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Pré-évaluation de la tenue aux radiations de réseaux de portes programmables (FPGA)

Trois types de FPGA de chez ACTEL (A1280A, RH1280 et A1460A) ont été soumis à des essais de sensibilité aux ions lourds, aux protons et à la dose cumulée. Les résultats des essais, menés sur des composants alimentés sous 5V et 3,3V sont présentés.

This paper provides a summary of Heavy ion, Proton and Total Dose tests on the three types of Actel FPGA's: A1280A, RH1280 and A1460A. The particle tests have been performed at both 5V and 3,3 V supply voltage.

Within the last few years the SEU and Total Dose vulnerability have been tested for various Actel FPGA types. The Total dose results show large variation in tolerance for various types of FPGA's, while the Heavy Ion results indicate about the same sensitivity for the different FPGA types, but large difference in sensitivity between C, S and I/O modules. In order to recommend the use of these devices in space application, additional testing have been performed to further characterise these types of components.

This study comprises component types from the two Actel FPGA families 's named "ACT2" and "ACT3". The devices are composed of combinatorial C-modules, I/O modules with transparent latches to the input and output paths, and S-modules, basically a C-module followed by a dedicated flip-flop. The ACT3 series replaced the transparent latches in the I/O modules with triggered flip-flops driven by a high performance clock.

The RH1280 type is Rad Hard to more than 100 krad. The A1460A indicated very little changes in supply current up to 10 krad(Si) and no functional failure could be detected with the present test method up to 50 krad(Si). The A1280A exhibits large currents already at 10 krad(Si) and fail to function around 18 krad(Si). Other experiments have shown that large differences could be expected from lot to lot, but all fail to function before 20 krad(Si).

The three types tested indicate similar heavy ion sensitivity, with the RH1280 type little more SEU hard than the other two. The HI cross sections versus LET values for RH1280 operating at 3,3V is shown in Fig. 1. The cross sections and threshold values depend strongly on logical value ('high and 'low') of the memory cell and also likely on the macros used for programming.

In space applications at LEO, the altitude and inclination of the orbit will have a large impact on the number of upsets a device will see. Detailed assessments of the proton upsets must be performed for each programme. In general, the tested FPGA tend to be a little worse upset rates than other complex device types. Upset calculations using Space Radiation and experimental cross sections are given in Table 1 below for A1460A and the Proteus orbit 1360 km ,60°.

Table 1. Upset rates for Actel A1460A in the orbit 1360 km, 60° for 5V and 3,3V.

A1460A	Heavy Ions Upsets /bit/day		Trapped Protons Upsets /bit/day	
Module	5 V	3,3 V	5 V	3,3 V
S	2E-5	5E-5	4E-4	2E-3
C	7E-8	5E-7	-	-
I/O	2E-6	1E-5	1E-4	3E-4

At the time of the conference, further heavy ion, proton and total dose tests on the new device types A1280XL and A32140 will be finished and reported as well. Heavy ion sensitivity of various macros will be investigated and reported.

Fig. 1 Heavy ion cross section vs LET values for RH1280 operating at 3,3V. "C0" and "C1" indicate logical low and high values.