DDR4T04G72 TID Test Report 100Krad - DC 2028

Revision date :	**08/10/2021**
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Scope :	**TEST** **COMMUNICATION**

Last revision approved by :

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DOCUMENT AMENDMENT RECORD

Author	Issue	Date	Reason for change
RIVADENEIRA Melissa	A	21/12/2020	Creation
RIVADENEIRA Melissa	B	12/03/2021	Rapport complet
RIVADENEIRA Melissa	C	08/10/2021	Raw Data added

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1. INTRODUCTION

This report describes the Total Ionization Dose (TID) campaign run on Teledyne's e2v DDR4 4GB Radiation Tolerant Memory. The aim of these tests is to evaluate the component tolerance hardness to a 100 krad(Si) radiation dose accumulation.The following report describes experimental conditions, test conditions and results .

2. 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"

3. REFERENCE DOCUMENTS

RD1. Teledyne-e2v Datasheet DS 60S 219041 (C), "4GB / 8GB Radiation Tolerant DDR4 Memory"

4. SAMPLES DESCRIPTION

4.1 Identification

Manufacturer's designation	DDR4T04G72
Manufacturer's name	Teledyne-e2v Semiconductors
Manufacturer's address	Avenue de Rochepleine, 38120 Saint-Egrève, France
Package designation	Plastic Ball Grid Array (PBGA) - 391 pins
Component family	DDR4T
Component designation	DDR4T04G72AZS1A
Datasheet reference	4GB / 8GB Radiation Tolerant DDR4 Memory, DS 60S 219041(C)-HIREL-10/20
Sampling size	5 x Biased ON(#1 to #5) and 5 x Biased OFF (#6 to #10)
Wafer diffusion lot	9DN28XYA2
Die Fabrication Date Code	2028
Die revision	Z01A

4.2 Short description of the device

The 4GB Radiation Tolerant DDR4 Memory Multi-Chip Package (MCP) is a Ultra High Density Memory based on two stacks of memory dies.

It is composed of 64 data bits and 8 ECC bits.

The memory speed reaches 2400MT/s.

The package is organic and sizes 15x20x1.92 mm.

5. GENERAL PROCEDURE

5.1Test System

Teledyne e2v uses its own industrial tester facility “the UltraFLEX test system” combined with a testboard embedding a LS1046A processor to ensure functional and parametrical testing of the devices. The full memory array is read and written several times. All electrical test purposes are presented together with TID results.

5.2 Radiation Dose and Annealing Steps

The TID campaign is composed of an irradiation step followed by a Room Temperature Annealing (RTA) and an Extended Temperature Annealing (ETA).

Timeline on parts Biased ON

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	101.87	310	-	12/11/2020	14:48	26/11/2020**	09:30
-	-	-	24 h / Room (RTA)	30/11/2020	12:10	01/12/2020**	12:15
			24/100°C* (ETA)	03/12/2020	13:04	04/12/2020**	13:35
-	-	-	96h/Room* (RTA)	04/12/2020	15:03	08/12/2020**	14:31
			144h/100°C* (ETA)	08/12/2020	15:36	14/12/2020**	13:50

Table 1: Irradiation Timeline of parts biased OFF

*Due to clamp after 24 hours during extended temperature annealing (100°C), the test has been stopped. Parts have been biased at room temperature during 96h before a restart at 100°C of the remaining time. Repositioning the parts in the sockets allowed us to recover from clamp and to continue the annealing at 100°C.

** The parts were sent to Teledyne e2v using dry ice for test.

Timeline on parts Biased OFF

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	103.24	310	-	12/11/2020	14:48	26/11/2020**	09:30
-	-	-	24 h / Room (RTA)	30/11/2020	12:10	01/12/2020**	12:15
			160h/100°C (ETA)	03/12/2020	13:04	10/12/2020**	13:40

Table 2: Irradiation Timeline of parts biased OFF

** The parts were sent to Teledyne using dry ice for test.

6. EXPERIMENTAL CONDITIONS

6.1 Radiation Source Dose Rate and Annealing

The dose exposures were 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.

During the dose exposures, devices under test have been irradiated in an ambient temperature of 24°C ±6°C.

During annealing step at 100°C±5°C, the temperature was controlled and monitored by using an external monitoring system.

Before exposure, dose rate calibration, using an active dosimeter SAPHYMO gamma probe, was performed at each board location.

After each Step the samples were sent to Teledyne e2V using dry ice for electrical measurements taking into account the maximum time window for tests.

Instrument	Reference	Next Calibration Date
BILT Mainframe	HRX/FVM/00110	Calibrated with multi-meter (HRX/FVM/00397)
BILT Module BE582 channel 1 to 4	HRX/FVM/00448	
Multi-meter Fluke 287/289	HRX/FVM/00397	March 05, 2021
BINDER Model 115 Oven ***(for annealing 100°C only)***	HRX/FVM/00772	January 7, 2021

Table 3 : Equipment used during Irradiation Exposures and Annealing steps

7. BIAS CONDITIONS

During exposures, bias board was provided by Teledyne e2v allowing to bias 5 samples ON in accordance with the electrical circuit will half of I/O s in pull up mode. The 5 remaining samples were biased OFF with all pins connected to ground.

During annealing steps the same stress conditions have been applied at room and 100°C temperatures.

Power supply
VDD = 1.2V
VREFCA = 0.6V
VTT = 0.6V
VPP = 2.5V

Table 4: Bias Conditions during Irradiation Exposures and Annealing

8. TEST CONDITIONS AND PARAMETERS MEASURED

8.1 Test conditions

The 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

Before and after each step, all the samples were electrically tested. During transportation, samples remained 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

Electrical tests are performed at ambient temperature. All functional and parametrical tests are run and measured at each step. Three parametric categories are closely monitored during these tests (table 5): static current, dynamic current and supply trips.

Tests	Description
Static Current	Current seen in static mode
Dynamic Current	Current seen during Write/Read cycle
TRIPS	Leakage between supply and ground

Table 5: Description of illustrated parametric tests

9. RESULTS

9.1 Test summary

Parameters are classify as “PASS” if all the samples passed the tests within upper and lower specification limits. The following table summarizes the results for each test category.

	BIASED ON				BIASED OFF			
TESTS	INIT	100krad	RTA	ETA	INIT	100krad	RTA	ETA
FUNCTIONAL	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
LEAKAGE	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
OPEN	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
SHORT	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
TRIP	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
CONSUMPTION	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS

Table 6: Result summary table

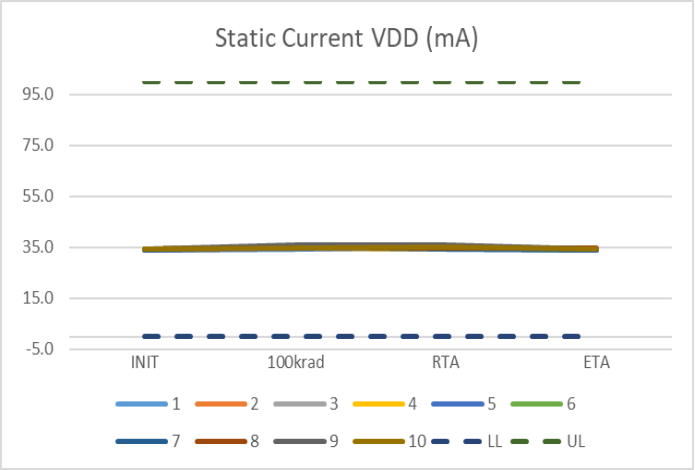
All the samples successfully passed electrical tests at each step of the TID 100 krad campaign on the DDR4T04G72 device.

9.2 Electrical Data

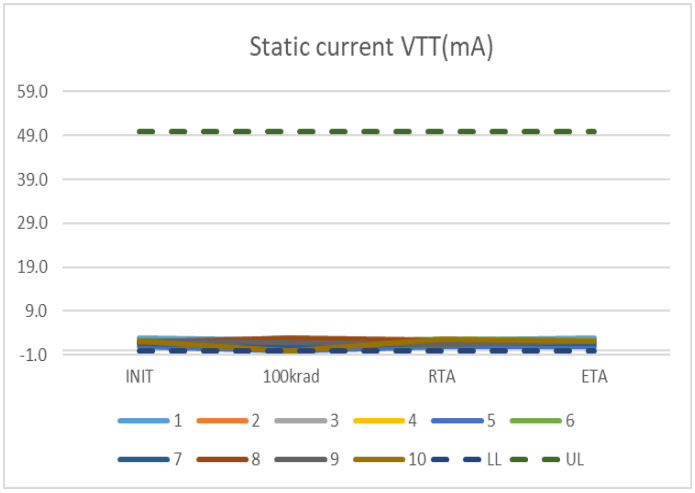
The following data and curves represent the variation of some representative parameters at each step of the TID phase for 100krad(Si).

9.2.1 Consumption

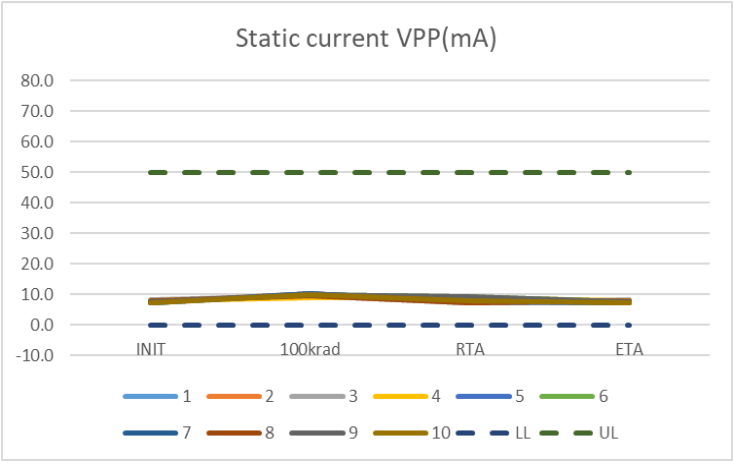
Static Current VDD (mA)				
Serial	INIT	100krad	RTA	ETA
1	33.704	35.452	34.695	33.734
2	34.123	34.933	34.580	34.153
3	34.170	34.578	34.091	34.200
4	34.064	34.530	34.199	34.094
5	33.738	34.289	35.084	33.768
6	34.359	35.178	35.313	34.389
7	33.905	35.068	34.412	33.935
8	34.473	35.232	34.798	34.503
9	34.195	35.707	35.840	34.225
10	34.197	34.665	35.185	34.227



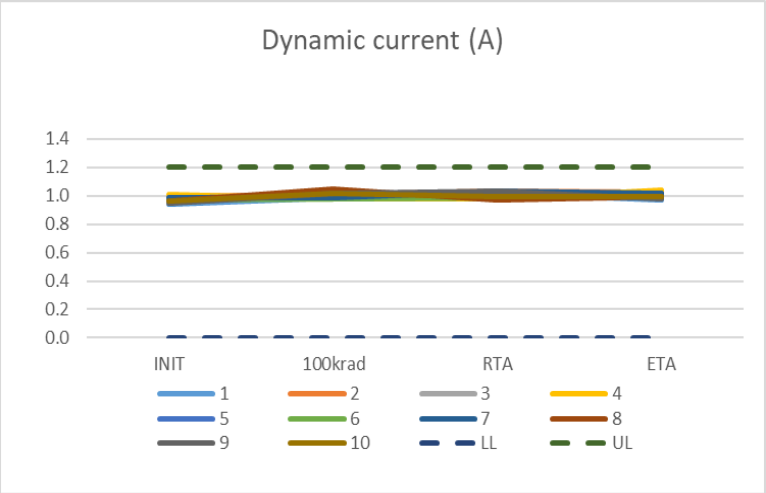
Static current VTT(mA)				
Serial	INIT	100krad	RTA	ETA
1	2.834	2.270	2.453	2.864
2	2.014	2.178	1.829	2.044
3	1.740	2.961	1.427	1.770
4	1.565	-0.025	1.718	1.595
5	0.967	0.042	0.890	0.997
6	2.457	1.518	2.666	2.487
7	1.546	0.891	1.694	1.576
8	1.989	2.813	2.435	2.019
9	2.195	1.889	1.512	2.225
10	2.062	-0.014	2.623	2.092



Static current VPP(mA)				
Serial	INIT	100krad	RTA	ETA
1	7.702	10.124	7.370	7.732
2	7.465	10.166	7.605	7.495
3	8.418	9.551	7.165	8.448
4	7.983	8.918	8.969	8.013
5	7.345	10.408	7.631	7.375
6	7.727	9.905	9.226	7.757
7	7.266	10.231	7.996	7.296
8	8.085	9.501	7.441	8.115
9	7.644	9.813	9.330	7.674
10	7.405	9.924	7.913	7.435

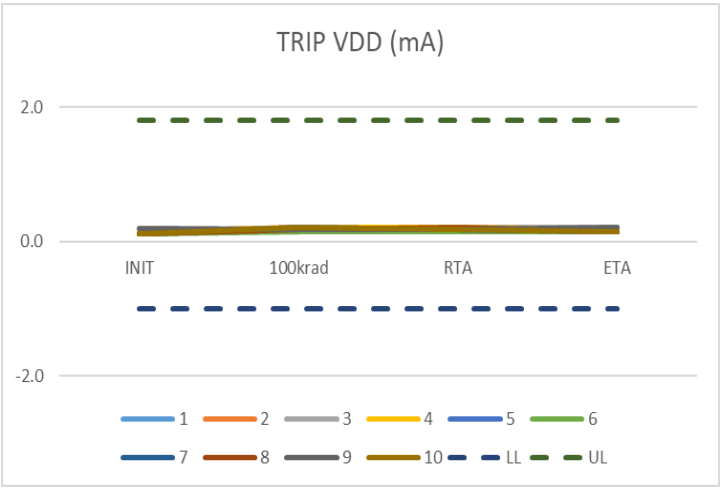


Dynamic current (A)				
Serial	INIT	100krad	RTA	ETA
1	0.938	0.984	1.015	0.968
2	0.993	1.007	1.030	1.023
3	0.969	0.984	0.976	0.999
4	1.008	0.976	0.976	1.038
5	0.985	0.992	1.015	1.015
6	0.969	0.976	0.984	0.999
7	0.985	0.984	1.030	1.015
8	0.962	1.046	0.968	0.992
9	0.946	1.015	1.030	0.976
10	0.962	1.015	0.992	0.992

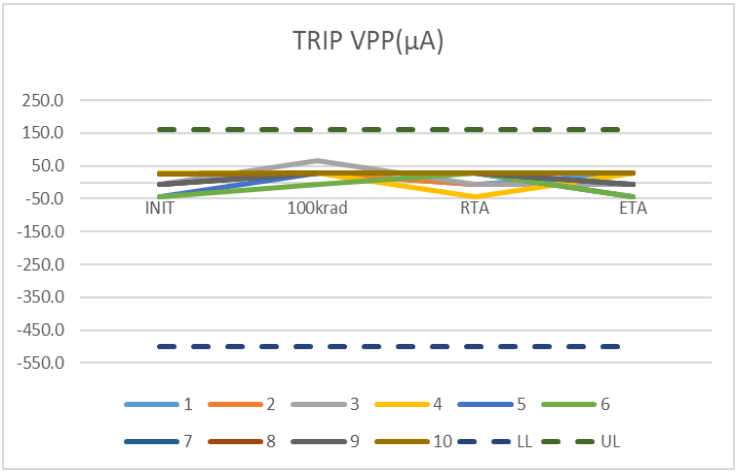


9.2.2 TRIPs

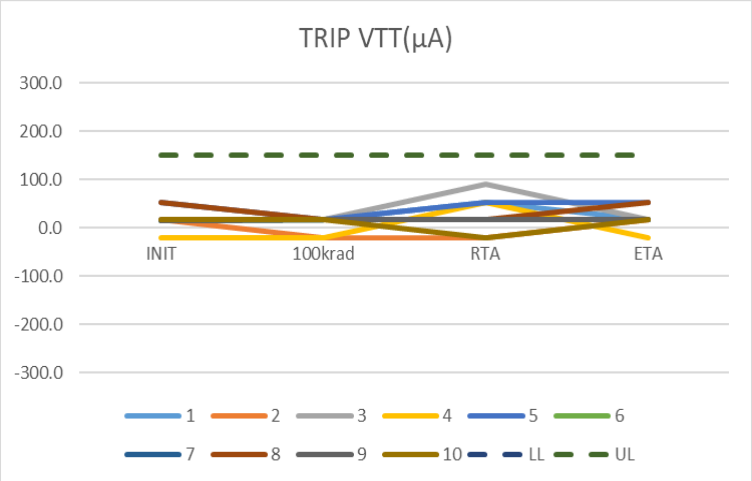
TRIP VDD (mA)				
Serial	INIT	100krad	RTA	ETA
1	0.151	0.181	0.181	0.181
2	0.151	0.218	0.181	0.181
3	0.188	0.181	0.218	0.218
4	0.151	0.218	0.218	0.181
5	0.114	0.181	0.181	0.144
6	0.114	0.144	0.144	0.144
7	0.114	0.218	0.181	0.144
8	0.114	0.181	0.218	0.144
9	0.188	0.181	0.181	0.218
10	0.114	0.218	0.181	0.144



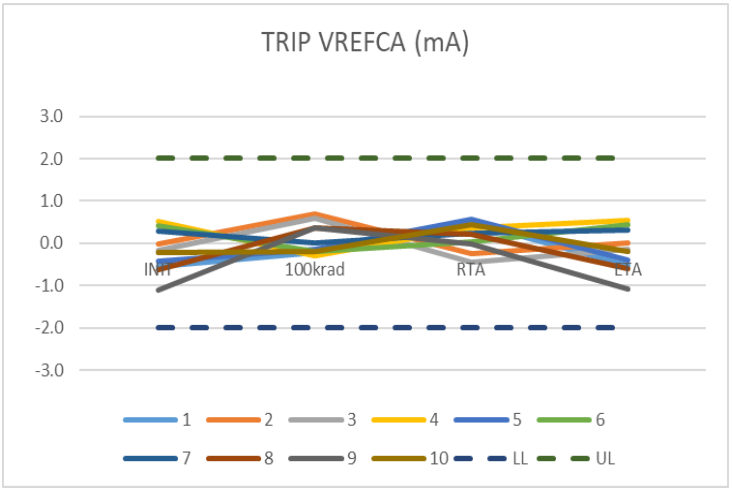
TRIP VPP(µA)				
Serial	INIT	100krad	RTA	ETA
1	29.579	29.609	-7.346	29.609
2	-7.376	29.609	-7.346	-7.346
3	-7.376	66.564	-7.346	-7.346
4	29.579	29.609	-44.302	29.609
5	-44.332	29.609	29.609	-44.302
6	-44.332	-7.346	29.609	-44.302
7	-7.376	29.609	29.609	-7.346
8	29.579	29.609	29.609	29.609
9	-7.376	29.609	29.609	-7.346
10	29.579	29.609	29.609	29.609



TRIP VTT(µA)				
Serial	INIT	100krad	RTA	ETA
1	16.660	16.690	53.613	16.690
2	16.660	-20.234	-20.234	16.690
3	16.660	16.690	90.536	16.690
4	-20.264	-20.234	53.613	-20.234
5	53.583	16.690	53.613	53.613
6	16.660	16.690	16.690	16.690
7	16.660	16.690	16.690	16.690
8	53.583	16.690	16.690	53.613
9	16.660	16.690	16.690	16.690
10	16.660	16.690	-20.234	16.690



TRIP VREFCA (mA)				
Serial	INIT	100krad	RTA	ETA
1	-0.547	-0.212	0.480	-0.517
2	-0.026	0.688	-0.248	0.004
3	-0.172	0.598	-0.460	-0.142
4	0.507	-0.293	0.354	0.537
5	-0.421	-0.155	0.566	-0.391
6	0.409	-0.195	0.037	0.439
7	0.279	0.020	0.240	0.309
8	-0.632	0.358	0.212	-0.602
9	-1.100	0.374	-0.024	-1.070
10	-0.221	-0.195	0.431	-0.191



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

10. CONCLUSION

The TID campaign was performed on Teledyne e2v's DDR4T04G72 devices (DC 2028, wafer diffusion lot 9DN28XYA2) at 100krad(Si). The tests were performed on 5 samples biased ON and 5 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 specifications.

The Teledyne e2v's DDR4T04G72 memory has been evaluated and set as a suitable part for space applications at a total ionizing dose of 100 krad(Si).