LS1046A TID 100 krad Test Report DC 1750

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Scope :	**CLIENTS - CUSTOMERS** **TEST**

Last revision approved by :

Approved by	Approbation Status	Date
BALL Mikael	Oui	28/10/2021
Porchez Thomas	Oui	28/10/2021

1. DOCUMENT AMENDMENT RECORD

Author	Issue	Date	Reason for change
RIVADENEIRA Melissa	A	18/12/2020	Creation
RIVADENEIRA Melissa	B	28/10/2021	Update on report structure

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2. INTRODUCTION

This report describes the Total Ionization Dose (TID) campaign run on the QorIQ LS1046A processor. The aim of these tests is to evaluate the LS1046A tolerance hardness to a 100 krad(Si) radiation dose accumulation.

The following information is composed of a description of the samples, the tests conditions, results and a conclusion.

3. APPLICABLE DOCUMENTS

AD1 ESCC basic specification no. 22900, issue 5, “Total dose steady-state irradiation test method”, June 2016

AD2 Mil-Std-883, method 1019.9, “Ionizing Radiation (Total Dose) Test Procedure”

4. REFERENCE DOCUMENTS

RD1. Teledyne-e2v Datasheet DS1202, reference 1202E-HIREL-08/20, “LS1046A, LS1026A QorIQ”

5. SAMPLES DESCRIPTION

5.1 Identification

Manufacturer’s designation	LS1046A
Manufacturer’s name	Teledyne-e2v Semiconductors
Manufacturer’s address	Avenue de Rochepleine, 38120 Saint-Egrève, France
Package designation	Flip-Chip Plastic Ball Grid Array (FC-PBGA) - 780 pins
Component family	QorIQ Layerscape Multicore processor
Component group	LS1046A product family
Component designation	LS1046AMN8Q1A
Datasheet reference	DS1202, reference 1202E-HIREL-08/20, “LS1046A, LS1026A QorIQ”
Sample size	6 x Biased ON (SN# 1, 2, 3, 4, 5, 6) 6 x Biased OFF (SN# 7, 8, 9, 10, 11, 12)
Wafer diffusion lot	T01100
Die Fabrication Date Code	1750

5.2 Functional description

The LS1046A processor integrates quad 64-bit Arm Cortex A72 cores with packet processing acceleration and high-speed peripherals. The LS1046A processor incorporates the following key features:

- Single cluster of four cores scaling up to 1.8 GHz ;
- DDR4 SDRAM memory controller with ECC operating up to 2.1 GT/s ;
- Hierarchical interconnect fabric operating up to 700 MHz ;
- Data Path Acceleration Architecture (DPAA) ;
- Two Dual UARTs (DUART) and six low-power UARTS (LPUARTS) ;
- Four I2C controllers ;
- Two RGMII interfaces ;
- Eight SerDes lanes for high-speed peripheral interfaces;
- QSPI controller ;
- General purpose IO (GPIO) ;
- Global programmable interrupt controller (GIC) ;
- Thermal monitoring unit (TMU).

6. GENERAL PROCEDURE

6.1Test System

In order to ensure a full coverage during electrical tests, Teledyne-e2v uses his proper industrial tester facility, the UltraFLEX test system. This digital tester is also used for LS1046A production, giving a 100% test coverage fitted with NXP, the original LS1046A die manufacturer. All electrical test purposes are presented with TID results.

6.2Radiation Dose and Annealing Steps

The TID campaign was performed in two phases: 50krad(Si) and 100krad(Si). Each phase is composed of an irradiation step followed by a Room Temperature Annealing (RTA) and an Extended Temperature Annealing (ETA).
Twelve parts were irradiated from 0 up to 50 krad and a second batch of twelve parts was irradiated from 0 up to 100 krad.

The following report will specially focus on the Phase 2 - radiation dose: 100krad(Si).

Irradiation 100krad(Si)

Total Irradiation Dose	Dosimetry data	Dose rate	Annealing steps	Date IN	Time IN	Date OUT	Time OUT
krad (Si)	K rad(Si)	rad(Si)/h					
100	99	210	-	25/09/2020	10:00	15/10/2020 (*)	14:15
-	-	-	24 h / Room	19/10/2020	10:30	20/10/2020 (*)	11:00
-	-	-	168 h / 100°C	22/10/2020	11:40	29/10/2020 (*) (**)	11:30

Table 1 : Details of the irradiation and annealing steps

Note (*): After exposure steps and after each annealing step, parts have been sent to Teledyne E2V using dry ice for electrical measurements.

Note (**): During ETA Tj = +100°C for biased ON parts and Ta = +100°C for OFF parts.

7. EXPERIMENTAL CONDITIONS

7.1 Radiation Source Dose Rate and Annealing

The dose exposures have been performed at GAMRAY facility in Toulouse (France). In this irradiation facility, a Cobalt 60 source is used with the possibility to vary the dose rate by simply adjusting the distance to the source (Irradiation certification is presented in Annex) Before exposure, a dose rate calibration on each board location is performed using an active dosimeter SAPHYMO gamma probe.

After each Step the samples were sent to Te2V using dry ice for electrical measurements taking into account the maximum time window for tests.

7.2 Bias during Dose Exposures and Measurements conditions

7.2.1 Bias conditions

During exposures, 6 samples were biased ON using a dummy software and 6 samples were biased OFF with all pins connected to ground on a dedicated bias board with socket.

During annealing steps, the same stress conditions have been applied at room and high temperatures.

Power supplies	Voltage (V)
VDD	1
+3V3	3.3
DVDD	3.3
G1VDD	1.2
TA_BB_VDD	0.9
USB_HVDD	3.3
OVDD	1.8
LVDD	2.5
EVDD	3.3
TH_VDD	1.8
TVDD	2.5
XVDD	1.35
PLL_AVDD	1.8
VDDUSB	1
SVDD	1

Table 2 : Power supplies conditions

7.2.2 Exposure conditions

During radiation exposure, DUTs were stimulated using a running software.
This software controlled LEDs on the board that informed us of any failure. The test bench also included a current monitoring in order to detect any current variation during exposure.

8. TEST CONDITIONS AND PARAMETERS MEASURED

8.1 Test conditions

This test was carried out with electrical measurements conducted in the 'not in-flux' method in accordance with [AD1]. After radiation and annealing steps, samples were removed from the bias and they were placed in a standard protective ESD package for transport.

8.2 Post-irradiation and annealing procedure

Electrical testing was achieved before and after each step. The samples were stored in dry ice to ensure stability of irradiation during shipment between irradiation and testing locations. The time delay to perform the electrical measurements after opening the dry ice container was less than two hours.

8.3 Measured parameters

The testing platform runs 14 300 tests to ensure the correct functionality of the parts.It represents 100% of original NXP's coverage.The groups of parameters tested during the samples electrical measurement are listed below:

Test group	Description
ACSCAN	Test from DFT: transition fault detection
BIST	Built in self test
DCSCAN	Test from DFT: Stuck-at fault detection
FUNC (Bf)	Functional test (CORE,Peripherals,etc…)
FUSE	Internal register fused during final test at NXP
JTAG	Jtag functional test
DCSPEC	VOL and VOH test
HSSI	High speed serial interface test
LTG	High speed serial interface test
BOSS	EOS detection
LKG	Leakage on I/Os
OPENS	Open circuits
SHORTS	Short circuits
TRIP	Leakage between supply and ground
ODM	Memory DDR controller test
SIDD	Static power Consumption

Table 1: Parameters measured during electrical testing

9. TEMPERATURE REQUIREMENTS

9.1Electrical test temperature

A temperature measurement was performed during each electrical testing step. The recorded values varied within a range from 30°C to 35°C.

9.2Transport Temperature

The samples were stored in a dry ice container during their transport between the irradiation facility and test facility. The temperature was measured to be less than -60°C throughout, in accordance with the requirements of [AD2].

10. RESULTS

10.1Test Summary

All measured parameters were classified as “PASS” if all the twelve samples passed the tests within upper and low specification limits.

The following table summarizes the results of electrical measurements done on each step of the 100krad phase.

	Biased ON				Biased OFF			
Tests	INIT	100krad	RTA	ETA	INIT	100krad	RTA	ETA
ACSCAN	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
BIST	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
DCSCAN	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
FUNC (Bf)	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
FUSE	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
JTAG	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
DCSPEC	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
HSSI	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
LTG	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
BOSS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
LKG	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
OPENS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
SHORTS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
TRIP	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
ODM	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
SIDD	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS

Table 2: Test Summary

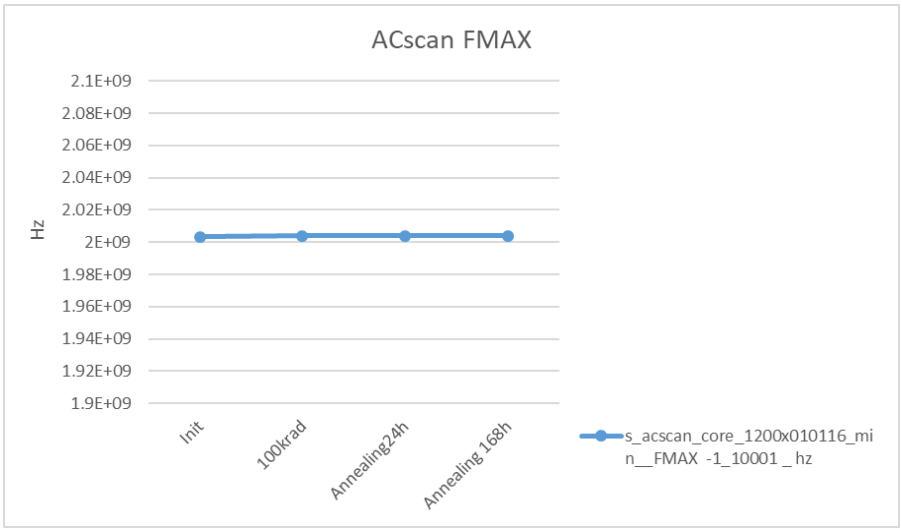
All the samples successfully passed electrical tests at each step of the TID campaign on LS1046A.

10.2Graphical results

The following graphs represent the variation of some representative parameters at each step of the TID phase for 100krad(Si). “LL” corresponds to lower limit set for production testing and “UL” stands for Upper limit.

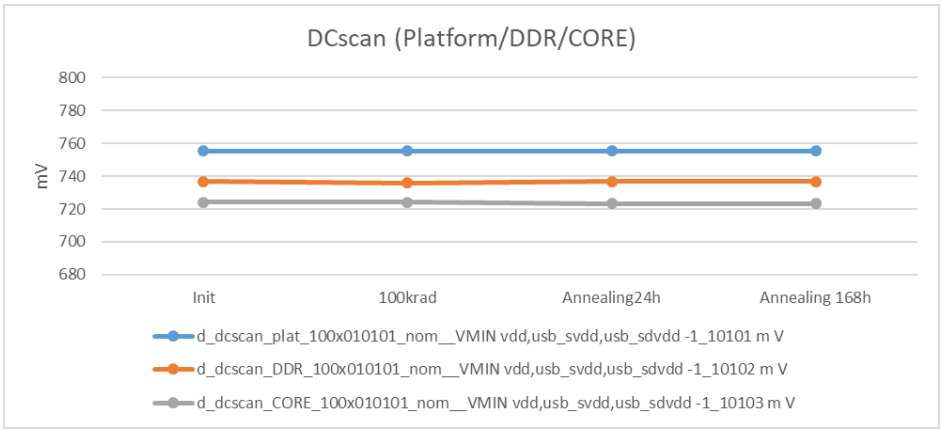
10.2.1 Frequency

LL=N/A
UL=N/A



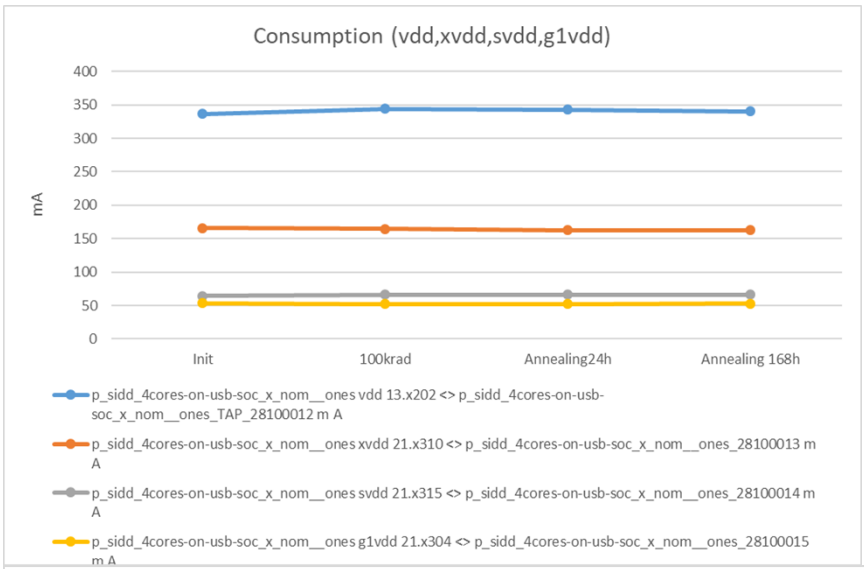
10.2.2 DC scan on platform, core and DDR

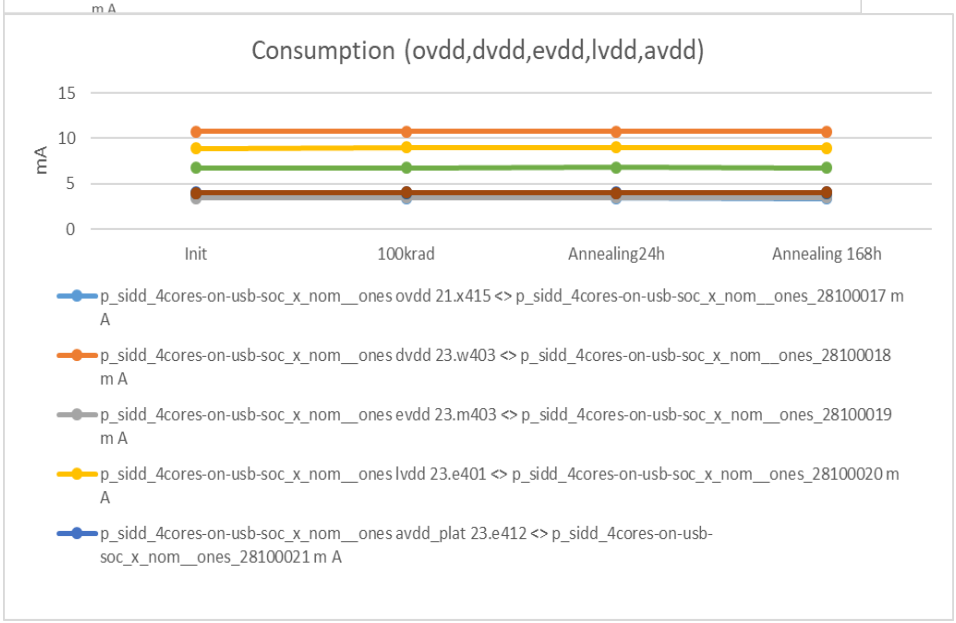
LL=550mv
UL=1000mv

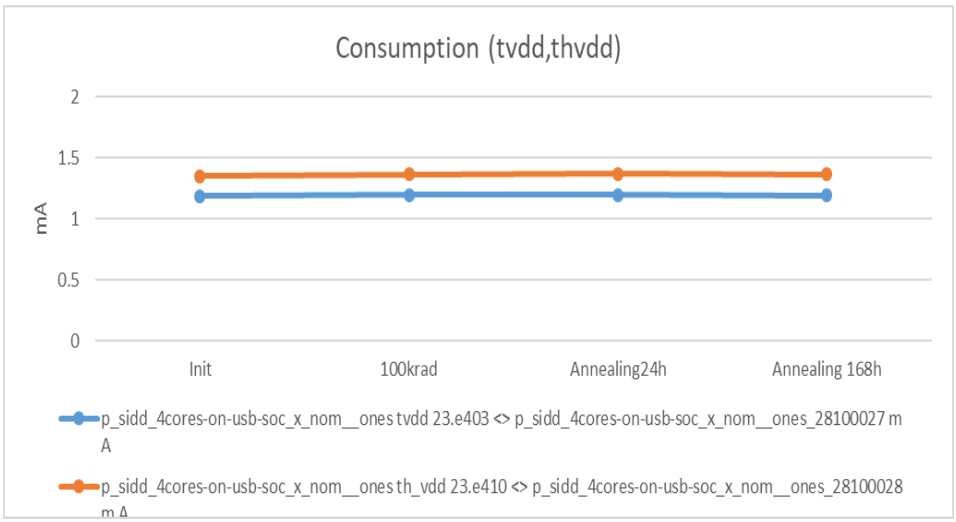


10.2.3 Consumption

LL=N/A
UL=1000mA

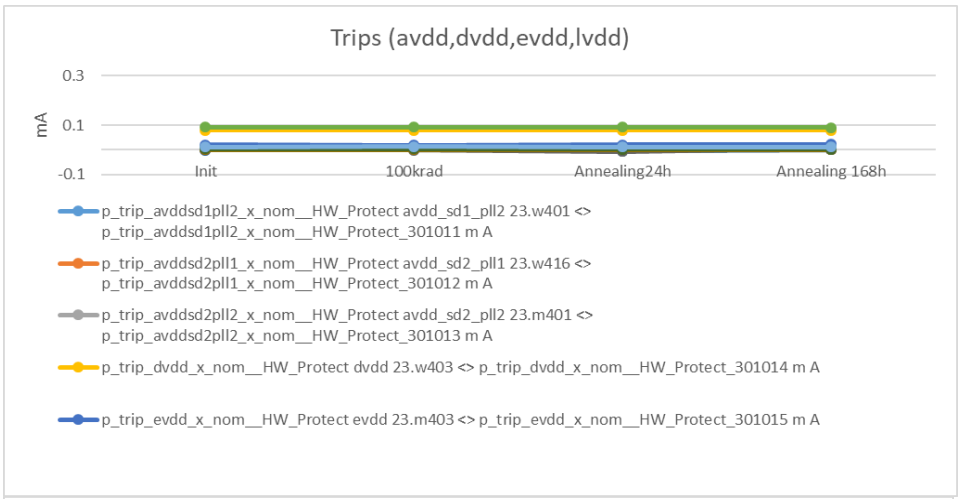


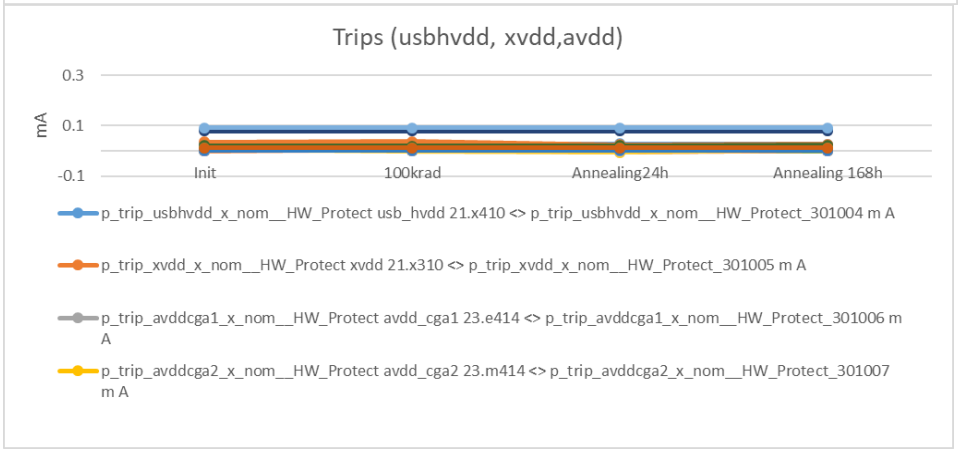


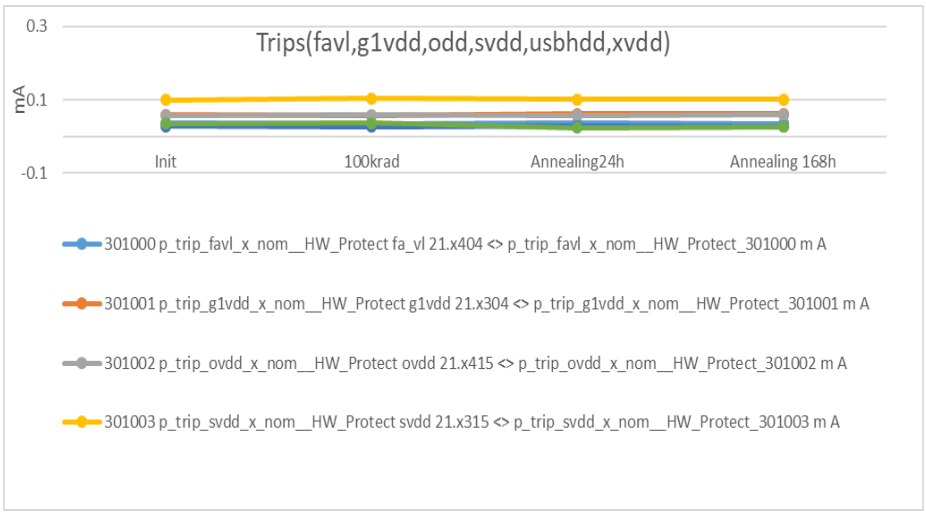


10.2.4 Trips

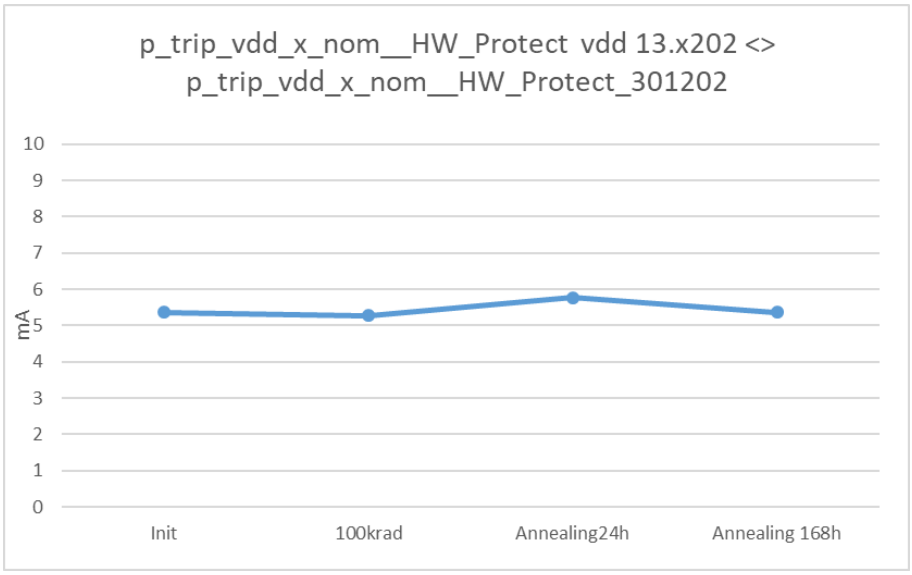
LL=N/A
UL=10mA







LL= N/A
UL=3500mA



No significant variation has been seen on electrical performances after irradiation.

11. CONCLUSION

The TID campaign was performed on Teledyne e2v's LS1046A devices (DC 1750 and wafer diffusion lot T01100) at 100krad(Si) with a 210 rad/h dose rate. The tests were performed on 6 samples biased ON and 6 samples biased OFF. Irradiated samples were annealed at room and high temperatures for accelerated ageing process. After each step, devices were sent to Teledyne e2v using dry ice to perform electrical testing in order to check the samples integrity regarding the expected test specification.

Parametric results remained within the specification limits after each step. A focus was made on specific parameters to check the absence of a significant variation on each samples induced by the irradiation or annealing processes. No drift was observed.

The Teledyne e2v's LS1046A microprocessor has been evaluated and set as a suitable part for space applications at a total ionizing dose of 100 krad(Si).

12. ANNEX: CO60 IRRADIATION CERTIFICATE

Co60 IRRADIATION CERTIFICATE

Customer: HIR Case followed up by: MF
FAO: Rodolphe SELLIER

Source: Coblat-60 (Co60)	
Certificate	N° 36708 of 08/10/2015
Activity	14.8 TBq of 04/09/2015

Reference : PV/ATR/PCBx3-Pb/XXX1/HIR/MF/2008 Rev: 0
Device irradiated : NA
Irradiation certificate applied only to the device subjected to the irradiation
In agreement with the quality procedure according ESCC 22900 (Pro.026 Rev. 12)

Irradiation environment

	Units	Min	Max	Time-weighted average
Temperature	°C	19.3	20.8	20.0
Relative humidity	%	34.9	61.2	50.4

Dose rate measurement

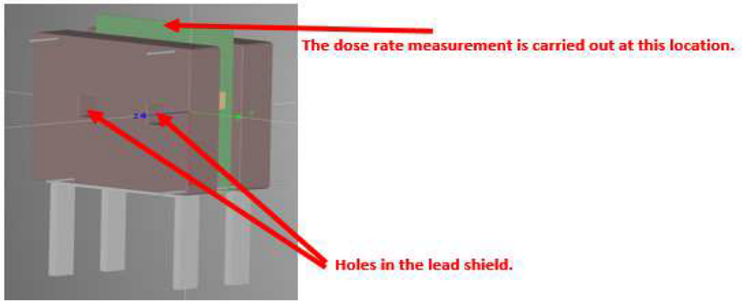
The instruments used for dose rate measurement is a PTW ionization chamber(TM30013) and universal dosemeter UNIDOS E which is controlled annually.

UNIDOS E	Serial number: 82253	Certificate number: 19D297	Date: 06/11/2019
TM30013	Serial number: 9314	Certificate number: 19D297	Date: 06/11/2019

The measurement unit of the international system for the dose rate is Gy/s. We commonly use rad/h (1 Gy/h = 100 rad/h).
The dose rate is measured at the center of the device.

TRAD position	Date	Dose rate [rad/h] (Kerma in the air) *
210-Pb1	24/08/2020	219.30
210-Pb2	24/08/2020	216.18
210-Pb3	24/08/2020	219.45

*** To be noted: See below the location where the dose rate measurements has been performed. TRAD don't granted that the dose rate is the same inside the holes of each lead shield.**



TRAD , Bat. Gallium , l'Occitane . 31670 LABEGE.
Tel: (33) 5 61 00 95 60. Fax: (33) 5 61 00 95 61. EMAIL: trad@trad.fr

Dosimetry

Each exit and input of Cobalt-60 source is logged in a digital file. We compute the dose at each step taking into account the source decay, the dose rate measured by the gamma probe and the downtime irradiation.

TRAD position	Date	Total ionizing dose [krad] (Kerma in the air)	Lot No. (If applicable)
210-Pb1	28/08/2020	0	Run 1
	07/09/2020	50.46	
210-Pb2	28/08/2020	0	
	07/09/2020	49.74	
210-Pb3	28/08/2020	0	
	07/09/2020	50.49	
210-Pb1	25/09/2020	0	Run 2
	15/10/2020	101.22	
210-Pb2	25/09/2020	0	
	15/10/2020	99.78	
210-Pb3	25/09/2020	0	
	15/10/2020	101.29	

Measurement uncertainty : 9.6% *The measurement uncertainty is expressed at two standard uncertainties (k=2).*

ESCC 22900: The dose at the device under test shall be measured to a resolution of better than 10%. The test devices shall be exposed to within 10% of the specified radiation dose level(s).

The gamma-ray dose rate of a Cobalt 60 source shall be calibrated in accordance with the requirements of ESCC Basic Specification No. 21500 to 5% or better. Dosimetry shall be traceable to national standards.

Written by	Quality control and Approved by
15/10/2020 M. FULLALOVE	15/10/2020 Y. PADIÉ