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Design Of A Radiation Tolerant System For Total Ionizing Dose Monitoring Using Floating Gate And Radfet Dosimeters

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1. Abstract

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

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 DUT part that contains the dosimeters sensors and the circuitry needed to manage them.

3. TID Monitoring procedure

The TIDMon measures every second the TID sensors and also the voltage regulators and the current source of the board in order to monitor the level of degradation of the tester.

4. Radiation Assurance

A Triple Modular Redundancy (TMR) mitigation technique is applied on the FPGAs 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: 5.6.10^5 rad(SI) 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 measuring accuracy of 16 rad(SI).

The board worked without issues during the several test campaigns performed at CHARM mixed-field facility or with 60Co irradiation.

6. Conclusions

The TIDMon allows us to finely characterize the test 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 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.