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Radiation testing campaign results for understanding the suitability of FPGAs in detector electronics

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SRAM based Field Programmable Gate Arrays (FPGAs) have been rarely used in High Energy Physics (HEP) due to their sensitivity to radiation. The last generation of commercial FPGAs based on 28 nm feature size and on Silicon On Insulator (SOI) technologies are more tolerant to radiation to the level that their use in front-end electronics is now feasible.
FPGAs provide re-programmability, high-speed computation and fast data transmission through the embedded serial transceivers. They could replace expensive custom application specific integrated circuits in front end electronics in locations with moderate radiation field. The use of a FPGA in HEP experiments is only limited by our ability to mitigate single event effects induced by the high energy hadrons present in the radiation field.
In this paper, we summarize results of a two-year study of Xilinx 7-series devices on their susceptibility to a HEP experiment radiation field. Experimental results from irradiation campaigns in the USA and Europe on ionizing dose studies up to 300 krad, and single event effects measurements performed with high-energy neutrons up to 1x10exp11 n/cm2 and protons up to 1x10exp13 p/cm2, will be presented.
After the proton exposure, the devices tested presented no permanent operational failure except for a 10% increase in the core-logic power consumption, well within the component specification.
To mitigate single event upsets we have implemented techniques such as Triple Module Redundancy (TMR) and soft error scrubbing. The effectiveness of these implementations will be presented in detail.
The paper also describes the various errors detected in the FPGA Multi Gigabit Transceivers (MGT). The estimated lane error rate suggests that the configurable logic that interfaces with the MGT is the most sensitive part of the FPGA. Proper application of mitigation methods, however, can significantly reduce this sensitivity. Future experiments are planned with improved TMR and scrubbing mitigation.

Collaboration

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