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Fault-tolerant modular sensor electronics to perform long-term measurements with small satellite remote sensing instruments

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Single-event effects caused by ionizing radiation pose significant challenges for satellites, potentially leading to mission failures. In the case of COTS-based nanosatellites, extensive effort must be invested in mitigation strategies and redundancy concepts. As imaging instruments increasingly target longer mission durations for remote sensing applications—such as monitoring long-term climate processes—reliable system designs become essential.

Highly integrated System-on-Module (SoM) architectures enable high processing performance for imaging applications while maintaining low resource requirements in terms of power and mass. These architectures offer key advantages, including flexibility,(re)programmability, modularity, and module reuse. To achieve a fault-tolerant design, we modeled the radiation environment, assessing hazards at the module level to mitigate risks to an acceptable level through appropriate countermeasures. This approach results in an electronics design that integrates both hardware and software redundancies, combined with reconfiguration strategies, to ensure system availability and reliability for mission durations exceeding three years in Low-Earth Orbit (LEO).

In this contribution, we present a dual-imager electronics system based on the SRAM-based Xilinx Zynq-7000 architecture. This system supports a wide range of imaging sensors in the visible and near-infrared spectral ranges and is a key component of a limb-sounding spatial heterodyne interferometer designed to measure atmospheric temperatures. The instrument is scheduled to fly on the Atmospheric Coupling and Dynamics Explorer (ARCADE) mission as part of the International Satellite Program in Research and Education (INSPIRE) satellite series.

Primary author: Mr NEUBERT, Tom (FZJ)

Co-authors: Dr ZIMMERMANN, Egon (FZJ); Mr SCHARDT, Georg (FZJ); Prof. NATOUR, Ghaleb (RWTH); Dr RONGEN, Heinz (FZJ)

Presenter: Mr NEUBERT, Tom (FZJ)

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