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

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The Total Ionizing Dose Monitor (TIDMon) is a radiation tolerant system designed to measure the effect of the TID on a new prototype of Floating Gate Dosimeter (FGDOS) and compare it against the Radiation-sensing Field Effect Transistors (RadFETs) dosimeter.

In this work we present the design strategy adopted for the control of the sensors and the architecture, the radiation reliability and the performance achieved by the system.

2. Design Choices

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

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 reading 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.
- The FGDOS Controller performs the reading procedure for up to four FGDOS.

Two IP cores are dedicated to the sensors:
- The FGDOS Controller performs the measurements and manages up to four FGDOS.
- 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: 230 MeV protons (up to 9.10^11 p/cm^2)
  - Displacement damage: 1 MeV neutrons (up to 4.10^12 n/cm^2)
  - TID: Co source up to 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 blind time is reduced to the minimum.
- The TIDMon can achieve a measurement accuracy of 16 mrad(Si).
- The board worked without issues during several test campaigns performed at CHARM mixed-field facility or with 60Co irradiation.

6. Conclusions

- 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.
- The tester architecture proved to be robust against various harsh radioactive environments and can operate up to 30 krad(Si).
- The next step to consider for the Tester architecture will be to extend the lifetime of the tester 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.