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ESA RADIATION REPORT

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TITLE

Radiation Pre-Evaluation of FPGA Actel A1020B Manufacuted by MEC and TI

EUROPEAN SPACE AGENCY
CONTRACT REPORT

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SUMMARY

Total dose tests have been performed on Actel FPGA A1020B devices manufactured by Texas Instrument (TI) and Matshushita (MEC), biased at 5V and irradiated using a Cobalt-60 source at a dose rate of 600 rad(Si)/hour. The devices passed the specification limit for the supply current at a cumulated dose of 2,2 kRad(Si) (TI) and 2,9 kRad(Si) (MEC), respectively. The TI-device failed functional test at 6,2 kRad(Si) and the MEC-devices at about 10,5 kRad(Si). The functional test was performed at a clock frequency of 5 MHz and included power off/on every 300 rad(Si) for test of the charge pump in the start-up phase .

Single Event Latch-up (SEL) tests have been performed on the TI device type. SEL were detected at LET = 28 MeV/mg/cm^2 with a probability of 1.5 10-6 cm^2. For LET= 20, no SEL was detected.

DOCUMENT CHANGE RECORD

Changes between issues are marked with a left-bar.

Issue	Date	Paragraphs affected	Change information
1	16 Aug 1999	All	New document

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1. ABSTRACT

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Single Event Latch-up (SEL) tests have been performed on the TI device type. SEL were detected at LET = 28 MeV/mg/cm^2 with a cross section of 1.5 10-6 cm^2. At LET= 20 MeV/mg/cm^2, no SEL was detected.

PROJECT DETAILS

PROJECT	:	PROBA
CUSTOMER	:	ESA/ESTEC,

TEST SAMPLE DETAILS

PART TYPE	:	A1020B	
FUNCTIONAL ASSIGNMENT	:	FPGA	
MANUFACTURER	:	Actel (Matshushita (MEC)and Texas Instrument (TI) die)	
QUALITY LEVEL	:	MEC	- 385135 Mil Class B
		TI	- Commercial
DATE CODE	:	MEC	- 9735
		TI	- 9808
PACKAGE	:	MEC	- 84 pin CQFP
		TI	- 84 pin CQFP
SAMPLE SIZE	:	MEC	- 2 pcs
		TI	- 1 pcs, TID
		TI	- 2 pcs, SEL
SERIAL NUMBER	:	MEC	- #T1, #T2
		TI	- #T3 , #S4, #S5

ELECTRICAL TEST DETAILS

DEVICE LAYOUT DESIGN		Shift registers for C modules > 90 % utilization
TESTED PARAMETERS	:	Supply Current, Icc, and functionality @5MHz
TEST EQUIPMENT	:	Dedicated test board based on golden chip principal
TEST TEMPERATURE	:	Room Temperature

IRRADIATION DETAILS

TEST FACILITY	:	Department of Sjukhusfysik, Borås hospital
IRRADIATION SOURCE	:	^{60}Co gamma rays
DOSE RATE	:	0,6 krad(Si)/h
BIAS CONDITIONS	:	Vcc = 5V
ANNEALING CONDITIONS	:	Not performed
COMMENTS	:	Biased in-situ tests Functional tests performed every 300 rad(Si) in connection with bias being turned on/off.

2. TEST SAMPLES

The A1020B is the first generation FPGA (ACT1) from Actel. The die of the tested devices were manufactured by MEC in 0.6u and TI in 0.6 u technology. The devices employ antifuse technology implemented in ONO gate 0.6 um 2 and 3 level metal CMOS. This device is á 2000 gate FPGA with 560 dedicated flip-flops (C-modules)

	Marking / *Top side*	Marking / *Bottom Side*
MEC	Actel Logo A1020B PG84B 9735 5962-9096503MUA	 U1P054 Philippines
TI	Actel Logo A1020B -1 PG84B 9708	 TI-60813442 Philippines

3. TEST TECHNIQUES

3.1 Test Methods

Total dose tests have been performed in a static mode by load data into the DUTs, pause for a pre-set of time and check for errors. To test for start-up problems , the bias to the DUTs was always turned off/on before function test. The supply current to the DUT was monitored continuously. The following test cycle was performed:

DUT turned off during 10 seconds
DUT turned on
DUT tested for functionality at 5 MHz
DUT biased for 30 minutes (300 rad(Si) (supply current monitored)

The DUTs are tested using a “virtual golden chip” test method. The principal of the technique is to compare each output from the DUT with the correct data stored and controlled by a monitor board closely connected to the DUT-board.
The layout of the DUTs have been a bit pattern consisting of consecutive 0 1 0 1 etc in individually controlled 64-bit ring counters. The DUTs have been programmed to more than 78% with 3 ring counters using the C-modules.

ELECTRICAL TEST CONDITIONS

TEST PARAMETER	TEST CONDITIONS
Icc	Vcc = 5,0 V
Functionality	f_{CLK} = 5 MHz

3.2 Facility

The total dose tests were performed at the hospital of Borås. This facility has a Cobalt-60 source suitable for low dose rate testing.
The exposition rate was calibrated by staff from Department of Sjukhusfysik at Borås hospital. The source is calibrated for dose rate to water and then calculated for expected dose rate to Silicon. The determined dose is correct within 5%.

Single Event Latch-up tests were performed at the heavy ion facility at UCL/Belgium.

4. TID RESULTS

The results of the tests are presented in figure 1 below. At a cumulated dose of 2 krad(Si), the supply current had increased with more than 10% of its initial value. Up to 6 krad(Si) both MEC and TI functioned and showed about the same increase in supply current. Just above 6 krad(Si), the first functional failure were detected in the TI device in connection with power off/on. After 8 kRad(Si), the bias for SN#T3 (TI) was turned off with the DUT still in the irradiation field. MEC devices indicated functional failure little above 10 krad(Si) cumulated dose. The test was terminated after 11,2 kRad(Si). None of the devices were functioning. In the figure some short spikes are present superimposed on the supply current curve. They are due to current measurements during the start-up of a functionality test when the DUTs are turned off and on.

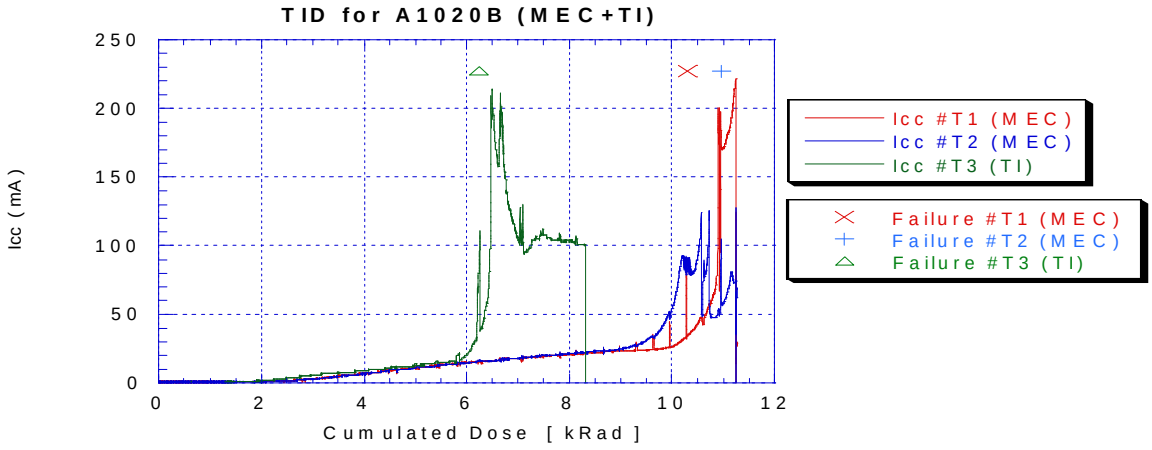

Figure 1. Supply Current (Icc) as a function of cumulated dose. The devices were powered off/on for 5 seconds each 300 krad(Si). The first functional failures are indicated in the curves.

5. SEL RESULTS

Single Event Latch-up tests have been performed using the same test board and control equipment as in the total dose tests. Two samples have been delidded and prepared for SEL tests. The DUTs are individually biased and any SEL will result in immediate shut down of the power. During testing problems were encountered to fully shut down the SEL due to the I/O lines of the FPGA pulling power from the test board. Complete shut down of the SEL was only possible by powering off the test board..

Up to LET = 20 MeV/mg/cm^2 , no SEL could be detected. At LET= 28 MeV/mg/cm^2 , the SEL cross section was found to be around 1.5 10^{-6} cm^2, and at LET= 34 MeV/mg/cm^2 it was found to be about 3 cm^2. The results form the performed tests agreed well with earlier results from NASA, see figure 2 below.

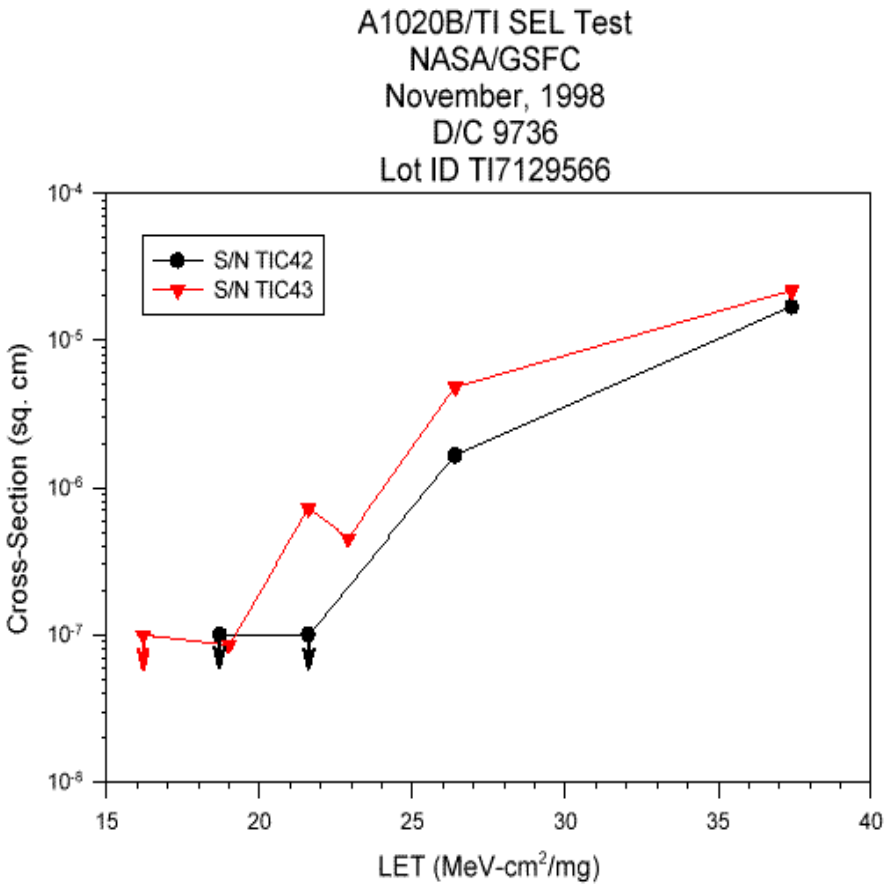

Figure 2 Single Event latch-up cross section as a function of LET value for A1020B manufactured by TI. The graph is taken from NASA/GSFC radiation internet home page.