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Single Event Transient acquisition and mapping for space device Characterization

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ABSTRACT

It is necessary for space applications to evaluate the sensitivity of electronic devices to radiations. It was demonstrated that radiations can cause different types of effects to the devices and possibly damage them [1] [2]. The interest in the effect of Single Event Transient (SET) has recently risen because of the increased ability of parasitic signals to propagate through advanced circuit with gate lengths shorter than 0.65 nm and to reach memory elements (in this case they become Single Event Upset (SEUs)). Analog devices are especially susceptible to perturbations by such events which can induce severe consequences, from simple artifacts up to the permanent fail of the device. This kinds of phenomena are very difficult to detect and to acquire, because they are not periodical. Furthermore, they can vary a lot depending on different parameters such as device technology and biasing. The main obstacle for the analysis is due to the maximum frequency of these signals, which is unknown. It is consequently difficult to set a correct sample frequency for the acquisition system. In this document a methodology to evaluate SETs in analog devices is presented. This method allows to acquire automatically these events and to easily study the sensitivity of the device by analyzing a "SETs cartography". The advantages are different: it allows to easily acquire and analyze the SETs in an automatic way; the obtained results allow the user to accurately characterize the device under test; and, finally, the costs due to the implementation of the tests are lower than a classical analysis performed by a particle accelerator.

1. Introduction

In space applications the effect induced by radiations can influence the reliability and efficiency of the systems, which is extremely important to ensure the best device's performances. However, it needs to be underlined that it is necessary to consider a lot of aspects when testing devices dedicated to space applications. Space industry has always preferred to work with former technologies, which have a known behavior, and a proven reliability. The major problem is that the development of the electronic technologies is evolving very quickly, and devices are becoming denser and denser: they are renewed faster on the market than space program development times. For space industries, it could be particularly complicated to find devices belonging to old technologies. As a consequence, space industries need to adapt themselves by using the last technologies on the market, with all the difficulties linked to ensuring their reliability.

In this environment, this paper focuses on the study of Single Event Transients (SET). These are transient pulses caused by radiation induced charges which are collected and dissipated at sensitive nodes of the device [3–5]. They can have different duration depending on technology type, biasing conditions and particle energy intensity. The most reliable method used to study this kind of events includes a heavy ion accelerator test. However, in this project a different approach, based on a pulsed laser test technique, will be shown. This document presents a methodology which allows to easily study SET effects on electronic devices.

2. Test methodology

Different methods can be found in literature for evaluating SETs in electronic devices [1,2]. Various approaches used to evaluate SET sensitivity have been described. In this document a different methodology is presented and it is based on pulsed laser testing. The most important characteristic of this new approach is the flexibility and the user friendly interface. Fig. 1 describes the setup used to apply our methodology. The device is set up on a test board and biased with power and control signals. Then, a pulsed laser scans the device from the backside surface with a continuous electrical monitoring of at least one of the sensitive outputs. Each time a SET is detected, an acquisition is triggered to save the oscilloscope trace of the SET profile. The acquisition can be controlled directly by the computer using a dedicated Labview application. The last step of the process is the data treatment done with a Matlab application. In order to explain how to use this methodology an example with an analog device is described in the following part. This technique

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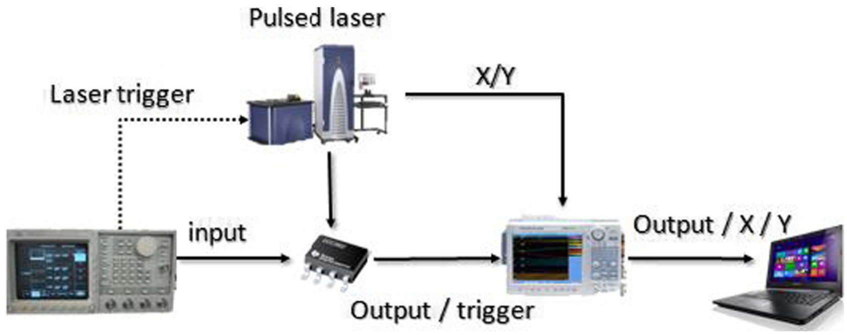

Fig. 1. Test setup.

Table 1
Meridian parameter description.

Meridian parameters	
Wavelength	1064 nm
Pulse width	7.19 ps
Energy per pulse	From pJ to 3 nJ
Laser spot size	6 μm, 2,5 μm and 1 μm

allows to reduce the investigation time and the cost of a heavy ion accelerator testing. It can be applied to every device that need to be qualified. Thanks to the developed applications, the user can easily control the system and automatically treat the data, improving significantly the understanding of the effect occurring into the device.

3. Methodologies comparison

The purpose of this methodology is not to replace the traditional methods [6], but it is to propose a new way, which can be used as a useful complement in order to easily study the sensitivity of electronic devices to radiations. Differently from classical methods based on heavy ion particle accelerator tests, it is possible to obtain different advantages on the analysis with pulsed laser stimulation [7]. First the laser can be set up in order to get a spot smaller than 1 μm of diameter on the sample. In this way, it is possible to evaluate the sensitivity of the circuit with an important **spatial resolution**, sometimes up to transistor level, which is not to feasible with the heavy ion technique. A synchronization is possible between the laser pulse and the device's signals. In this way **temporal information** can be used to trigger an event and evaluate its importance. It has been demonstrated that electronic devices are sensitive to the timing of the laser pulse in relation to the circuit clock. In this way better measurements on device sensitivity can be obtained. Up to now, only one tool is able to send a particle at a given time, and it is very expensive to use.

As mentioned above the relative **SEE threshold** of a circuit may be easily determined by adjusting the laser intensity and the number of pulses at each laser position. However, the threshold energy given by the laser power is not convertible to regular LET threshold.

Beside technical aspects there is also a convenience on using a pulsed laser test deriving from different characteristics. First it is completely compatible with foundry facilities. There is no ionizing radiation threat, the entire system can be closed in a light-tight box to avoid the possibility of eye damage. Therefore, no vacuum is necessary for the testing, the energy can be varied by merely changing the laser power.

Moreover, laser testing is cheaper than heavy ion testing. As laser technology continues to advance it is anticipated that the cost of laser testing will further decrease.

In opposition to pulsed laser stimulation the proposed method is **user-friendly** thanks to the Matlab application, the user can perform different analyses depending on specific requirements and needs.

And it is possible to quickly obtain a SET Cartography. In this way it is possible to test a device in a short time but making a trade off with accuracy.

Obviously this technique has not only advantages, it has also different limitations: for example, ***no absolute measurement of SEE threshold* is possible**: it is not possible to have an absolute threshold reference because light and ions do not interact in the same way with the semiconductor material. Consequently, if a test was carried out with both heavy ion accelerator and pulsed laser, it would give different results on LET thresholds measurements. In addition, there is ***no direct measurement of SEE LET thresholds***: the measurement of the variation of the cross-section with LET needs to be evaluated to calculate error rates. The laser can be used to estimate the limiting cross section indirectly by identifying which nodes are sensitive to single events and then using the circuit layout to add up all the sensitive areas.

A disadvantage of the laser beam is that the pulses are not able to pass through metal layers of a device. This is a problem during a device testing because it can happen that the most sensitive regions of the

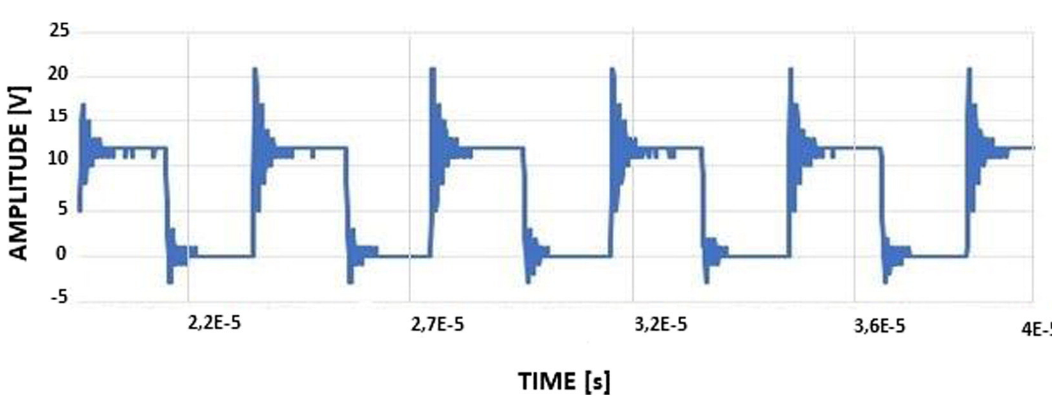

Fig. 2. Example of a normal output of the PWM.

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