Development of a payload for the characterization of fram microcontrollers to radiations

Paper ID: 33888
student

MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Space Environmental Effects and Spacecraft Protection (6)

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DEVELOPMENT OF A PAYLOAD FOR THE CHARACTERIZATION OF FRAM MICROCONTROLLERS TO RADIATIONS

Abstract

The space radiation environment can have serious effects on spacecraft electronics. The effect of incoming cosmic rays of galactic, solar origin and their interaction with the Earth's magnetic field limit system endurance and reliability. Transient effects from individual high-energy protons or heavy ions can in fact disrupt system operation irreversibly causing system faults that can be very dangerous.

To test radiation effects on COTS FRAM-microcontrollers, we created a payload tile for the AraMIS-C1 structure (modular architecture for small satellites, developed by Politecnico di Torino) called 1B521 Radiation Characterization Payload. The satellite that includes this payload will be launched in a LEO (Low Earth Orbit) approximately between 600-800 km distance from the Earth. Spacecraft systems operating in this area must be hardened to withstand the radiation environment, and the electronics must be designed with several layers of redundancy.

The damages produced by radiations are the cumulative effects of the dose received (TID) that can cause functional failures, and the effects of a single particle hit (SEE) that mainly cause single event upset (SEU) and single event latch-up (SEL). Finding SEU and SEL sensitivity of the microcontroller is the main goal of the mission. FRAM (ferroelectric memories) cells store the information as a PZT film polarization and a charged particle hit has a very small possibility to cause a change in the polarization. The ferroelectric dielectric leads to a different behaviour of the cell compared with a DRAM one, producing many advantages especially for what concerns the overall power consumption in read/write cycles and the non-volatility properties of the device.

The problems due to ionizing radiation are in our opinion concentrated in the CMOS logic surrounding the memory array. Our payload is hosted in a board included in a 1U Cubesat satellite. The board presents two identical microcontrollers MSP430FR6989 (Texas Instruments) that run the same program, but one uses software hardening techniques that should prevent malfunctions due to transient errors like SEUs and SEFI. We also monitor SELs and when such an event is detected the system will power cycle the payload to prevent physical damage. The on-board computer of the satellite monitors the behaviour of the payload, logging any malfunctioning and creating an error report. We are waiting for a launch opportunity to get live data and verify our assumption that FRAM based microcontrollers can be extremely useful in low cost university satellites and to test the effectiveness of software hardening.