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PUBLICATION

AMC Radiation Monitoring Module for ATCA/TCA Based Low Level RF Control System - 17th International Conference Mixed Design of Integrated Circuits and Systems

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AMC Radiation Monitoring Module for ATCA/µTCA Based Low Level RF Control System

17th International Conference Mixed Design of Integrated Circuits and Systems
MIXDES 2010
Wroclaw, Poland, 24-26 June 2010

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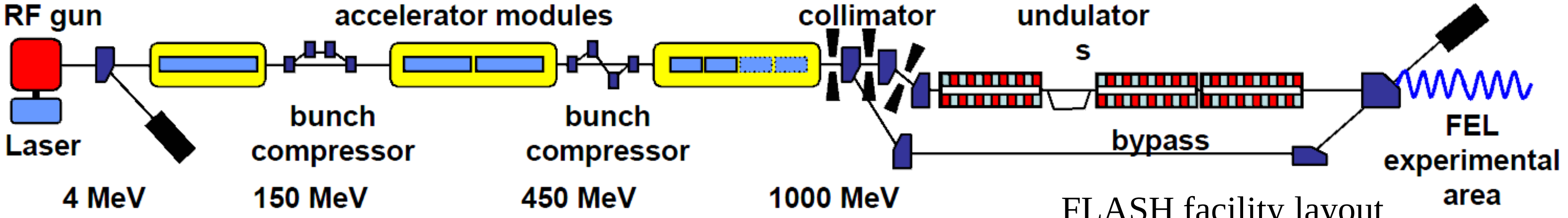
Stypendysta projektu „Innowacyjna dydaktyka bez ograniczeń - zintegrowany rozwój Politechniki Łódzkiej - zarządzanie uczelnią, nowoczesna oferta edukacyjna i wzmacnianie zdolności do zatrudniania, także osób niepełnosprawnych”

Outline

1. Radiation issues in aspect of linear accelerator control systems.
2. Two approaches to the architecture of Radiation Monitoring System.
3. Dosimetry methods.
4. Module hardware overview.
5. VHDL firmware for the Module
6. Conclusions and future plans.

Radiation issues in aspect of linear accelerator control systems



FLASH facility layout

Gamma and neutron radiation are produced as parasitic effect of normal operation of a linear accelerator and have negative influence on electronic equipment installed inside the tunnel.

Gamma radiation: general degradation of electronics electrical parameters

Neutron fluence :

- Single Event Upsets (SEU)
- Single Event Functional Interrupt (SEFI)
- Single Event Transient (SET)
- Single Event Latch-up (SEL)

Expected radiation environment characteristic values	
Detection ability	Gamma radiation and neutron fluence
Fluence range	10^6 - 10^{10} neutron·cm^{-2}
The lowest fluence	10^4 - 10^5 neutron·cm^{-2}
Dose range	10^2 – 10^3 Gy
The lowest dose	10^{-3} – 10^{-2} Gy
Energy range	up to 20 MeV

Radiation issues in aspect of linear accelerator control systems

Knowledge of accelerator's radiation environment and doses absorbed by electronics helps to:

- estimate electronic lifetime
- schedule replacement of electronic devices
- detect of errors in control systems caused by radiation high level

It may increase reliability of accelerator control systems and decrease costs of machine maintenance.

(LLRF System based on xTCA)

Two aproaches to the architecture of Radiation Monitoring System

Radiation Monitoring System

System integrated with xTCA architecture

Main advantages:
•Full integration with LLRF system
•No issues connected with communication interfaces and powering
•Easy dose gauge exactly inside ATCA crates
•No extra wiring

Main disadvantages:
•Crates' shielding may decrease sensitivity of dosimeters

System with independent architecture

Main advantages:
•Flexible and full reconfigurable system
•Possibility to gauge doses near xTCA crates and other desired places

Main disadvantages:
•Issues concerning communication interfaces
•Problems with powering
•Extra wiring

Dosimetry methods

Dosimeters for AMC Radiation Monitoring Module should fulfill following requirements:

- **High selectivity** – selective measurement of neutron and gamma radiation
- **Dynamic and wide dose ranges** – $10^{-3}:10^{3}$ Gy for gamma and $10^{4}:10^{10}$ neutron·cm^{-2}
- **Easy integration with digital readout subsystem**
- **Small size and low costs of dosimeters**

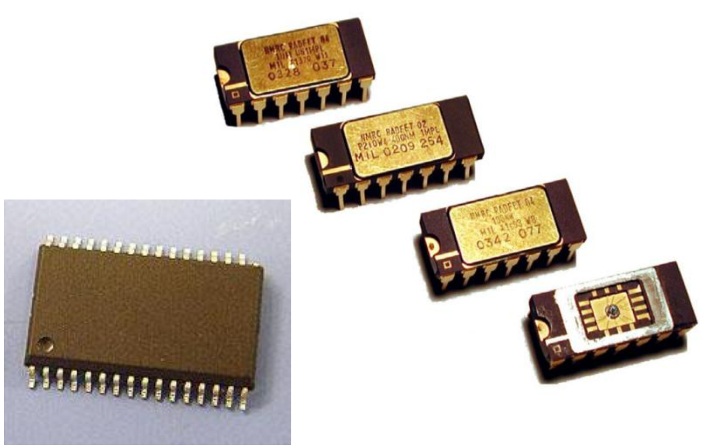
The dosimeters chosen for the module:

Gamma radiation:

400 nm (Implanted) or 100nm Tyndall RadFET (Radiation sensitive Field Effect Transistor)

Neutron fluence:

Samsung K6T4008C1B SRAM memory with decreased supply voltage



Samsung SRAM chip and Tyndall RadFETs

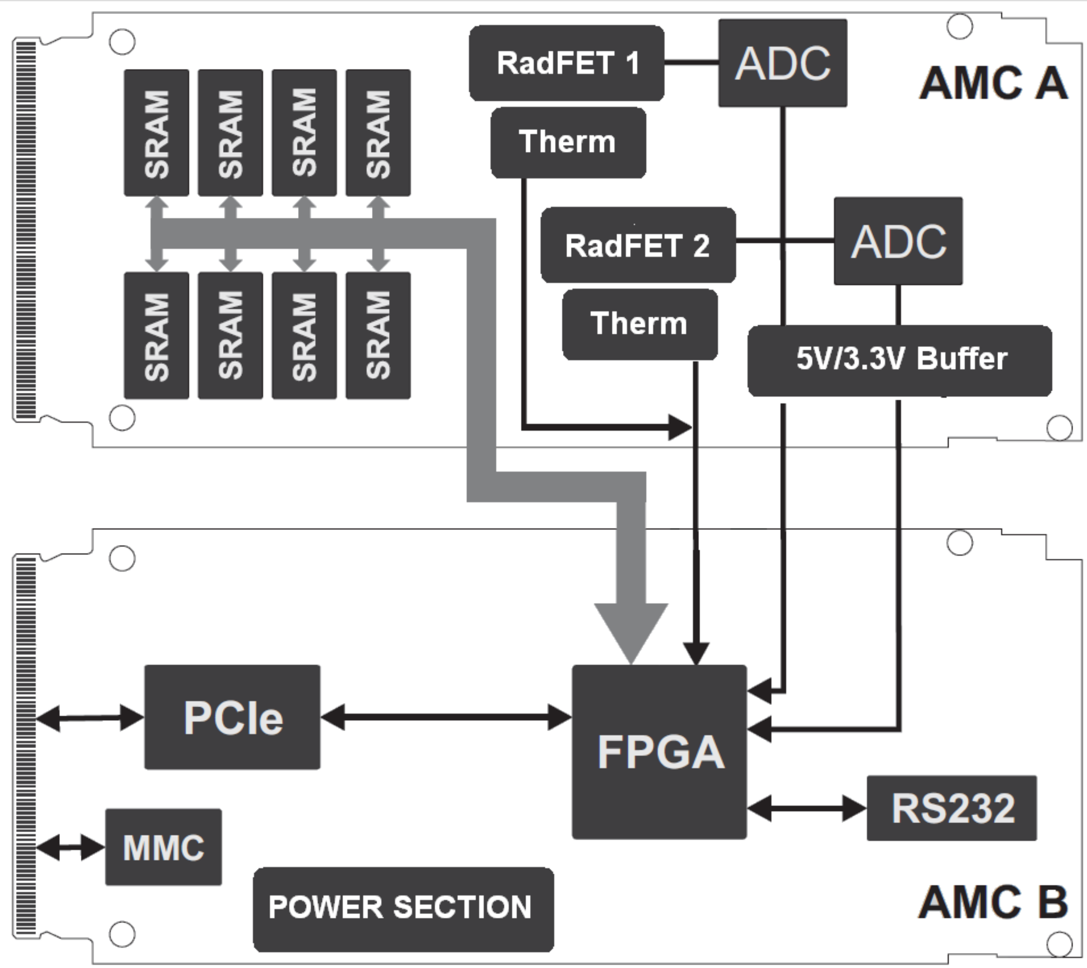
Module hardware overview

<u>Module is built as a AMC board.</u>

It is divided into two submodules – AMC A and AMC B linked via 120 pins connector.

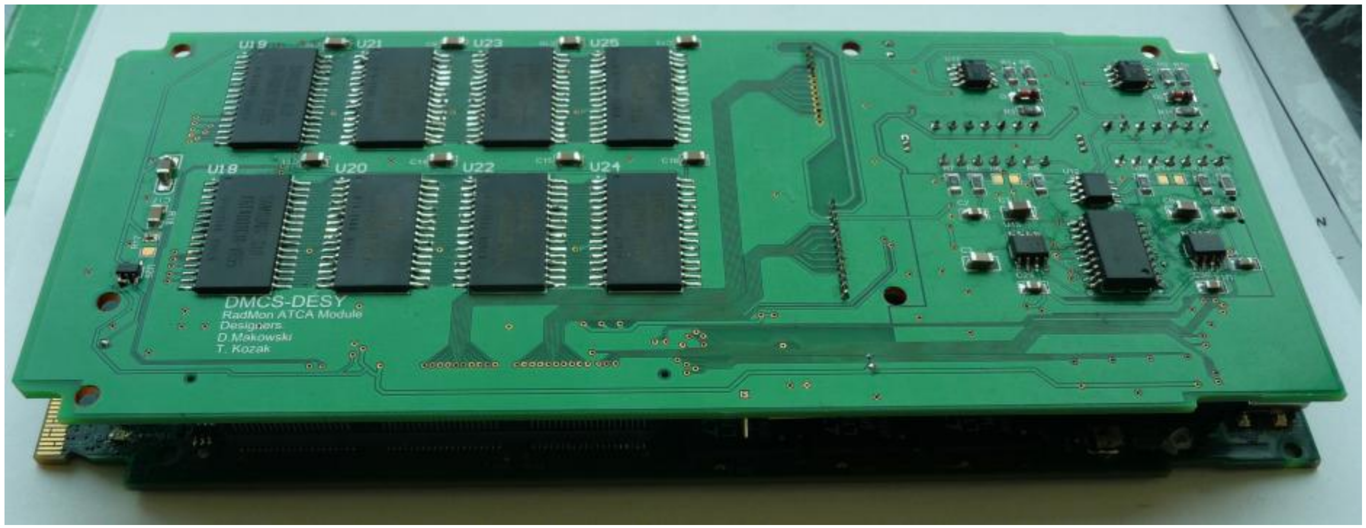
- The AMC B carry out the main data processing unit (Virtex 5 PFGA), MMC, power units and communication links.

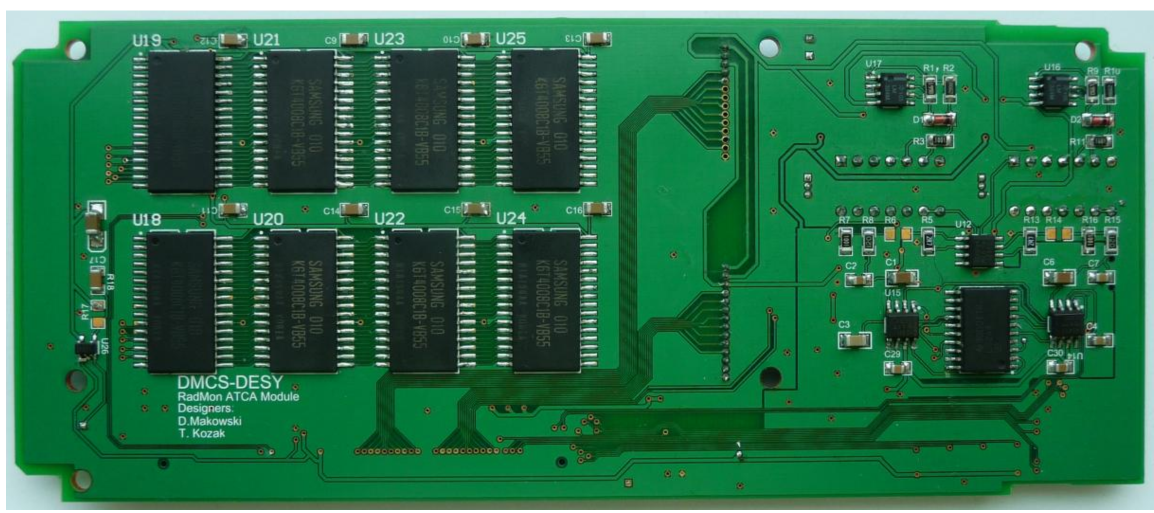
- The AMC contains eights Samsung SRAM chips and two RadFETs readout circuits with two digital thermometers.



Block diagram of AMC Radiation Monitoring Module

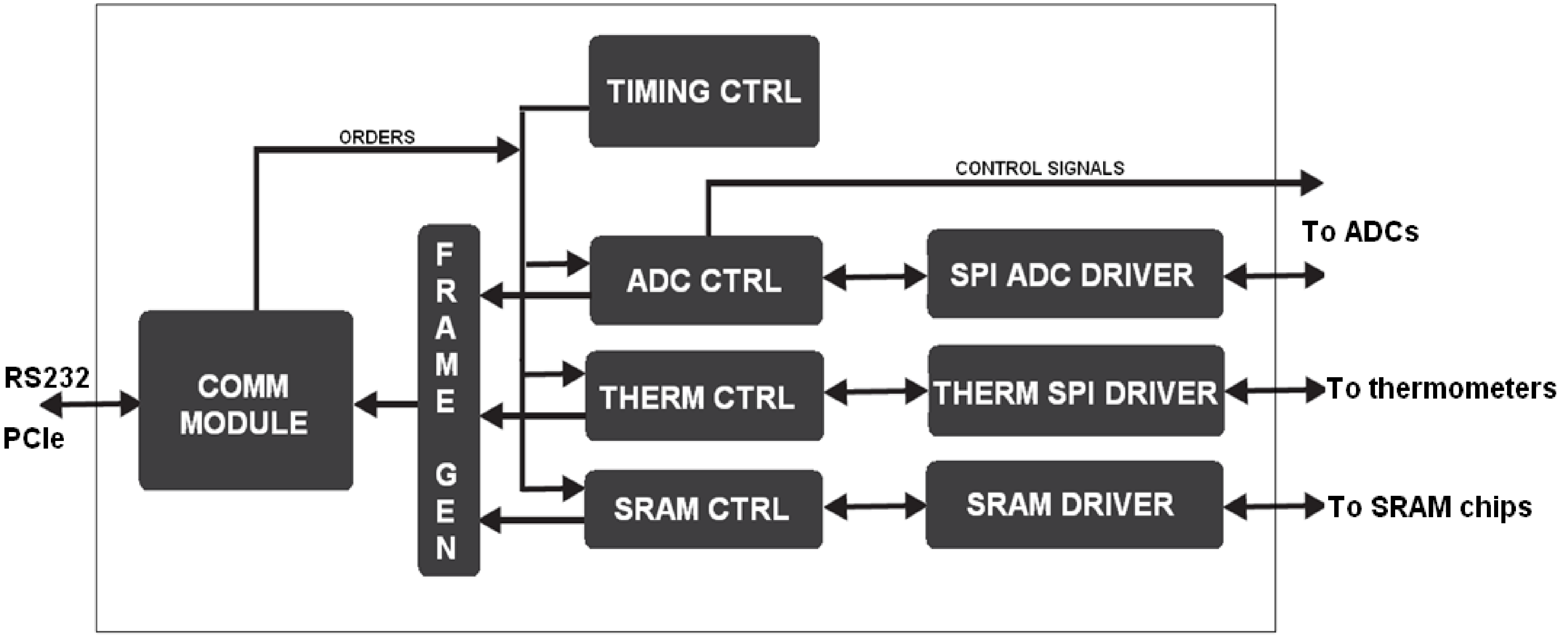
Components of the System - Active radiation detector





Pictures of assembled AMC Radiation Monitoring Module

VHDL firmware for the Module



Block diagram of VHDL module designed for AMC Radiation Monitoring Module

Conclusions and future plans

Conclusions:

1. Integration with LLRF control system solves communication interfaces, powering and extra wiring issues .
2. Module is suitable to be installed in LLRF system based on ATCA or µTCA architecture.
3. Modular construction of VHDL code increases flexibility of solution – new communication interfaces can be easily added e.g. GbEthernet
4. Cheap, easily accessible, small dosimeters which should fulfill requirements of the project

Future plans:

1. Test of the solution in target environment of the linear accelerator
2. Design of the second revision which correct errors present in current version and will be suitable for AMC B with Ethernet links.

Thank you for your attention

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Report of RFTech presentation during Mixdes conference

(June 26-27, Wroclaw, Poland)

Title of presentation:

AMC Radiation Monitoring Module for ATCA/µTCA Based Low Level RF Control System

Presenter:

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Tomasz Kozak presented a radiation monitoring module dedicated for xTCA-based LLRF control system of linear accelerator. Since, the hardware of the LLRF system is installed in the accelerator tunnel, monitoring of gamma and neutron radiation is recommended. The radiation monitoring module allows to measure radiation in the ATCA or uTCA shelf in the nearest proximity of the LLRF hardware. In critical situation alarm signal can be triggered.

Abstract: Modern Advanced/Micro Telecommunications Computing Architecture (ATCA/μTCA) standards gain popularity, not only in telecommunication industry, but also in High Energy Physics (HEP) area. These platforms are considered as the future platform for Low Level RF (LLRF) control system of the X-ray Free Electron Laser (XFEL) project realized at DESY facility. One of the most important features of an ATCA/μTCA based control system is its high reliability, which can be decreased by negative influence of neutron and gamma radiation produced during normal operation of linear accelerators. The XFEL laser will be built in a single tunnel to decrease costs of the project. Therefore, the LLRF system will be exposed to harmful radiation. It is recommended to monitor doses absorbed by electronic equipment. The gathered data could help to estimate lifetime of electronic devices and to schedule essential equipment replacement. The radiation detector should be integrated with ATCA/μTCA system to allow measurements in close proximity of electronic, which helps to increase the accuracy of measurements. The paper describes a radiation monitoring module capable of monitoring gamma radiation and neutron fluence in real-time which fulfils the mentioned requirements and is designed in accordance with the AMC specification.

Index Term: Advanced Telecommunications Computing Architecture, RF Control System, gamma radiation dosimetry, neutron radiation dosimetry, linear accelerator, X-ray Free Electron Laser

Remarks:

The attendance at the MIXDES2010 conference allows me to met people familiar with xTCA systems issues. It helped me to look at xTCA systems from wider point of view. I received also some valuable remarks about possible future development of the AMC Radiation Monitoring Module. Moreover, interesting lectures about LLRF system operation at FLASH facility and digital data acquisition and processing in HEP experiments were given during the "xTCA for Instrumentation" special session.

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