Design of Bulk Built-In Current Sensors to Detect Single Event Effects and Laser-Induced Fault Injection Attempts

Jean-Max Dutertre, Rodrigo Possamai Bastos, Olivier Potin, Marie-Lise Flottes, Giorgio Di Natale, Bruno Rouzeyre

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**Design of Bulk Built-In Current Sensors to Detect Single Event Effects and Laser-Induced Fault Injection Attempts**

Bulk Built-In Current Sensors (BBICS) are fault detection mechanisms embedded in integrated systems. BBICS are able to monitor anomalous transient currents like the so-called single event effects induced by radiation or even malicious injection sources. This work reviews BBICS principles and introduce new sensor architectures that improve the transient-fault detection sensitivity. In addition, a test chip is presented for the validation of the sensor concept under the laser-induced effects.

### Integrated circuits are more and more Transient-Fault (TF) sensitive through new technologies

![Diagram showing the increase in transient-fault sensitivity](image)

- Physical Limits
- Operating Frequency
- System Complexity
- Demand for Robust Systems
- Computer Network (Internet)
- Confidential Communication
- Demand for Crypto-Systems

### Mitigation of Transient faults by using CED schemes based on Bulk Built-In Current Sensors (BBICS):

**System’s Block**

- Transient-Fault (TF) sensitive through new technologies
- Lower abstraction levels
- Higher abstraction levels

**Cases of Transient Faults in an Inverter Protected by a PMOS-BBICS and a NMOS-BBICS:**

**Case 0:**
- PMOS on, NMOS off
- In = 0, Out = 1

**Case 1:**
- PMOS off, NMOS on
- In = 1, Out = 0

**Drain current that would contribute to produce a transient fault**

- Laser-induced NMOS current Case 0
- Laser-induced PMOS current Case 1A
- Laser-induced PMOS current Case 1B

**Layout of 65-nm CMOS test chip with BBICS devices**

**Conclusions and Perspectives:**

1. Laser-based experiments revealed:
   - Classic PMOS transistors drive bulk currents much higher than drain currents, limiting efficient transient-fault detection sensitivity of PMOS-BBICS.
   - Use of triple-well CMOS technology improves the transient-fault detection sensitivity of PMOS-BBICS.
   - Transient fault injection testing using a 65-nm CMOS test chip showed the effectiveness of BBICS in detecting transient faults.

2. Use of triple-well CMOS technology allows a distinction of the bulk current and improves the transient-fault detection sensitivity of BBICS.

3. Use of triple-well CMOS technology amplifies bulk current by an order of magnitude above drain current.

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1. **Centre Microélectronique de Provence - Georges Charpak, Gardanne, France** (dutertre@emse.fr)
2. **Université Grenoble Alpes, CNRS, Laboratoire TIMA, Grenoble, France** (bastos@imag.fr)
3. **LIRMM (Université Montpellier II / CNRS UMR 5506), Montpellier, France** (flottes, dinatale, rouzeyre@lirmm.fr)

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