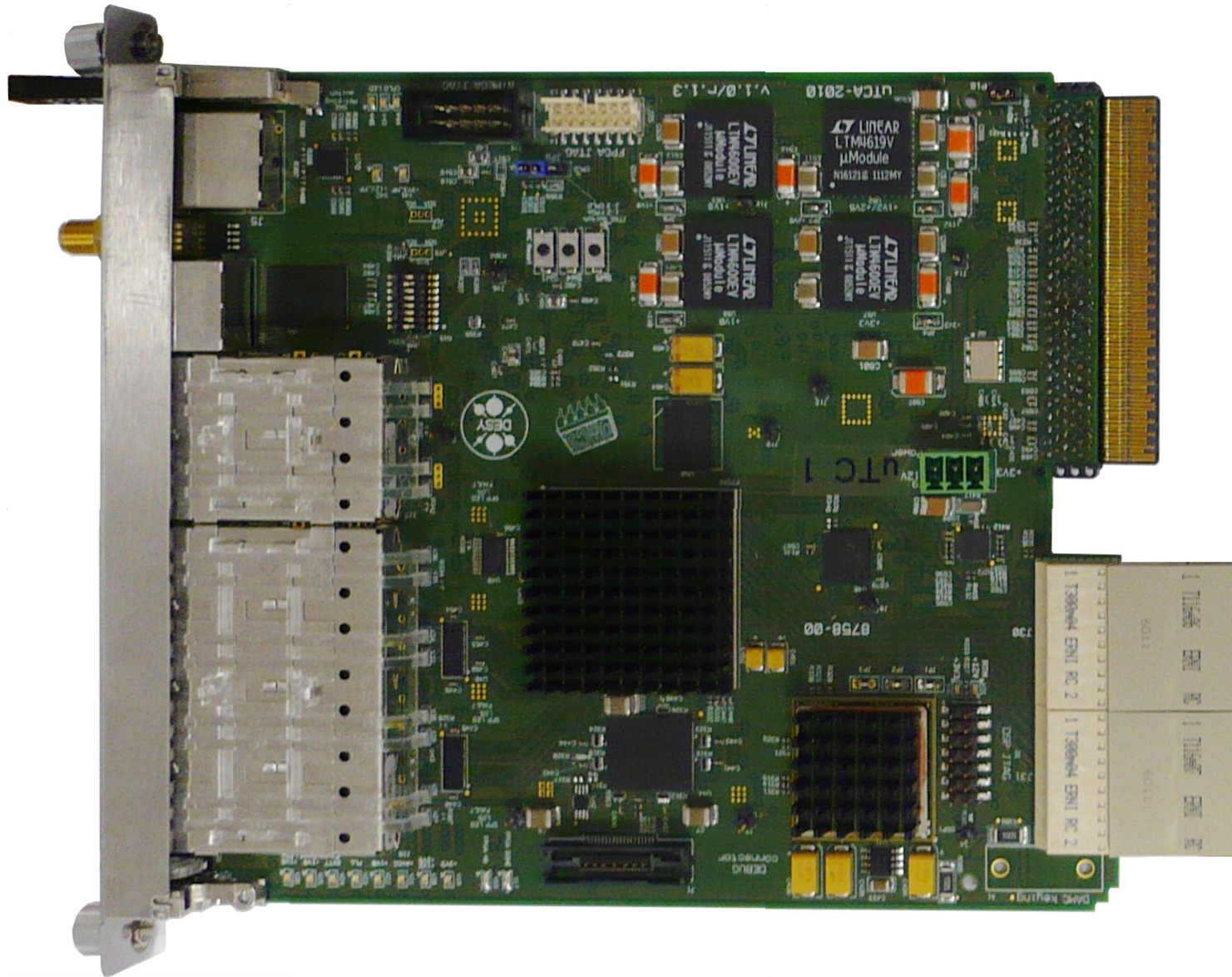
## uTCA - based LLRF Controller (2)

- Two modes of operation:

    - Low Level Radio Frequency controller

    - Fast Beam-Based Feedback Processor

- Enough processing power for execution of the cavity field stabilizing algorithms (PID, feed-forward) in the feedback loop

- Dedicated low-latency P2P connections

- PCIe and Gigabit Ethernet

- Firmware upgrade feature

- Memory (QDR II/DDR2)

- Compliance with MTCA.4 standard

uTCA - based LLRF Controller (3)
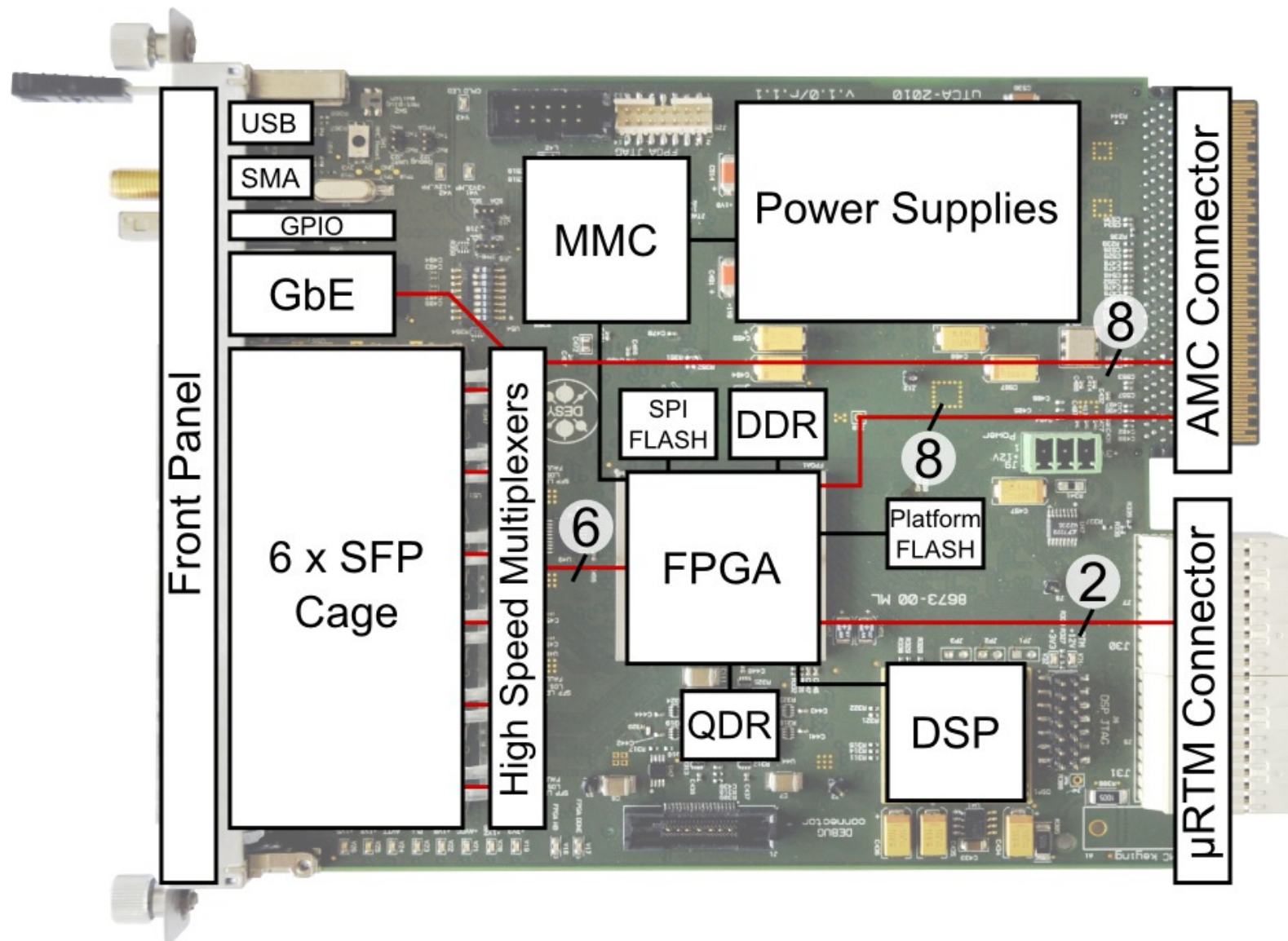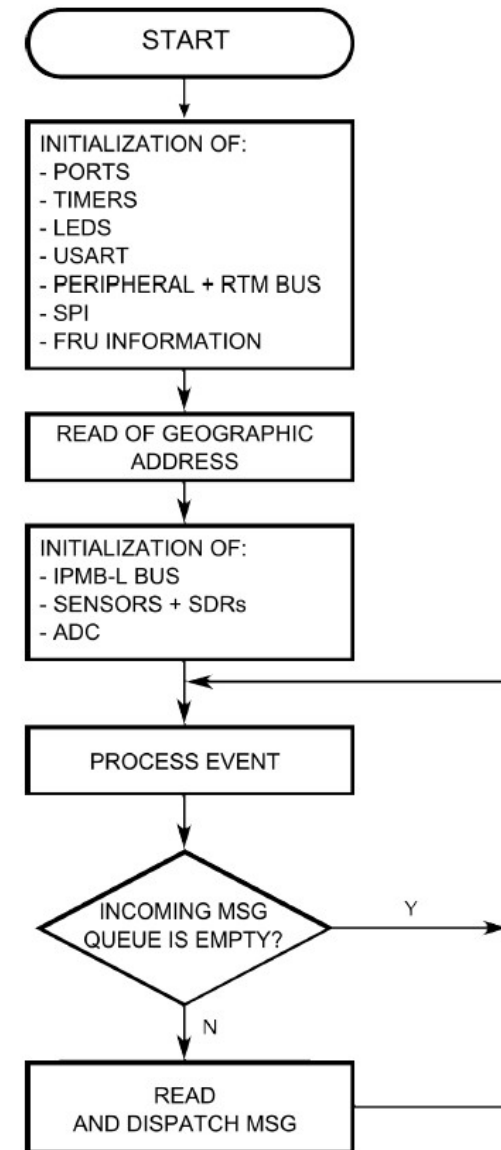
Hardware – Block Diagram of MMC
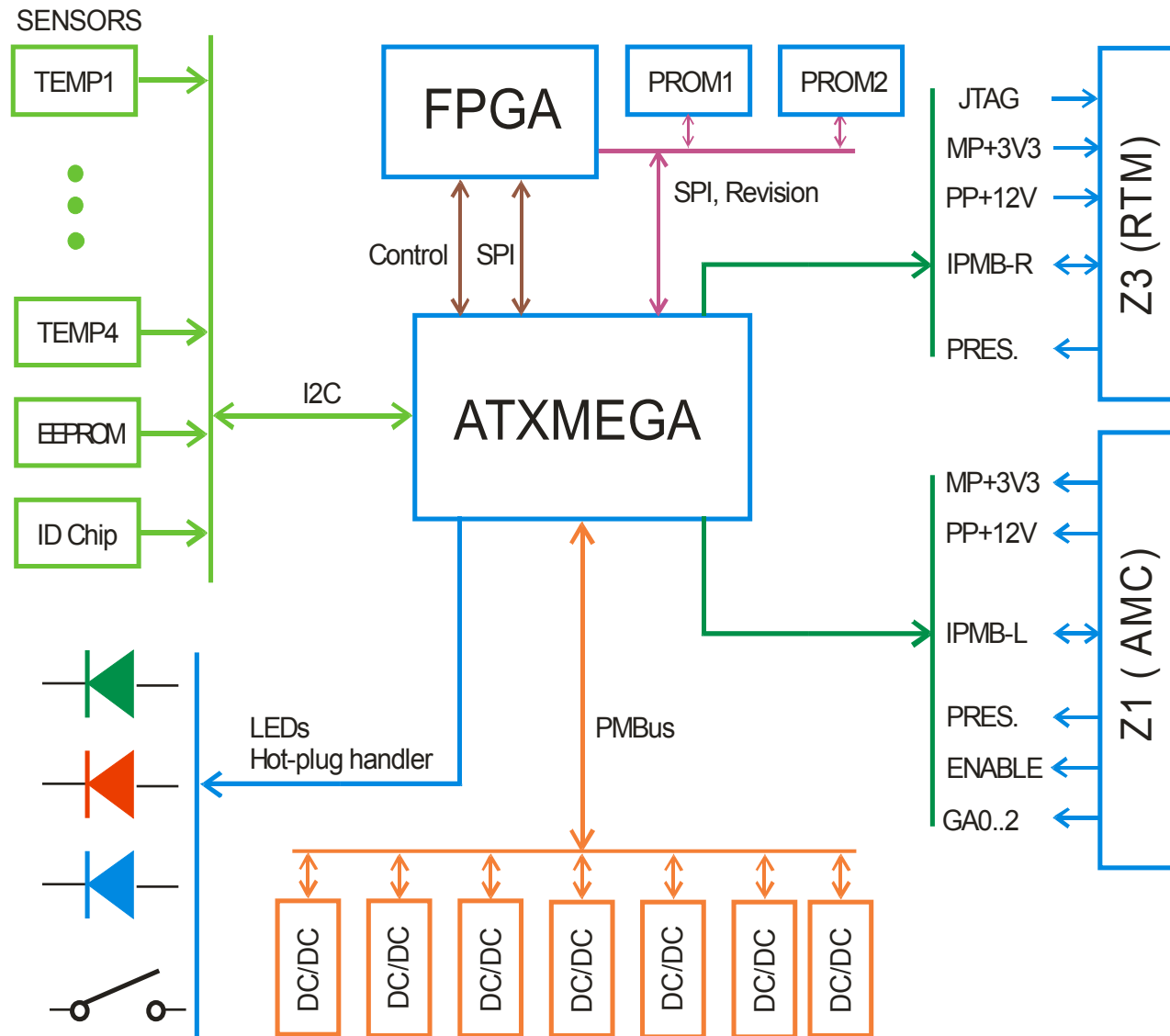
Software – MMC Implementation (1)

- Initialization
  - Initialization of software structures
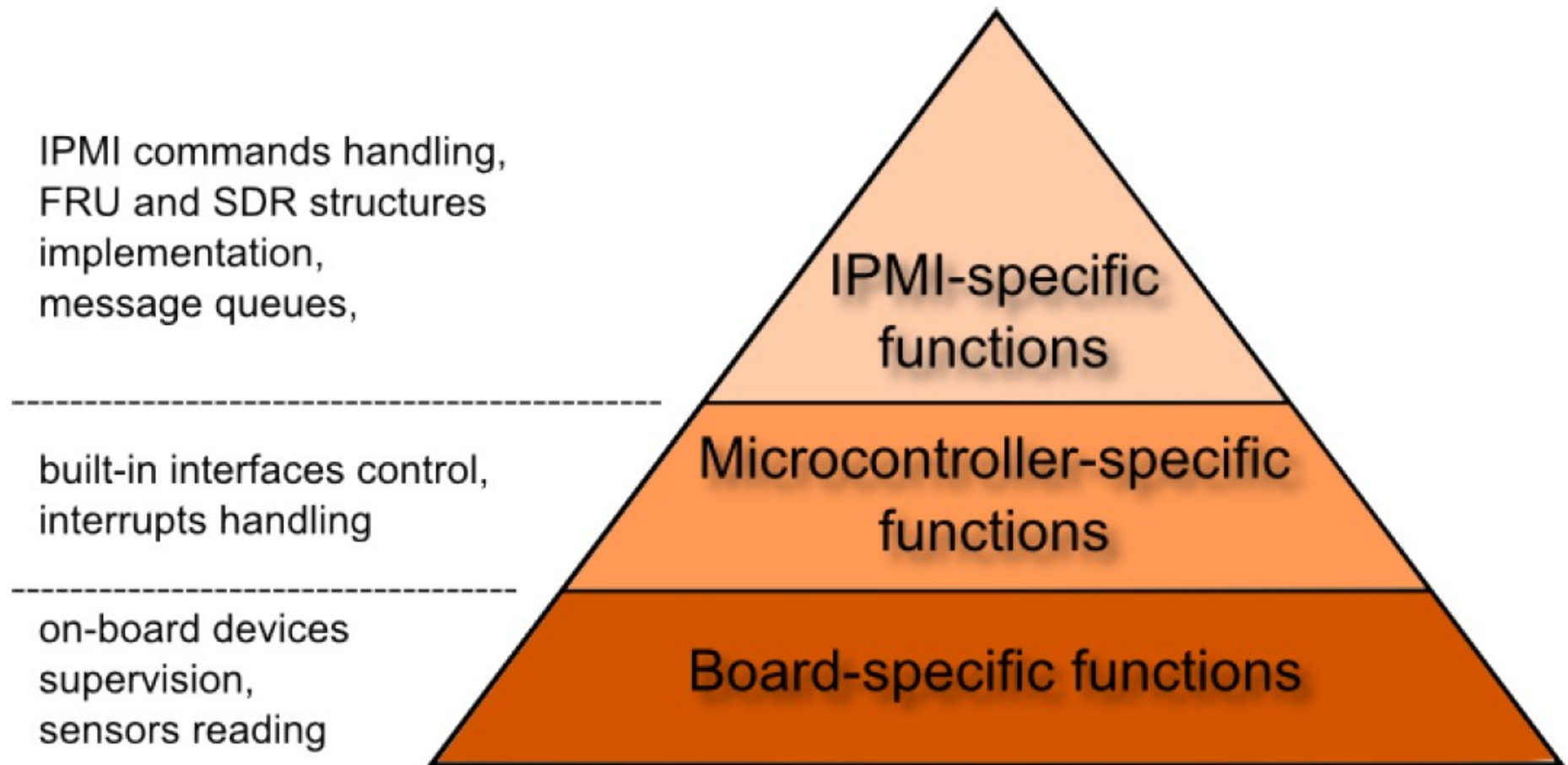 - Configuration of peripheral devices
- Main loop
  - Event processing
  - Messages handling

```
        ┌───────────────────┐
        │       START        │
        └───────────────────┘
                 │
                 ▼
    ┌───────────────────────────┐
    │ INITIALIZATION OF:         │
    │ - PORTS                    │
    │ - TIMERS                   │
    │ - LEDS                     │
    │ - USART                    │
    │ - PERIPHERAL + RTM BUS     │
    │ - SPI                      │
    │ - FRU INFORMATION          │
    └───────────────────────────┘
                 │
                 ▼
    ┌───────────────────────────┐
    │ READ OF GEOGRAPHIC         │
    │ ADDRESS                    │
    └───────────────────────────┘
                 │
                 ▼
    ┌───────────────────────────┐
    │ INITIALIZATION OF:         │
    │ - IPMB-L BUS               │
    │ - SENSORS + SDRs           │
    │ - ADC                      │
    └───────────────────────────┘
                 │
                 ▼
    ┌───────────────────────────┐
    │      PROCESS EVENT         │
    └───────────────────────────┘
                 │
                 ▼
            ◇ INCOMING MSG
              QUEUE IS EMPTY?  ──Y──┐
                 │N                 │
                 ▼                  │
    ┌───────────────────────────┐  │
    │         READ               │  │
    │   AND DISPATCH MSG         │──┘
    └───────────────────────────┘
```

Software – MMC Implementation (1)

- Works aimed to code portability - in progress
- Software layers

IPMI commands handling,
FRU and SDR structures
implementation,
message queues,

---

built-in interfaces control,
interrupts handling

---

on-board devices
supervision,
sensors reading

IPMI-specific functions

Microcontroller-specific functions

Board-specific functions

MMC – Summary

- Presented MMC meets basic requirements of MicroTCA and xTCA for Physics specification

- The MMC firmware was tested in the laboratory and various facilities at DESY

- Future plan is to prepare universal, portable firmware

xTCA for Physics Extension

MTCA.4 RTM Extension
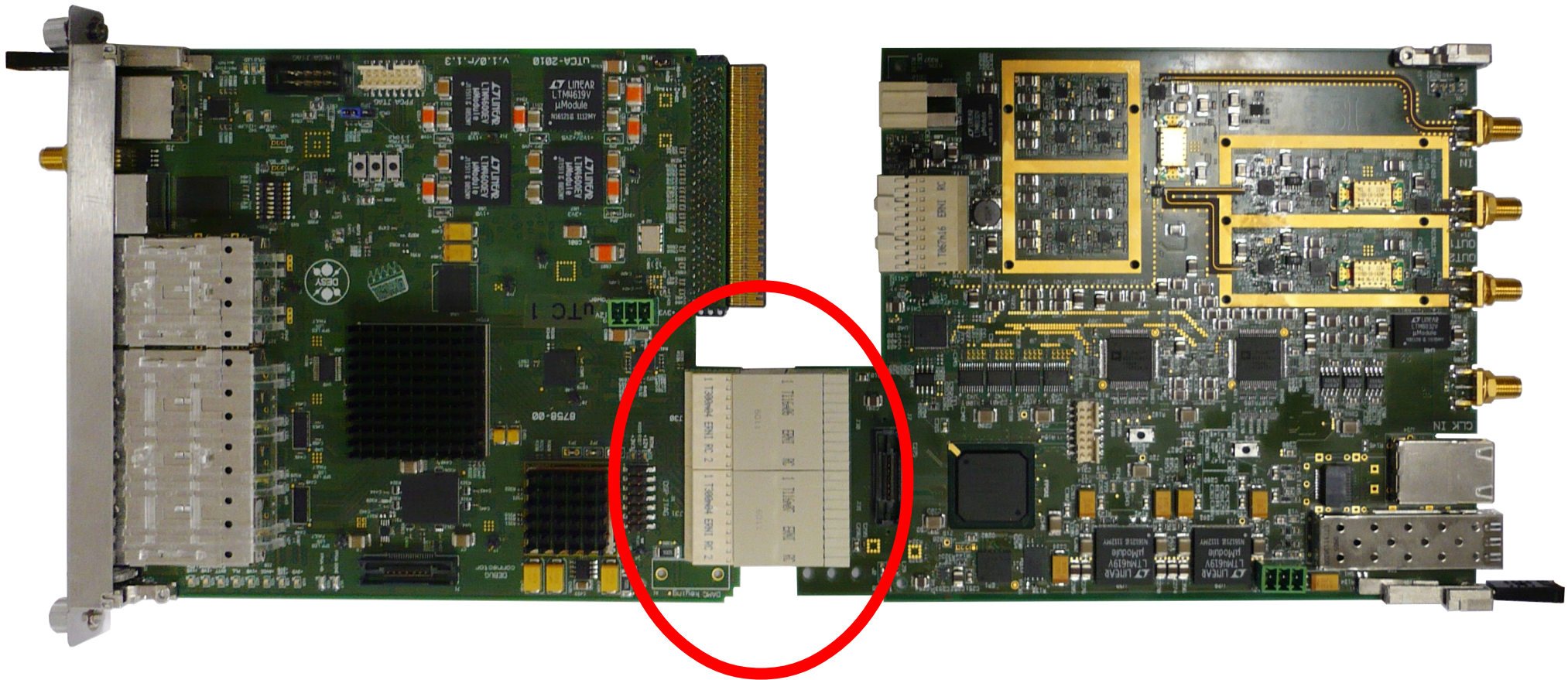
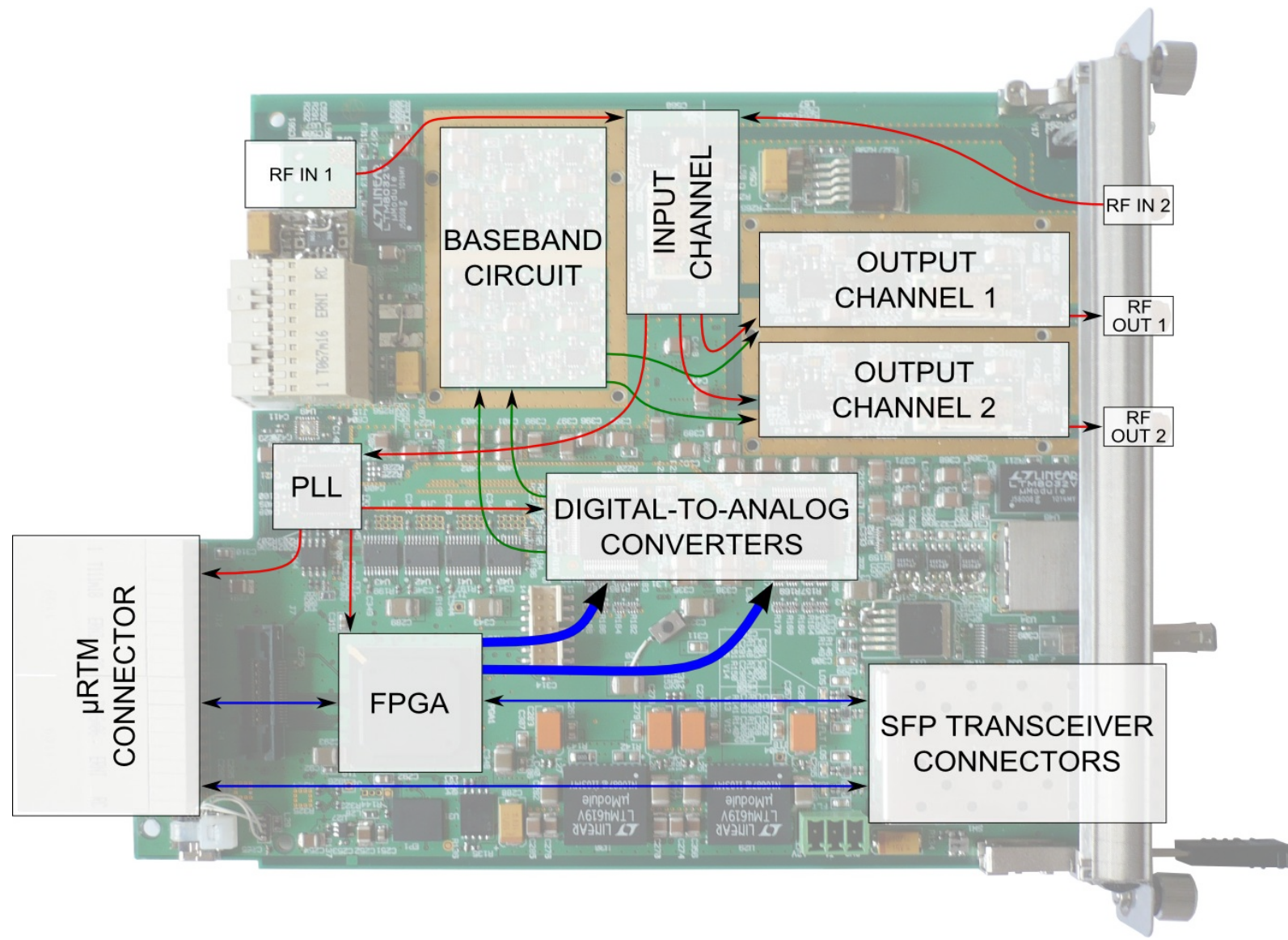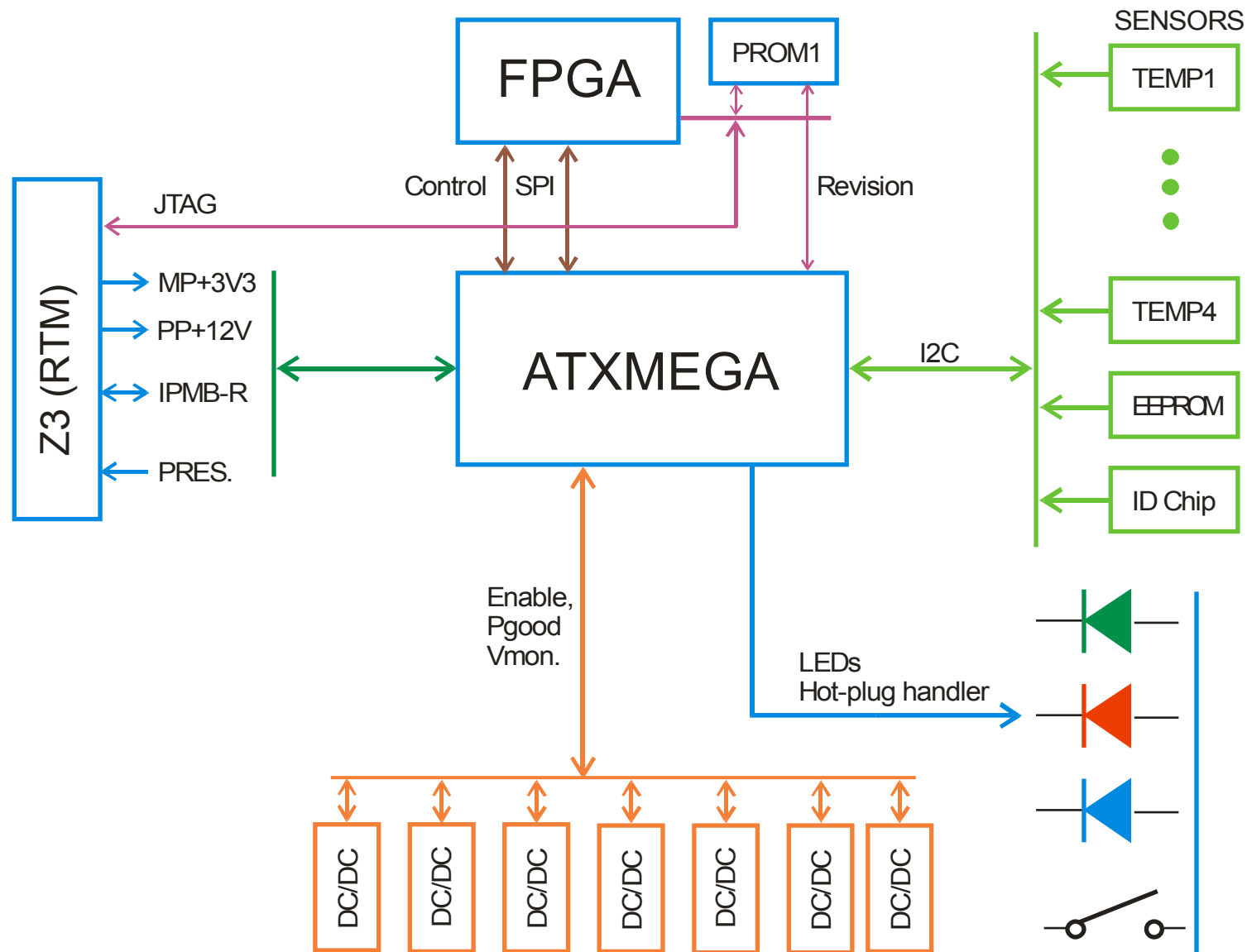**AMC Module**   Zone 3 Connector   **RTM Module**

IPMI and RTM – MTCA.4 spec.
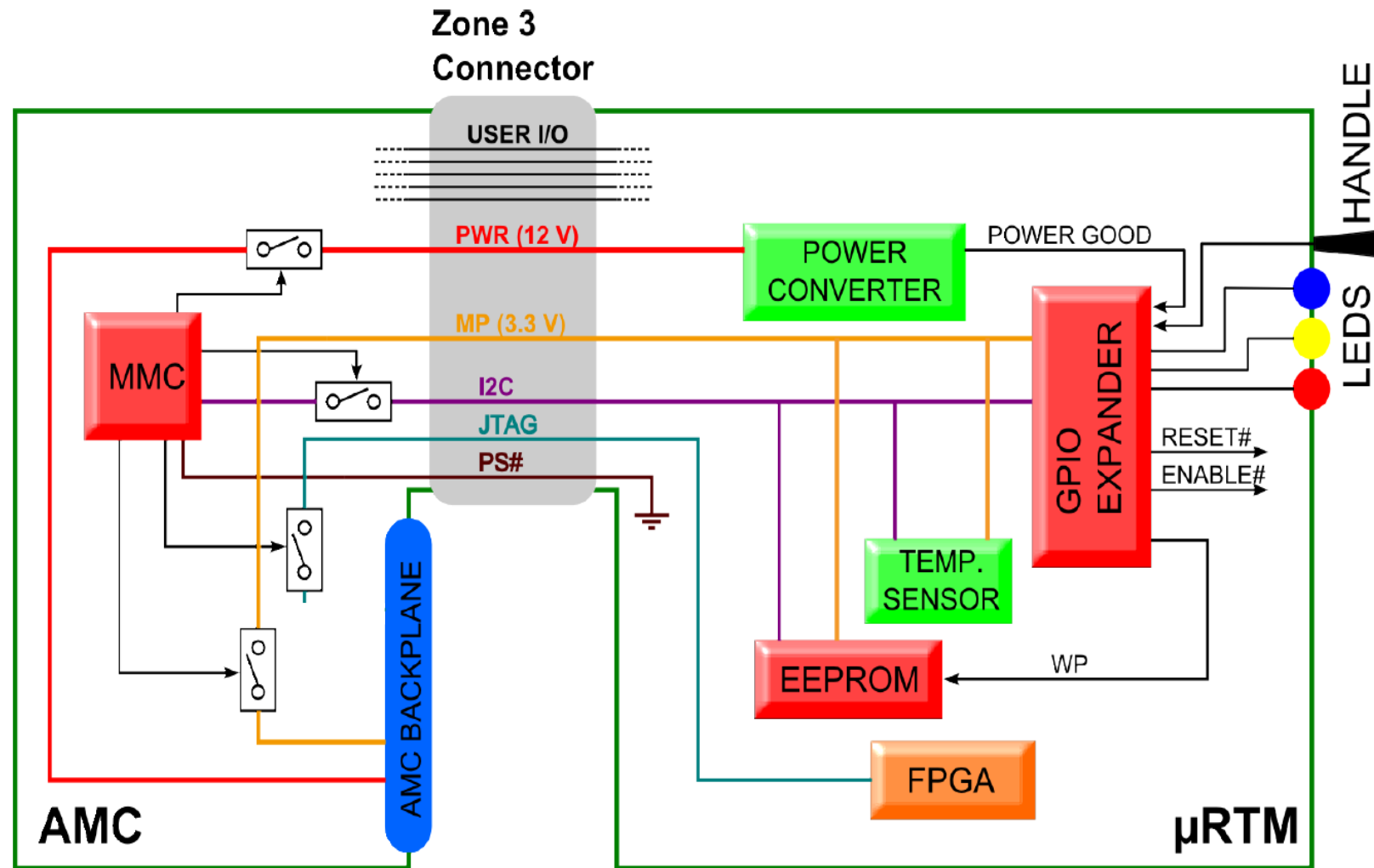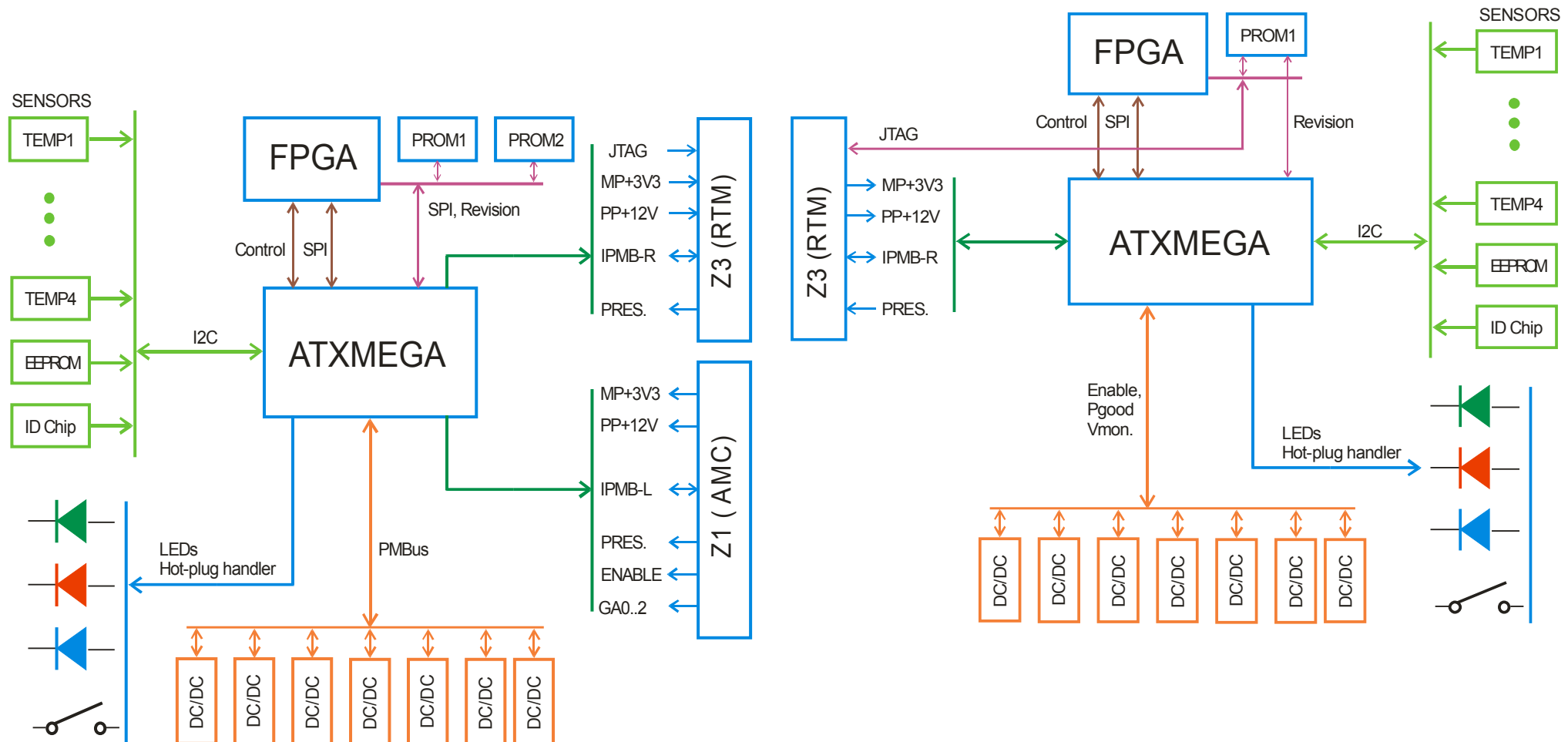
Vector Modulator as RTM (1)
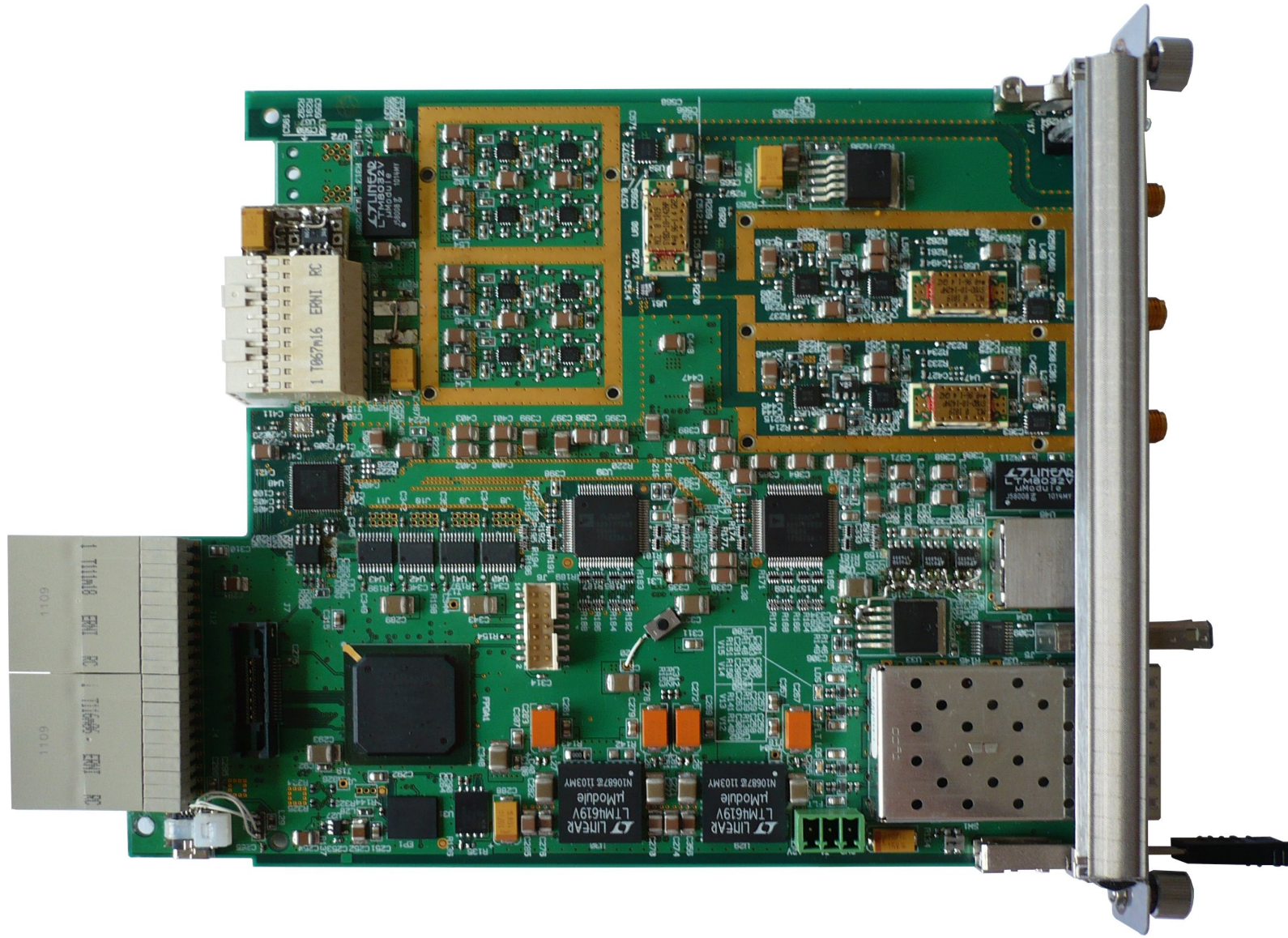
# Vector Modulator as RTM (2)

IPMI on Vector Modulator

AMC and RTM Management

Zone 3 E-Keying

- DESY Zone 3 recommendation for digital and analogue classes

- Various, bidirectional analogue and digital signals

- MTCA.4 keying only verifies voltage levels

- Require E-Keying with MMC and RTM controller support to avoid signal collisions

N	Data Signal in Volts
1	LVDS
2	$0 - \pm1$
3	$>\pm1 - \pm3.3$
4	$>\pm3.3 - \pm10$
5	$>\pm10$
6	Reserved
7	Reserved
8	Reserved

IPMI signals

CLK, unidirectional

Bidirectional IOs

Bidirectional IOs

Gigalinks
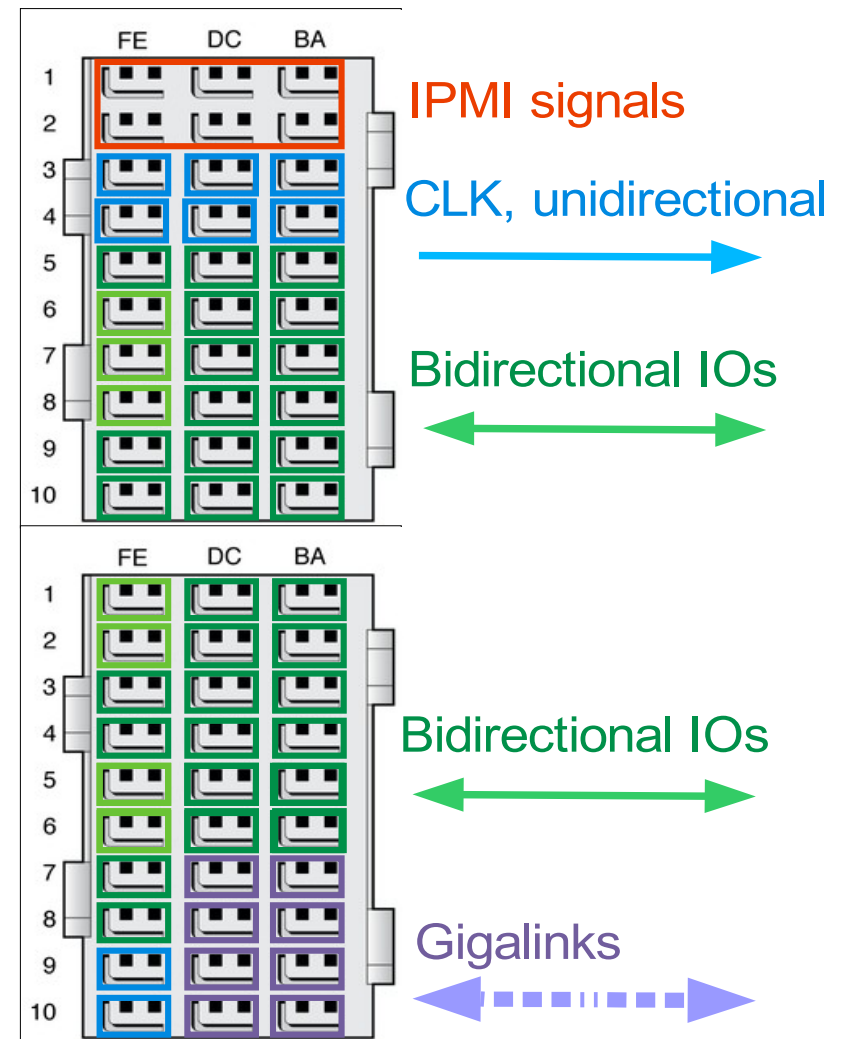
F. Ludwig, '...Zone 3 classes...'

Thank you for your attention

Questions ?
Comments ?