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PUBLICATION

Intelligent Platform Management Controller for Low Level RF Control System ATCA Carrier Board

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Intelligent Platform Management Controller for Low Level RF Control System ATCA Carrier Board

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Outline

- 1 Motivation
 - ATCA standard
 - ATCA standard and Shelf Management
 - LLRF Control System of XFEL
- 2 IPMC Hardware
 - Microprocessor Selection
 - Power Distribution and System Architecture
- 3 IPMC Software
 - Code Organization
 - Real-Time Pseudokernel
 - IPMC Structure
- 4 Tests and Evaluation
 - Tests at FLASH



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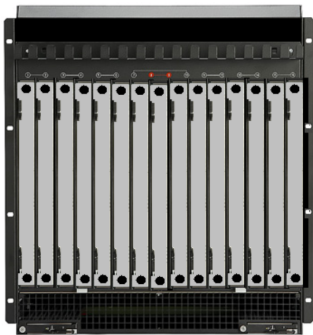
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ATCA standard and HEP

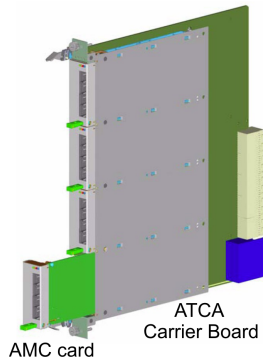
- ATCA standard boast with high:
 - Reliability,
 - Availability,
 - Serviceability.
- Modular design is also a desirable feature.
- All this caused that ATCA standard is more and more popular in High Energy Physics.



ATCA and AMC standards



(a) ATCA shelf



(b) ATCA Carrier Board with
AMC modules



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Intelligent Platform Management in ATCA shelf

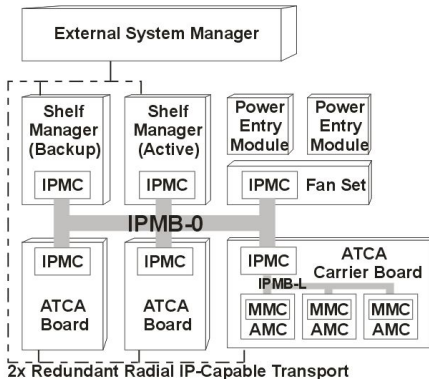


Figure: Shelf Manager, IPMC and MMC



The Role of IPMC

- Control of hot-swap activation and deactivation,
- Management of on-board sensors,
- Early detection of faults - event generation,
- Electronic Keying management,
- Supervision of Advanced Mezzanine Cards.



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LLRF Control System of XFEL

LLRF System of XFEL accelerator is composed:

- ATCA carrier board with three AMC bays
- Vector Modulator module
- Timing module
- Data Acquisition Modules



LLRF Control System of XFEL

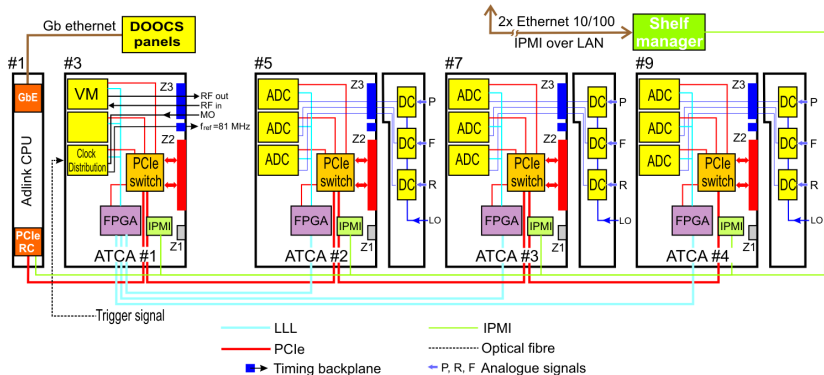


Figure: Block diagram of ATCA-based LLRF control system

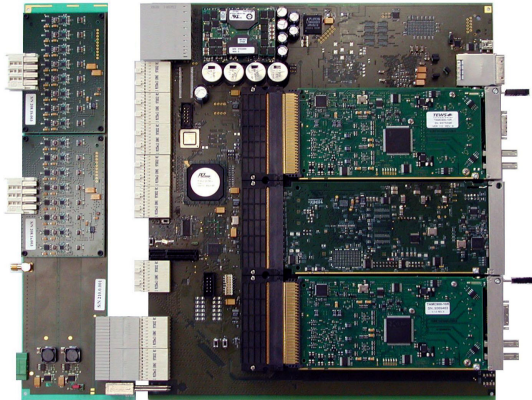


Carrier Board for LLRF

- Fully ATCA-compliant,
- Able to house up to three AMC modules,
- PCI Express and Gigabit Ethernet interfaces over backplane,
- Equipped with various sensors - temperature, voltage, current,
- Requires IPMC for management.



ATCA Carrier Board for LLRF System



IPMC Requirements for LLRF Carrier Board

- Compliance with base IPMI commands required by ATCA,
- Compliance with PICMG 3.0 extension commands,
- Carrier Board management:
 - Hot-swap functionality,
 - Electronic Keying for PCIe and GbE,
 - Blue LED control,
 - Hardware Address recognition.
- Firmware upgradeability.



IPMC Requirements for LLRF Carrier Board (cont.)

- Supervision of three AMC modules:
 - Hot-swap activation and deactivation,
 - Message bridging with the Shelf Manager,
 - Electronic Keying functionality,
 - Power supply control.
- External sensor monitoring,
- Debugging and diagnostic functionality,
- Economical, easy to implement, low-area solution.



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- IPMC implemented using Atmel AVR ATmega 1281,
- Excellent compromise between price and efficiency,
- Very good utilization of resources:
 - Around 70 % of program memory,
 - Under 90 % of SRAM memory.
- Free programming tools:
 - Atmel AVR Studio,
 - Including debugger.
- Drawback - only one built-in Two-Wire Interface (TWI) controller,



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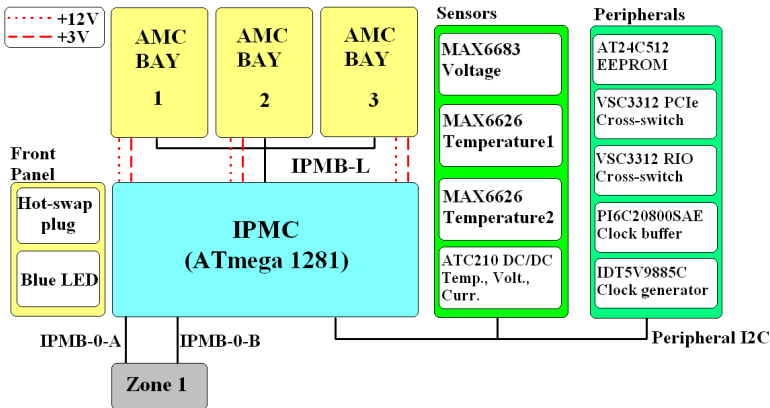


Figure: IPMC and peripheral devices



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Software Sections

Partitioning of software follows requirements for IPMC:

- IPMI library section for both base IPMI and PICMG 3.0 messaging,
- Communication section for MMC \leftrightarrow IPMC and IPMC \leftrightarrow ShMC messaging,
- AMC management section - activation, deactivation, EK,
- Sensor management section - initializing, monitoring, event detection,
- Firmware upgrade section as specified by HPM.1,
- Debugging section generating human-readable messages over a serial interface.



Hardware dependency

- Low-level drivers are hardware-dependent:
- High level functions available,
- Separated from underlying drivers,
- Doxygen-generated API provided,
- Example functions:
 - I2C_Read - reads IPMI messages from a ring buffer filled by drivers,
 - ipmi_get_device_id - prepares a response to the 'Get Device ID' command,
 - prepare_Set_Event_Receiver - prepares a 'Set Event Receiver' request to an AMC module.
- A different hardware architecture needs only to substitute the drivers for microprocessor peripherals and external devices.



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The Problem

- HEP control systems require low response times to various events,
- IPMI messages:
 - Slow IPMI message handling → Many sender retries → Bus stuffing,
- External interrupts:
 - Slow ISR → Missing other events,
- Hot-swap interaction:
 - Slow response to activation / deactivation requests → User confusion, system unavailability



The Solution

- Operating system too robust for this application,
- Event-driven cyclic executives solution in conjunction with external device interrupts,
- Minimized ISR times - if possible, only feed the main event handling loop,
- Event handling loop stops only for short ISRs.

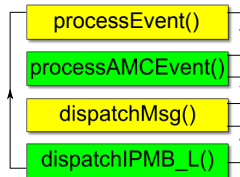


Figure: Main IPMC loop



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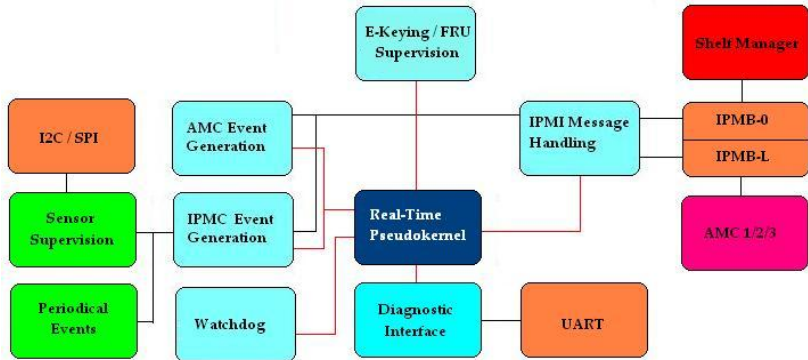


Figure: IPMC Overview



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Tests at FLASH

- Three test sessions - January, March and September 2009,
- IPMC functionality of the LLRF CB was tested,
- AMC modules and a Rear Transition Module (RTM) were installed,
- IPMC tasks:
 - Activate the LLRF Carrier Board,
 - Activate three AMC modules,
 - Establish PCIe links using Electronic Keying,
 - Deactivate the devices after the tests,
- All tasks were completed successfully.



Summary

- It is possible to produce a proprietary IPMC following the available documentation.
- Proposed IPMC is well-suited for HEP applications.
- Tests in FLASH accelerator prove its compatibility with the LLRF Control System.
- Proposed IPMC is able to manage commercially-available AMC modules.
- Separation of application logic from low-level drivers allow customization for other hardware architectures.



The End

Thank you for your attention

