Design of a Radiation Tolerant System for Total Ionizing Dose Monitoring Using Floating Gate and RadFET Dosimeters

Rudy Ferraro, Salvatore Danzeca, Matteo Brucoli, Alessandro Masi, Markus Brugger, Luigi Dilillo

To cite this version:

Rudy Ferraro, Salvatore Danzeca, Matteo Brucoli, Alessandro Masi, Markus Brugger, et al.. Design of a Radiation Tolerant System for Total Ionizing Dose Monitoring Using Floating Gate and RadFET Dosimeters. TWEPP: Topical Workshop on Electronics for Particle Physics, Sep 2016, Karlsruhe, Germany. lirmm-01382578

HAL Id: lirmm-01382578
https://hal-lirmm.ccsd.cnrs.fr/lirmm-01382578

Submitted on 17 Oct 2016

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
2. Design Choices

Two parts compose the system:

- **The tester part** which is a generic radiation tolerant architecture able to acquire mixed-signals from the DUT and perform complex data processing.
- **The DUTs part** that contains the dosimeters sensors and the circuitry needed to manage them.

The tester part is composed of:

- A Flash-based FPGA which offers us the possibility to improve continuously the embedded sensor controllers and to manage online different test configurations.
- A 16-bit ADC and OpAmps that allow the measuring of the DUT values: RadFET voltages, RadFET current source and floating gate currents.
- **Monitored Voltage Converters** for the powering of the DUTs and Tester elements.

Four IP cores constitute the generic tester part:

- The CoreABC, an assembler-based configurable softcore provided by MicroSemi which is the master of the system. The core contains in assembly-based language the rendering routine of the sensors.
- The CoreUART, a configurable APB serial controller provided by MicroSemi.
- The ADC Controller which provides the measurements of the analogue values of the sensors and the reference values of the board.
- Two IP cores are dedicated to the sensors:
  - The FGDOS Controller which performs the measurements of the analogue values of the sensors and the reference values of the board.
  - The RadFETs Controller performs the reading procedure for up to two RadFETs.

4. Radiation Assurance

- A Triple Modular Redundancy (TMR) mitigation technique is applied on the FPGA IP cores at the register level by means of a commercial synthesis tool and at the memory level manually.
- The board is entirely based on COTS components tested against radiation effects:
  - SEE and TID: > 30 MeV protons (up to 9.10¹¹ p/cm²) and 1 MeV neutrons (up to 4.10¹² n/cm²)
  - TID: > 50 krad (Si) TID

5. Results

- In the nominal configuration of the FGDOS with a sampling of 1 Hz, the TIDMon is able to charge the sensors in less than 1 sample, thus the accuracy of 16 mrad(Si)
- The TIDMon can achieve a measuring of the accumulated dose limited by the increase of the ADC current consumption as a result of the accumulated dose.
- The TIDMon allows us to finely characterize and find the best conditioning to use the FGDOS with the maximum of performance as a TID sensor for CERN dosimetry purposes.

6. Conclusions

- The TIDMon allows us to finely characterize and use the FGDOS with the maximum of performance as a TID sensor for CERN dosimetry purposes.
- The tester architecture proved to be robust against various harsh radioactive environments and can operate up to 50 krad(Si).
- The next step to consider for the Tester architecture will be to extend the lifetime of the architecture actually limited by the increase of the ADC current consumption as a result of the accumulated dose.
- The performances and the modularity of the test architecture provides us a quick and robust, ready-to-use test system able for other CERN radiation testing activities.