ESA STUDY CONTRACT REPORT

No ESA Study Contract Report will be accepted unless this sheet is inserted at the beginning of each volume of the Report.

ESA Contract No:	SUBJECT:	CONTRACTOR:
4000105666/12/NL/SFe	**COO4: Total Ionizing Dose Testing of STMicroelectronics TS4061 Voltage Reference**	**TRAD**

* ESA CR( )No:	No. of Volumes: **2** This is Volume No: **2**	CONTRACTOR'S REFERENCE: **TRAD/TE/TS4061-HDR/31303A/ESA/FW/1312 Rev1**

ABSTRACT:

This document is **deliverable D3: HDR Test Report**, under the Frame Contract 4000105666 with ESA on the Radiation Characterisation of Commercial EEE Components for Space Applications and more specifically on the fourth Call-of-Order for the Total Ionising Dose Testing of ST Microelectronics TS4061 Voltage Reference.

This report presents the results from the High Dose Rate (HDR) tests on the TS4061 performed in the SCK-CEN facility at MOL in Belgium. Failures were observed on the Vk and Ikmin parameters at total dose levels above 200 krad. These drifts impacted all the other measured parameters.

The work described in this report was done under ESA Contract. Responsibility for the contents resides in the author or organisation that prepared it.

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** NAME OF ESA STUDY MANAGER:	** ESA BUDGET HEADING:
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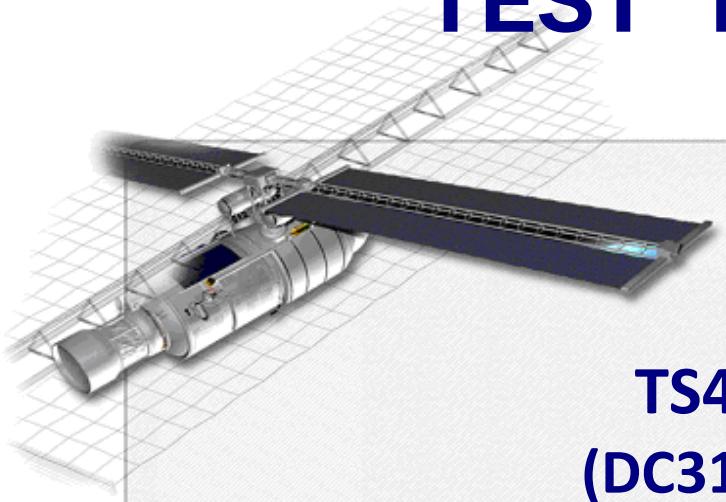
* Sections to be completed by ESA

** Information to be provided by ESA Study Manager

TOTAL IONIZING DOSE TEST REPORT



TS4061
(DC31303A)
Voltage Reference
From
STMicroelectronics

TRAD/TE/TS4061-HDR/31303A/ESA/FW/1312		Labège, 2 July 2014
TRAD Tests & radiations afaq ISO 9001 Qualité AFNOR CERTIFICATION		TRAD, Bât Gallium 907, Voie l'Occitane - 31670 LABEGE France ☏: 05 61 00 95 60 Fax: 05 61 00 95 61 Email: trad@trad.fr Web Site: www.trad.fr SIRET 397 862 038 00056 - TVA FR59397862038
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Revision: 0	26/05/2014	
Revision: 1	§3.2, §6.1, §8.2.1 updated	
To: **ESA** **Christian POIVEY**		Project/Program: COO4 Ref: ESA Contract 4000105666/12/NL/SFe

CONTENTS

FIGURES

1. INTRODUCTION

This report describes the **High Dose Rate (HDR)** testing and characterization of the **TS4061** manufactured by **STMicroelectronics**. Testing began on 26 February 2014 and ended on 7 March 2014.

2. DOCUMENTS

2.1. Applicable documents

- Financial and technical proposal: TRAD/P/ESA/COO4/AV/161013 Rev.0
- Irradiation test plan: ITP/TRA/TS4061-HDR/FP10/STM/151013/1 of 20-01-2014
- Mail from G.Chaumont, dated 20/01/2014, subject: "RE: ESA TID tests on TS4061 - need answers"
- Mail from A Varotsou, dated 20/01/2014, subject: "Fwd: Deliverable 1 (D1) COO4: Test Plans LDR and HDR"

2.2. Reference documents

- Standard method: MIL-STD-883H method 1019.8 of 26/02/2010
- Datasheet: STMicroelectronics TS4061 rev8 of December 2013

3. PART INFORMATION

3.1. Identification

Part designation	TS4061
Manufacturer	STMicroelectronics
Part function	Voltage Reference

3.2. Procurement information

Package	FP-10
Date code	31303A
Customer P/O	1321
Number of tested parts	10 irradiated samples + 1 reference sample

3.3. Sample pictures

3.3.1. External view

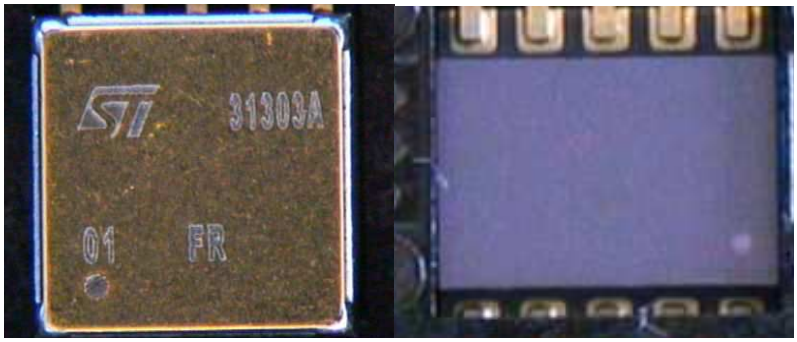


Figure 1: Package marking

3.3.2. Internal view

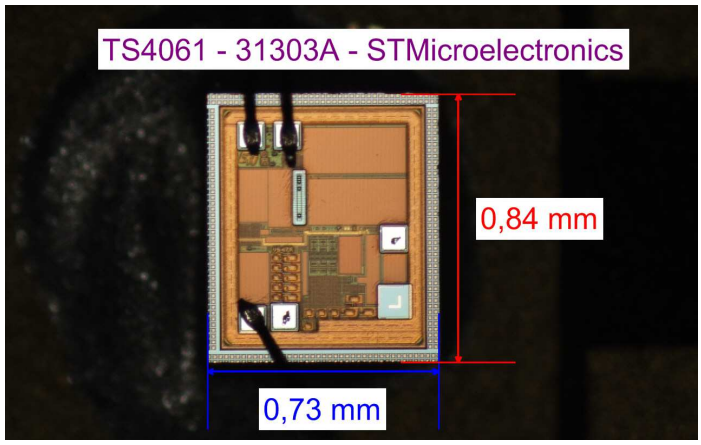


Figure 2: Internal overall view

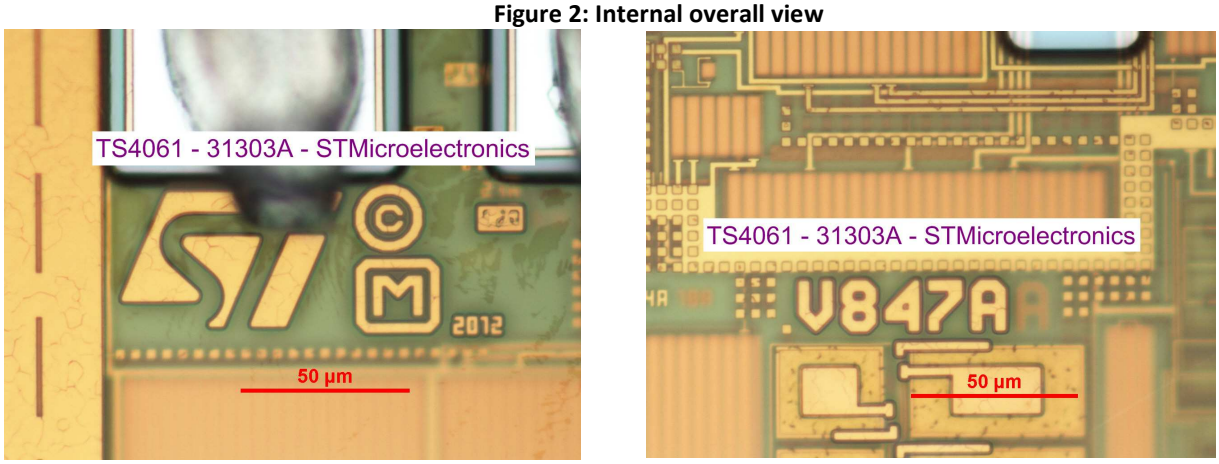


Figure 3: Die marking

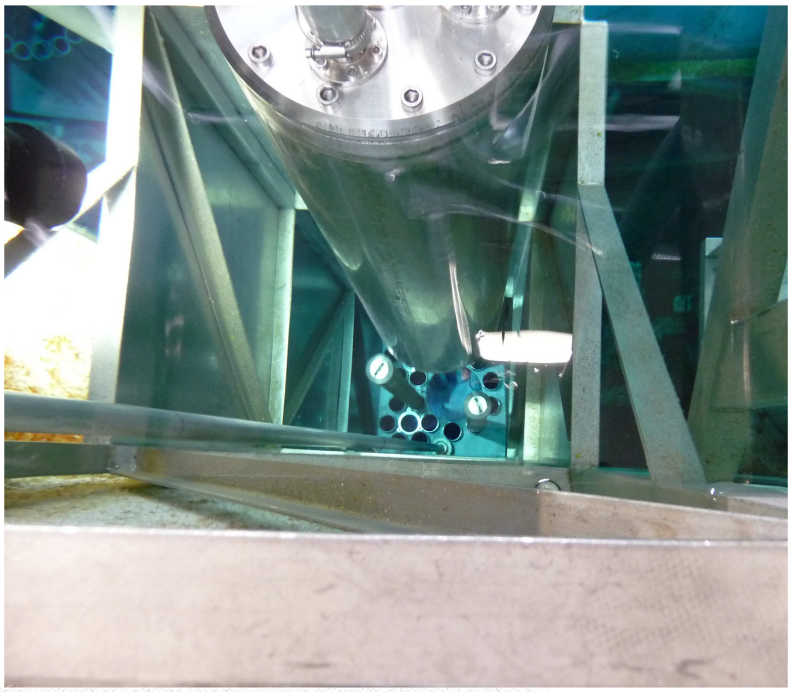
4. DOSIMETRY AND IRRADIATION FACILITY

4.1. Irradiation facility

Irradiation source	^{60}Co
Source location	SCK-CEN (Mol, Belgium)
Irradiation equipment	BR-2

4.1.1. Irradiation facility (SCK-CEN, MOL)

Gamma emitted radiation energies are 1.17 and 1.33 MeV.



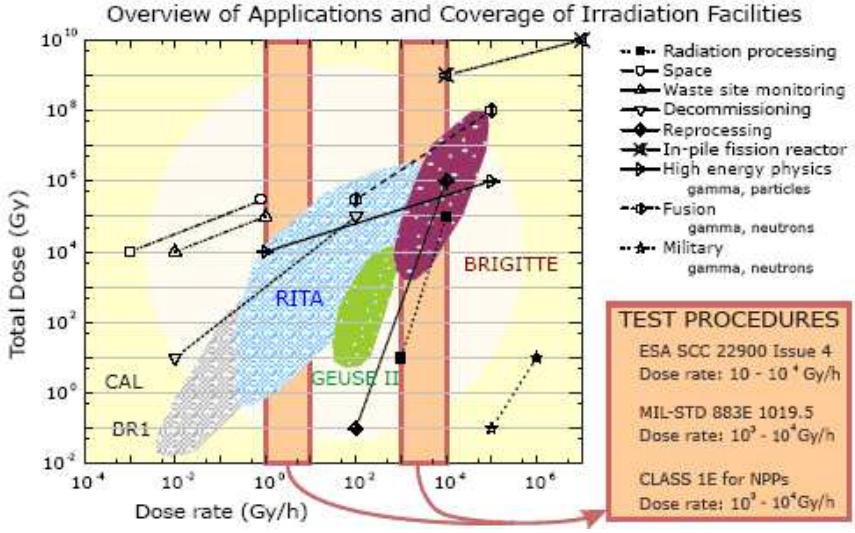


Figure 4 : Irradiation facility

SCKCEN is operating different gamma irradiation facilities, with gamma dose rates ranging from 0.1 Gy/h up to 50 kGy/h. The gamma sources are ^{60}Co. The gamma facilities cover most of the application areas dealing with ionising radiation.

The 6 different facilities have a wide range of requirements to provide representative, repeatable and reliable tests. These requirements are:

- A rather flexible dose rate from 0.1 Gy/h up to 50 kGy/h
- Reliable dose measurements: the dose rate is measured with Red Perspex (PMMA) or TLD's with accuracy better than 5%
- Atmosphere control: rinsing the samples with dry air, N^2, CO^2, etc
- Temperature control: an active temperature control up to 300 °C in several irradiation facilities
- Online measurement and biasing capabilities: standard instrumentation is available and also the possibility to install your own special instrumentation
- Irradiations in a high vacuum atmosphere up to 10^{-5} mbar are possible

4.2. Irradiation time log

Total dose limit (krad(Si))	300						
Levels for measurements (krad(Si))	0	25	50	75	100	200	300
Dose rate (krad(Si)/h)	180						

4.3. Annealing time log

Annealing at 25°C	24h
Annealing at 100°C	168h

5. BIAS SETUP

All irradiated components are biased under the following conditions. One component is not irradiated to act as a *REFERENCE*. All the parameters specified in the applicable ITP are measured on the *REFERENCE* and irradiated components.

5.1. Parts distribution

Serial number	**Reference**	**Samples irradiated**									
Mark	22	12	13	14	15	16	17	18	19	20	21
TRAD mark	1	2	3	4	5	6	7	8	9	10	11
Bias mode	REF	ON					OFF				

5.2. Bias condition

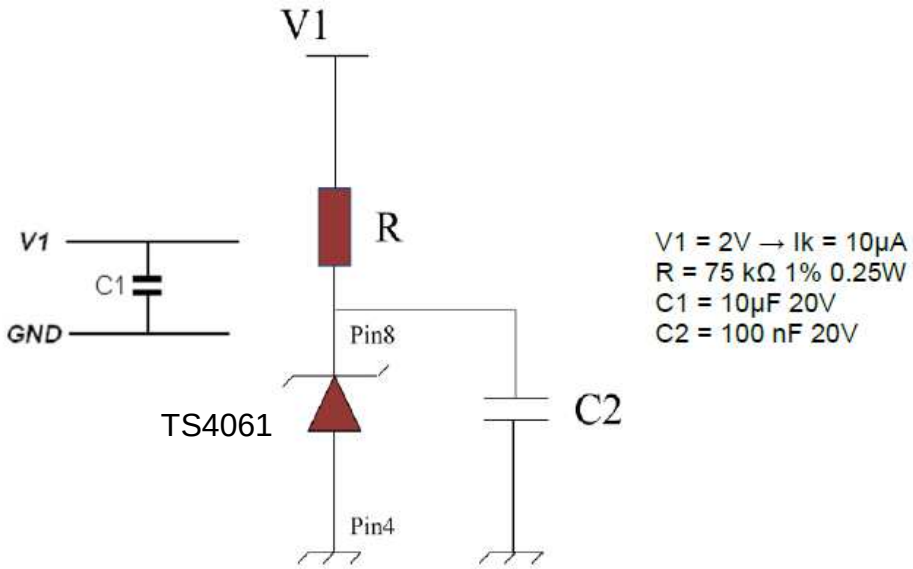


Figure 5 : Bias Condition

5.3. Bias equipment identification

Bias board	TRAD/CP1/E/TS4061-HDR/DIL14/FW/1402 TRAD/CP1/5-OF/DIL14/LS/1306
Equipment	GR-04

6. TEST SETUP

6.1. Test parameters

Parameters	Symbols	Test conditions	Limits**	
			Min	Max
Ta = 25°C, unless otherwise specified				
Reverse Breakdown Voltage	Vk	Ik = 10µA	1.2487V	1.2512V
Minimum Operating Current	Ikmin	Vk = 1.25V	-	10µA
Average Temperature Coefficient	DVk/DT*	Ik= 10µA	-	35ppm/°C
		Ik= 15mA		
Average Reverse Breakdown Voltage vs Operating Current Range	DVk1/Ik	10µA ≤ Ik ≤ 1mA	-	1mV
	DVk2/Ik	1mA ≤ Ik ≤ 15mA	-	4mV
Static Impedance	Rka	DIk = 10µA to 10 mA	-	0.3Ω
Wide Band Noise	en	Ik = 10 µA et f = 1 kHz	-	-

*For Average Temperature Coefficient calculation, Vk shall be measured at -55°C, -15°C, 25°C, 75°C and 125°C. This measurement shall only be calculated before irradiation, and after the last irradiation step, and after each annealing step. The formula used to calculate this coefficient is $\frac{Vkmax - Vkmin}{180°C \times Vk(25°C)} \times 10^6$.

** These limits are based on the Datasheet: STMicroelectronics TS4061 rev8 of December 2013. Since the chips tested have been packaged in a package not qualified by STM, limits are given for indication only.

6.2. Test equipment identification

Test board	TRAD/CT1/E/TS4061-HDR/31303A/ESA/FW/1402 TRAD/CT3/E/RHF1009A-LDR/XXX1/STM/APD/1301
Equipment	MI-59 ; SM-82 ; GR-53 ; MI-16
Test program	TS4061-HDR_B2_dev_v10.llb TS4061-HDR_B2_dev_v20.llb TS4061-HDR_B2_dev_v30.llb

7. NON CONFORMANCE

Test and measurement conditions were nominal.

8. RESULTS

8.1. Presentation of the results

For each parameter:
- The measurements performed at each irradiation step are registered in a table.
- Drifts between each measurement step and the “0” krad(Si) step are computed.

8.2. Drift of the parameters

8.2.1. Parts biased ON

The parameter Vk shows a drift at 200 kRad. The current Ik set at 10µA, as specified in the datasheet, does not allow the device to saturate properly.

This behaviour is confirmed on the Ikmin parameter (p. A-3 of the Appendix). The latter is not measurable at the 200 and 300 kRad steps. To perform the Ikmin measurement, the Ik current is increased until the output voltage Vk= 1.25V is obtained. In our case, at the 200 and 300 kRad steps, the output voltage Vk can not be reached in spite of the fact that the current was increased drastically (up to 15mA).

Parameters $\frac{DVK2}{DT}$, $\frac{DVK1}{DIk}$ and $\frac{DVK2}{DIk}$ were also impacted by the drift of Ik.

After annealing, the Ikmin parameter does not recover completely. However, even if the current is high for several parts all parameters are measurable.

8.2.2. Parts biased OFF

Parts biased OFF are less sensitive than parts biased ON. The degradation of the Vk parameter is less important at the 200 kRad and 300 kRad steps than the degradation observed on parts biased ON.

This tendency is confirmed on the Ik parameter, which is still measurable at 200 kRad in spite of the important rise of the current. At the 300 kRad step, Vk = 1.25V can not be reached in spite of the Ik current important increase (up to 15mA).

9. CONCLUSION

The total dose steady-state irradiation test using gamma rays from Cobalt 60 source has been carried out on **10 TS4061**, a **Voltage Reference** from **STMicroelectronics** up to **300 krad(Si)** at high dose rate (180 krad(Si)/h).

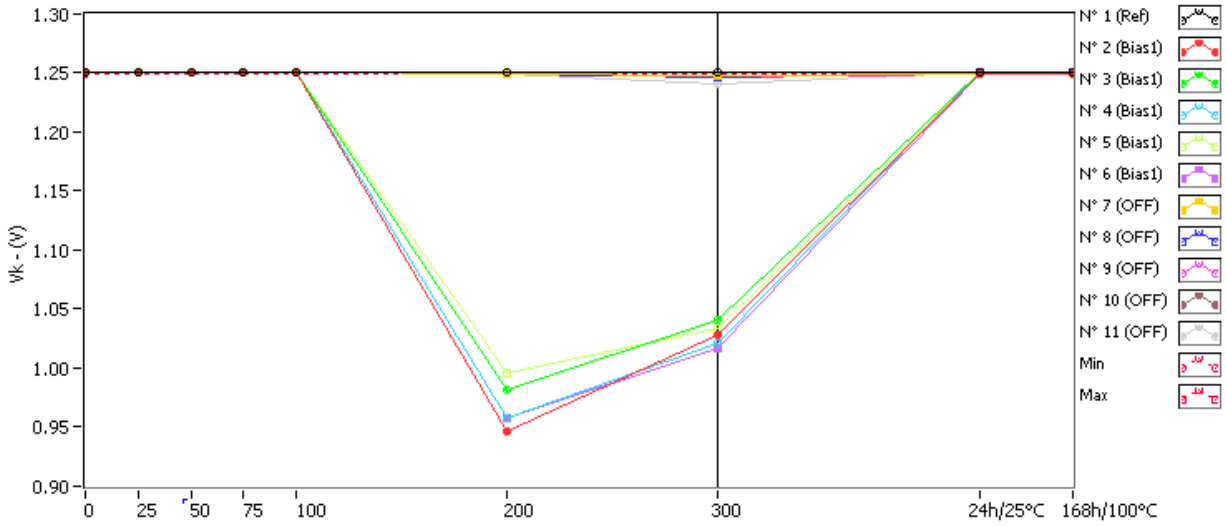
Failures were observed on the Vk and Ik parameters at total dose level above 200 krad. These drifts impacted all the other parameters measured. After the annealing steps, all the parameters are measurable.

10. APPENDIX 1 MEASURED PARAMETERS

Contents :

1. Vk

Ta=25°C ; Ik=10µA



Vk . (V) **Min = 1.2487 Max = 1.2512**

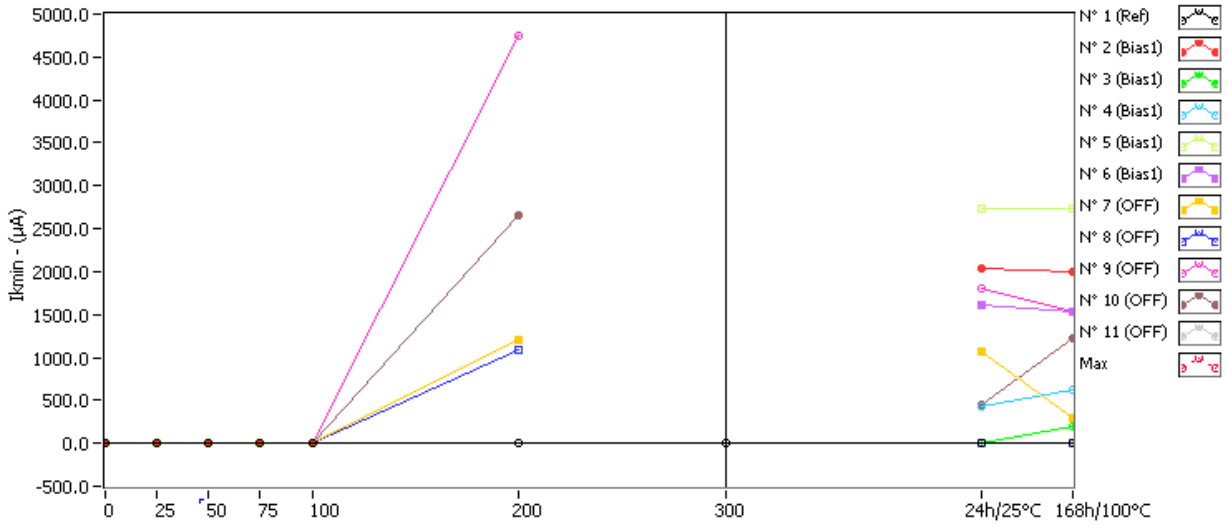
	0krad(Si)	25krad(Si)	50krad(Si)	75krad(Si)	100krad(Si)	200krad(Si)	300krad(Si)	24h/25°C	168h/100°C
N° 1 (Ref)	1.2506	1.2505	1.2505	1.2505	1.2505	1.2505	1.2505	1.2506	1.2506
N° 2 (Bias1)	1.2505	1.2503	1.2503	1.2503	1.2500	0.9465	1.0280	1.2496	1.2495
N° 3 (Bias1)	1.2510	1.2508	1.2508	1.2507	1.2504	0.9823	1.0402	1.2501	1.2499
N° 4 (Bias1)	1.2511	1.2510	1.2509	1.2508	1.2506	0.9579	1.0216	1.2500	1.2498
N° 5 (Bias1)	1.2506	1.2505	1.2504	1.2503	1.2501	0.9951	1.0340	1.2494	1.2493
N° 6 (Bias1)	1.2510	1.2509	1.2509	1.2508	1.2506	0.9582	1.0174	1.2498	1.2496
N° 7 (OFF)	1.2505	1.2504	1.2504	1.2504	1.2503	1.2497	1.2478	1.2497	1.2499
N° 8 (OFF)	1.2509	1.2509	1.2510	1.2509	1.2508	1.2499	1.2471	1.2503	1.2503
N° 9 (OFF)	1.2504	1.2504	1.2504	1.2504	1.2502	1.2490	1.2459	1.2495	1.2496
N° 10 (OFF)	1.2504	1.2504	1.2504	1.2503	1.2503	1.2495	1.2465	1.2499	1.2496
N° 11 (OFF)	1.2509	1.2508	1.2509	1.2508	1.2508	1.2492	1.2409	1.2503	1.2502

Delta [Vk]

	0krad(Si)	25krad(Si)	50krad(Si)	75krad(Si)	100krad(Si)	200krad(Si)	300krad(Si)	24h/25°C	168h/100°C
N° 1 (Ref)	---	-1.600E-5	-1.500E-5	-1.800E-5	-1.700E-5	-1.600E-5	-1.700E-5	1.000E-6	1.000E-6
N° 2 (Bias1)	---	-1.510E-4	-1.550E-4	-1.900E-4	-4.440E-4	-3.040E-1	-2.225E-1	-8.770E-4	-1.028E-3
N° 3 (Bias1)	---	-1.960E-4	-2.200E-4	-2.640E-4	-5.590E-4	-2.687E-1	-2.108E-1	-8.390E-4	-1.093E-3
N° 4 (Bias1)	---	-1.330E-4	-1.790E-4	-2.340E-4	-4.660E-4	-2.932E-1	-2.295E-1	-1.082E-3	-1.286E-3
N° 5 (Bias1)	---	-1.930E-4	-2.260E-4	-3.750E-4	-5.100E-4	-2.555E-1	-2.166E-1	-1.254E-3	-1.378E-3
N° 6 (Bias1)	---	-1.450E-4	-1.190E-4	-2.130E-4	-4.550E-4	-2.928E-1	-2.336E-1	-1.165E-3	-1.438E-3
N° 7 (OFF)	---	-8.100E-5	-7.500E-5	-8.000E-5	-1.520E-4	-7.800E-4	-2.706E-3	-7.580E-4	-5.990E-4
N° 8 (OFF)	---	-7.300E-5	3.000E-6	-1.100E-5	-1.190E-4	-1.055E-3	-3.886E-3	-6.780E-4	-6.950E-4
N° 9 (OFF)	---	-3.000E-5	2.600E-5	-2.400E-5	-1.630E-4	-1.373E-3	-4.500E-3	-8.850E-4	-8.320E-4
N° 10 (OFF)	---	-6.300E-5	-1.700E-5	-7.400E-5	-1.290E-4	-9.320E-4	-3.912E-3	-5.300E-4	-7.710E-4
N° 11 (OFF)	---	-5.000E-5	-2.300E-5	-5.800E-5	-1.120E-4	-1.646E-3	-9.952E-3	-5.830E-4	-6.780E-4
Average (OFF)	---	-1.636E-4	-1.798E-4	-2.552E-4	-4.868E-4	-2.828E-1	-2.226E-1	-1.043E-3	-1.245E-3
s (OFF)	---	2.896E-5	4.490E-5	7.230E-5	4.750E-5	2.000E-2	9.256E-3	1.803E-4	1.781E-4
Average+3s (OFF)	---	-7.671E-5	-4.511E-5	-3.829E-5	-3.443E-4	-2.228E-1	-1.948E-1	-5.024E-4	-7.104E-4
Average-3s (OFF)	---	-2.505E-4	-3.145E-4	-4.721E-4	-6.293E-4	-3.428E-1	-2.504E-1	-1.584E-3	-1.779E-3
Average (Bias1)	---	-5.940E-5	-1.720E-5	-4.940E-5	-1.350E-4	-1.157E-3	-4.991E-3	-6.868E-4	-7.150E-4
s (Bias1)	---	2.011E-5	3.758E-5	3.056E-5	2.176E-5	3.496E-4	2.849E-3	1.412E-4	8.951E-5
Average+3s (Bias1)	---	9.216E-7	9.554E-5	4.227E-5	-6.972E-5	-1.083E-4	3.555E-3	-2.631E-4	-4.465E-4
Average-3s (Bias1)	---	-1.197E-4	-1.299E-4	-1.411E-4	-2.003E-4	-2.206E-3	-1.354E-2	-1.111E-3	-9.835E-4

2. Ikmin

Ta=25°C ; Vk=1.25V



Ikmin . (µA) **Max = 10.0**

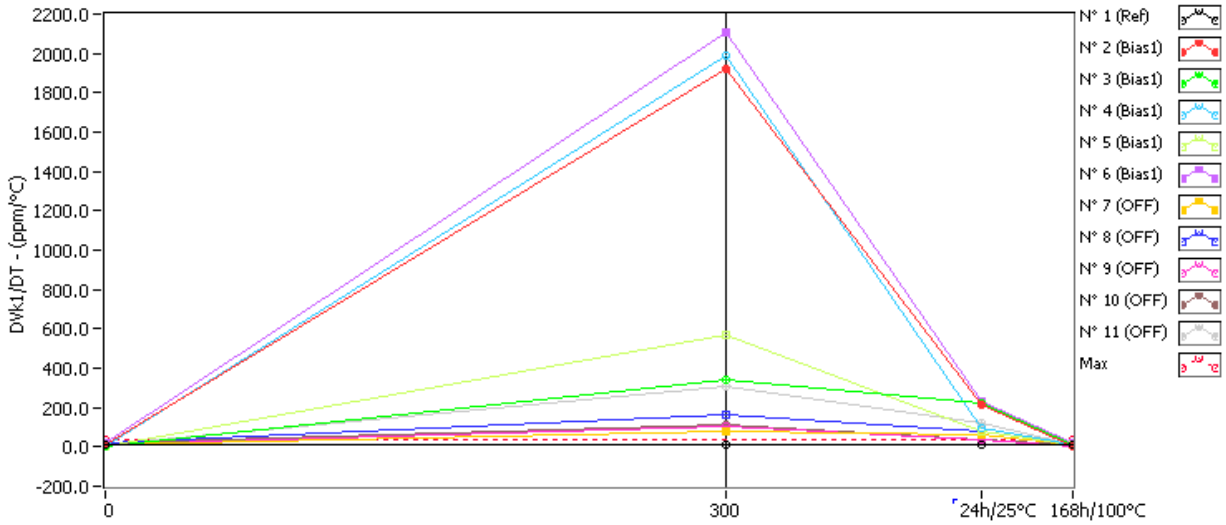
	0krad(Si)	25krad(Si)	50krad(Si)	75krad(Si)	100krad(Si)	200krad(Si)	300krad(Si)	24h/25°C	168h/100°C
N° 1 (Ref)	7.020	7.040	7.040	7.060	7.040	7.050	7.050	7.020	7.000
N° 2 (Bias1)	6.970	6.960	7.000	7.720	9.850	Not Measurable	Not Measurable	2035.000	2005.000
N° 3 (Bias1)	6.920	6.910	6.980	8.150	9.610	Not Measurable	Not Measurable	7.880	200.390
N° 4 (Bias1)	7.010	6.970	7.040	7.920	9.330	Not Measurable	Not Measurable	437.690	631.500
N° 5 (Bias1)	6.960	6.940	7.070	8.650	9.800	Not Measurable	Not Measurable	2728.000	2726.500
N° 6 (Bias1)	6.990	6.980	7.050	7.920	9.300	Not Measurable	Not Measurable	1610.000	1542.500
N° 7 (OFF)	7.010	7.000	7.000	7.000	7.010	1200.000	Not Measurable	1059.890	302.500
N° 8 (OFF)	6.990	7.000	7.000	7.000	7.010	1089.000	Not Measurable	7.040	6.500
N° 9 (OFF)	6.960	6.970	6.960	6.970	7.010	4750.000	Not Measurable	1809.000	1536.500
N° 10 (OFF)	7.070	7.070	7.080	7.080	7.090	2650.000	Not Measurable	446.890	1215.500
N° 11 (OFF)	6.980	6.980	6.990	6.980	6.990	4750.000	Not Measurable	7.010	6.950

Delta [Ikmin]

	0krad(Si)	25krad(Si)	50krad(Si)	75krad(Si)	100krad(Si)	200krad(Si)	300krad(Si)	24h/25°C	168h/100°C
N° 1 (Ref)	---	2.000E-2	2.000E-2	4.000E-2	2.000E-2	3.000E-2	3.000E-2	0.000E+0	-2.000E-2
N° 2 (Bias1)	---	-1.000E-2	3.000E-2	7.500E-1	2.880E+0	NaN	NaN	2.028E+3	1.998E+3
N° 3 (Bias1)	---	-1.000E-2	6.000E-2	1.230E+0	2.690E+0	NaN	NaN	9.600E-1	1.935E+2
N° 4 (Bias1)	---	-4.000E-2	3.000E-2	9.100E-1	2.320E+0	NaN	NaN	4.307E+2	6.245E+2
N° 5 (Bias1)	---	-2.000E-2	1.100E-1	1.690E+0	2.840E+0	NaN	NaN	2.721E+3	2.720E+3
N° 6 (Bias1)	---	-1.000E-2	6.000E-2	9.300E-1	2.310E+0	NaN	NaN	1.603E+3	1.536E+3
N° 7 (OFF)	---	-1.000E-2	-1.000E-2	-1.000E-2	0.000E+0	1.193E+3	NaN	1.053E+3	2.955E+2
N° 8 (OFF)	---	1.000E-2	1.000E-2	1.000E-2	2.000E-2	1.082E+3	NaN	5.000E-2	-4.900E-1
N° 9 (OFF)	---	1.000E-2	0.000E+0	1.000E-2	5.000E-2	4.743E+3	NaN	1.802E+3	1.530E+3
N° 10 (OFF)	---	0.000E+0	1.000E-2	1.000E-2	2.000E-2	2.643E+3	NaN	4.398E+2	1.208E+3
N° 11 (OFF)	---	0.000E+0	1.000E-2	0.000E+0	1.000E-2	4.743E+3	NaN	3.000E-2	-3.000E-2
Average (OFF)	---	-1.800E-2	5.800E-2	1.102E+0	2.608E+0	NaN	NaN	1.357E+3	1.414E+3
s (OFF)	---	1.304E-2	3.271E-2	3.716E-1	2.767E-1	0.000E+0	0.000E+0	1.126E+3	1.021E+3
Average+3s (OFF)	---	2.112E-2	1.561E-1	2.217E+0	3.438E+0	NaN	NaN	4.734E+3	4.479E+3
Average-3s (OFF)	---	-5.712E-2	-4.013E-2	-1.293E-2	1.778E+0	NaN	NaN	-2.020E+3	-1.650E+3
Average (Bias1)	---	2.000E-3	4.000E-3	4.000E-3	2.000E-2	2.881E+3	NaN	6.590E+2	6.066E+2
s (Bias1)	---	8.367E-3	8.944E-3	8.944E-3	1.871E-2	1.808E+3	0.000E+0	7.711E+2	7.154E+2
Average+3s (Bias1)	---	2.710E-2	3.083E-2	3.083E-2	7.612E-2	8.305E+3	NaN	2.972E+3	2.753E+3
Average-3s (Bias1)	---	-2.310E-2	-2.283E-2	-2.283E-2	-3.612E-2	-2.543E+3	NaN	-1.654E+3	-1.540E+3

3. DVk1/DT

DT=-55°C to 125°C ; Ik = 10µA



DVk1/DT . (ppm/°C) **Max = 35.0**

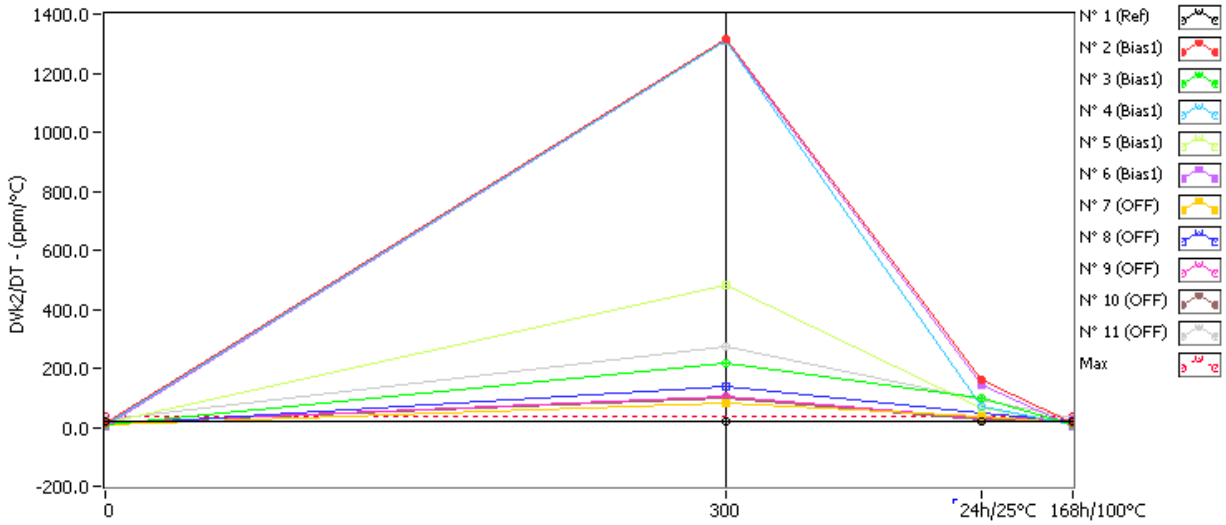
	0krad(Si)	300krad(Si)	24h/25°C	168h/100°C
N° 1 (Ref)	7.39	8.25	9.46	9.28
N° 2 (Bias1)	7.88	1924.09	215.46	6.10
N° 3 (Bias1)	5.91	338.20	224.19	14.86
N° 4 (Bias1)	3.47	1992.55	99.96	9.99
N° 5 (Bias1)	5.05	567.82	80.46	11.18
N° 6 (Bias1)	22.01	2105.21	229.08	21.82
N° 7 (OFF)	10.19	82.43	65.97	10.87
N° 8 (OFF)	18.02	160.26	82.79	8.16
N° 9 (OFF)	11.61	101.89	39.34	6.51
N° 10 (OFF)	18.20	110.67	40.30	10.76
N° 11 (OFF)	12.04	311.08	125.15	12.17

Delta [DVk1/DT]

	0krad(Si)	300krad(Si)	24h/25°C	168h/100°C
N° 1 (Ref)	---	8.544E-1	2.069E+0	1.888E+0
N° 2 (Bias1)	---	1.916E+3	2.076E+2	-1.779E+0
N° 3 (Bias1)	---	3.323E+2	2.183E+2	8.950E+0
N° 4 (Bias1)	---	1.989E+3	9.648E+1	6.516E+0
N° 5 (Bias1)	---	5.628E+2	7.541E+1	6.134E+0
N° 6 (Bias1)	---	2.083E+3	2.071E+2	-1.860E-1
N° 7 (OFF)	---	7.224E+1	5.578E+1	6.827E-1
N° 8 (OFF)	---	1.422E+2	6.476E+1	-9.861E+0
N° 9 (OFF)	---	9.027E+1	2.773E+1	-5.102E+0
N° 10 (OFF)	---	9.246E+1	2.210E+1	-7.447E+0
N° 11 (OFF)	---	2.990E+2	1.131E+2	1.254E-1
Average (OFF)	---	1.377E+3	1.610E+2	3.927E+0
s (OFF)	---	8.542E+2	6.903E+1	4.644E+0
Average+3s (OFF)	---	3.939E+3	3.681E+2	1.786E+1
Average-3s (OFF)	---	-1.186E+3	-4.613E+1	-1.001E+1
Average (Bias1)	---	1.393E+2	5.670E+1	-4.320E+0
s (Bias1)	---	9.303E+1	3.635E+1	4.634E+0
Average+3s (Bias1)	---	4.183E+2	1.657E+2	9.581E+0
Average-3s (Bias1)	---	-1.398E+2	-5.234E+1	-1.822E+1

4. DVk2/DT

DT=-55°C to 125°C ; Ik = 15mA



DVk2/DT . (ppm/°C) **Max = 35.0**

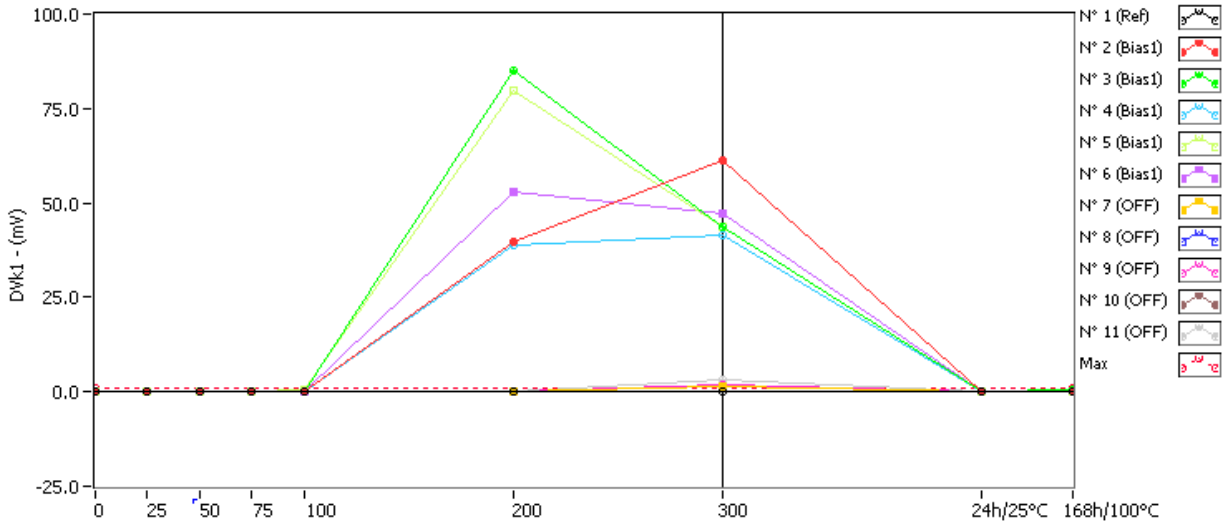
	0krad(Si)	300krad(Si)	24h/25°C	168h/100°C
N° 1 (Ref)	17.81	18.26	18.96	19.81
N° 2 (Bias1)	13.98	1317.73	161.33	11.63
N° 3 (Bias1)	8.26	216.51	99.14	7.88
N° 4 (Bias1)	10.78	1312.57	72.38	10.47
N° 5 (Bias1)	13.36	484.20	66.51	13.42
N° 6 (Bias1)	5.55	1311.62	140.98	4.11
N° 7 (OFF)	6.72	79.42	38.88	14.56
N° 8 (OFF)	11.07	139.84	47.49	18.87
N° 9 (OFF)	16.32	102.60	32.17	23.95
N° 10 (OFF)	12.73	96.61	25.14	21.64
N° 11 (OFF)	22.77	274.39	91.66	28.43

Delta [DVk2/DT]

	0krad(Si)	300krad(Si)	24h/25°C	168h/100°C
N° 1 (Ref)	---	4.518E-1	1.155E+0	2.000E+0
N° 2 (Bias1)	---	1.304E+3	1.473E+2	-2.354E+0
N° 3 (Bias1)	---	2.083E+2	9.087E+1	-3.807E-1
N° 4 (Bias1)	---	1.302E+3	6.159E+1	-3.101E-1
N° 5 (Bias1)	---	4.708E+2	5.316E+1	5.684E-2
N° 6 (Bias1)	---	1.306E+3	1.354E+2	-1.441E+0
N° 7 (OFF)	---	7.271E+1	3.216E+1	7.847E+0
N° 8 (OFF)	---	1.288E+2	3.642E+1	7.807E+0
N° 9 (OFF)	---	8.628E+1	1.585E+1	7.624E+0
N° 10 (OFF)	---	8.388E+1	1.242E+1	8.911E+0
N° 11 (OFF)	---	2.516E+2	6.889E+1	5.661E+0
Average (OFF)	---	9.181E+2	9.768E+1	-8.859E-1
s (OFF)	---	5.363E+2	4.249E+1	9.925E-1
Average+3s (OFF)	---	2.527E+3	2.252E+2	2.092E+0
Average-3s (OFF)	---	-6.907E+2	-2.980E+1	-3.863E+0
Average (Bias1)	---	1.247E+2	3.315E+1	7.570E+0
s (Bias1)	---	7.411E+1	2.246E+1	1.181E+0
Average+3s (Bias1)	---	3.470E+2	1.005E+2	1.111E+1
Average-3s (Bias1)	---	-9.769E+1	-3.424E+1	4.028E+0

5. DVk1

Ta=25°C ; 10µA < Ik < 1mA



DVk1 . (mV) **Max = 1.0**

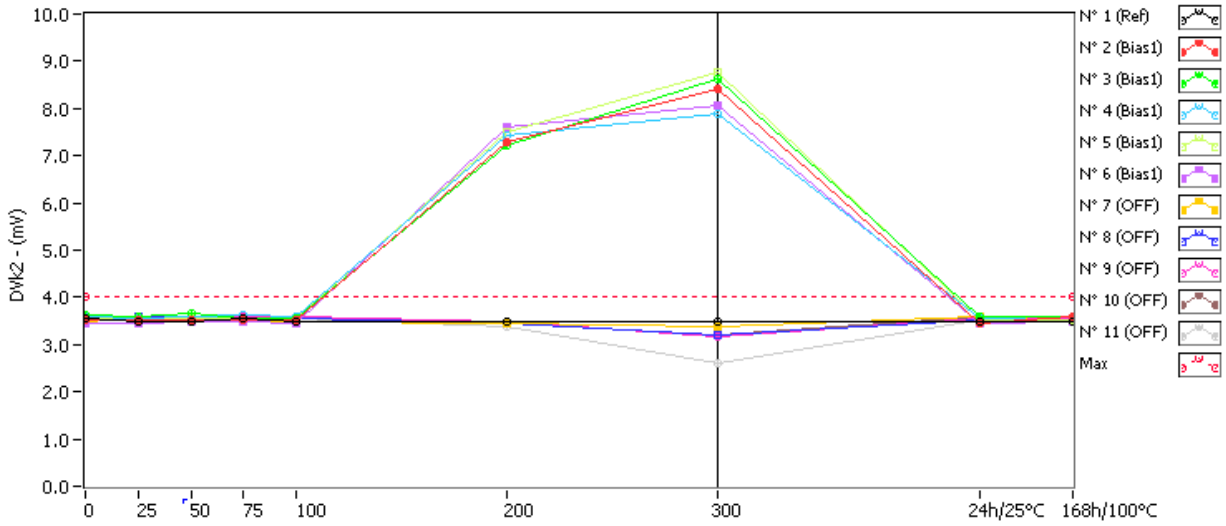
	0krad(Si)	25krad(Si)	50krad(Si)	75krad(Si)	100krad(Si)	200krad(Si)	300krad(Si)	24h/25°C	168h/100°C
N° 1 (Ref)	0.276	0.280	0.279	0.274	0.281	0.276	0.277	0.282	0.280
N° 2 (Bias1)	0.285	0.282	0.287	0.293	0.295	39.752	61.151	0.151	0.286
N° 3 (Bias1)	0.290	0.288	0.303	0.282	0.290	85.154	43.782	0.208	0.330
N° 4 (Bias1)	0.291	0.286	0.295	0.291	0.308	38.914	41.615	0.174	0.307
N° 5 (Bias1)	0.292	0.281	0.283	0.293	0.326	79.627	43.638	0.200	0.300
N° 6 (Bias1)	0.278	0.276	0.277	0.276	0.305	53.091	47.144	0.039	0.293
N° 7 (OFF)	0.279	0.291	0.307	0.306	0.289	0.239	1.358	0.265	0.287
N° 8 (OFF)	0.282	0.293	0.293	0.300	0.285	0.120	1.442	0.238	0.307
N° 9 (OFF)	0.280	0.285	0.288	0.293	0.284	0.088	1.705	0.300	0.309
N° 10 (OFF)	0.278	0.280	0.293	0.290	0.287	0.125	1.195	0.264	0.306
N° 11 (OFF)	0.280	0.283	0.287	0.294	0.295	0.105	3.257	0.262	0.298

Delta [DVk1]

	0krad(Si)	25krad(Si)	50krad(Si)	75krad(Si)	100krad(Si)	200krad(Si)	300krad(Si)	24h/25°C	168h/100°C
N° 1 (Ref)	---	3.900E-3	3.160E-3	-1.710E-3	5.460E-3	6.800E-4	9.200E-4	6.660E-3	3.790E-3
N° 2 (Bias1)	---	-3.810E-3	1.970E-3	8.020E-3	9.440E-3	3.947E+1	6.087E+1	-1.344E-1	1.120E-3
N° 3 (Bias1)	---	-1.700E-3	1.286E-2	-8.230E-3	1.000E-5	8.486E+1	4.349E+1	-8.168E-2	4.002E-2
N° 4 (Bias1)	---	-4.680E-3	4.510E-3	4.400E-4	1.715E-2	3.862E+1	4.132E+1	-1.166E-1	1.645E-2
N° 5 (Bias1)	---	-1.057E-2	-9.400E-3	1.080E-3	3.440E-2	7.934E+1	4.335E+1	-9.225E-2	7.760E-3
N° 6 (Bias1)	---	-2.240E-3	-1.610E-3	-2.330E-3	2.686E-2	5.281E+1	4.687E+1	-2.391E-1	1.441E-2
N° 7 (OFF)	---	1.205E-2	2.895E-2	2.748E-2	1.035E-2	-3.962E-2	1.079E+0	-1.318E-2	8.260E-3
N° 8 (OFF)	---	1.130E-2	1.126E-2	1.739E-2	2.680E-3	-1.620E-1	1.160E+0	-4.431E-2	2.470E-2
N° 9 (OFF)	---	5.130E-3	8.310E-3	1.379E-2	4.130E-3	-1.916E-1	1.426E+0	2.048E-2	2.989E-2
N° 10 (OFF)	---	2.950E-3	1.523E-2	1.222E-2	9.300E-3	-1.528E-1	9.176E-1	-1.309E-2	2.859E-2
N° 11 (OFF)	---	3.390E-3	7.770E-3	1.432E-2	1.589E-2	-1.744E-1	2.977E+0	-1.737E-2	1.818E-2
Average (OFF)	---	-4.600E-3	1.666E-3	-2.040E-4	1.757E-2	5.902E+1	4.718E+1	-1.328E-1	1.595E-2
s (OFF)	---	3.544E-3	8.165E-3	5.887E-3	1.364E-2	2.189E+1	7.906E+0	6.288E-2	1.474E-2
Average+3s (OFF)	---	6.033E-3	2.616E-2	1.746E-2	5.849E-2	1.247E+2	7.090E+1	5.585E-2	6.017E-2
Average-3s (OFF)	---	-1.523E-2	-2.283E-2	-1.787E-2	-2.335E-2	-6.664E+0	2.346E+1	-3.214E-1	-2.827E-2
Average (Bias1)	---	6.964E-3	1.430E-2	1.704E-2	8.470E-3	-1.441E-1	1.512E+0	-1.349E-2	2.192E-2
s (Bias1)	---	4.385E-3	8.707E-3	6.130E-3	5.283E-3	6.018E-2	8.395E-1	2.302E-2	8.893E-3
Average+3s (Bias1)	---	2.012E-2	4.043E-2	3.543E-2	2.432E-2	3.647E-2	4.031E+0	5.556E-2	4.860E-2
Average-3s (Bias1)	---	-6.191E-3	-1.182E-2	-1.350E-3	-7.379E-3	-3.246E-1	-1.007E+0	-8.255E-2	-4.754E-3

6. DVk2

Ta=25°C ; 1mA < Ik < 15mA



DVk2 . (mV) **Max = 4.0**

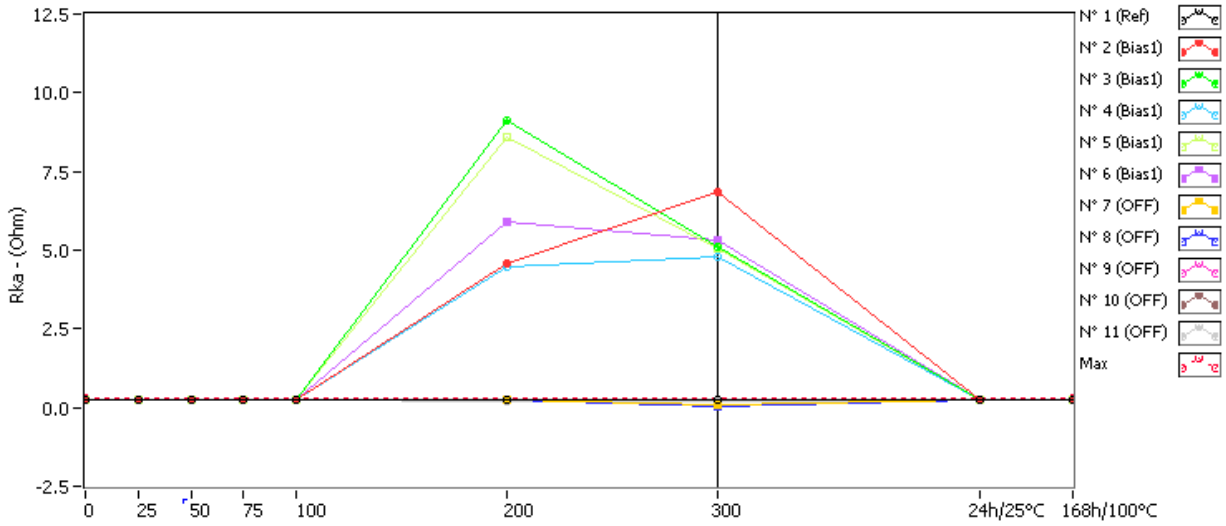
	0krad(Si)	25krad(Si)	50krad(Si)	75krad(Si)	100krad(Si)	200krad(Si)	300krad(Si)	24h/25°C	168h/100°C
N° 1 (Ref)	3.541	3.499	3.500	3.544	3.495	3.487	3.497	3.479	3.472
N° 2 (Bias1)	3.507	3.537	3.527	3.515	3.530	7.272	8.430	3.443	3.580
N° 3 (Bias1)	3.612	3.597	3.644	3.569	3.543	7.223	8.641	3.593	3.596
N° 4 (Bias1)	3.593	3.568	3.595	3.613	3.603	7.422	7.876	3.572	3.600
N° 5 (Bias1)	3.541	3.538	3.566	3.551	3.565	7.505	8.764	3.530	3.522
N° 6 (Bias1)	3.453	3.442	3.497	3.481	3.453	7.589	8.047	3.435	3.474
N° 7 (OFF)	3.482	3.550	3.509	3.496	3.497	3.460	3.372	3.577	3.490
N° 8 (OFF)	3.516	3.592	3.566	3.544	3.539	3.465	3.195	3.525	3.533
N° 9 (OFF)	3.588	3.561	3.581	3.599	3.577	3.490	3.176	3.546	3.551
N° 10 (OFF)	3.528	3.520	3.543	3.547	3.540	3.455	3.207	3.580	3.579
N° 11 (OFF)	3.597	3.603	3.592	3.538	3.547	3.388	2.589	3.522	3.550

Delta [DVk2]

	0krad(Si)	25krad(Si)	50krad(Si)	75krad(Si)	100krad(Si)	200krad(Si)	300krad(Si)	24h/25°C	168h/100°C
N° 1 (Ref)	---	-4.159E-2	-4.068E-2	3.140E-3	-4.576E-2	-5.423E-2	-4.367E-2	-6.220E-2	-6.832E-2
N° 2 (Bias1)	---	3.022E-2	2.020E-2	7.970E-3	2.339E-2	3.765E+0	4.924E+0	-6.364E-2	7.306E-2
N° 3 (Bias1)	---	-1.483E-2	3.282E-2	-4.266E-2	-6.871E-2	3.612E+0	5.029E+0	-1.900E-2	-1.531E-2
N° 4 (Bias1)	---	-2.499E-2	2.710E-3	2.011E-2	1.015E-2	3.829E+0	4.283E+0	-2.081E-2	7.620E-3
N° 5 (Bias1)	---	-3.340E-3	2.521E-2	9.820E-3	2.362E-2	3.964E+0	5.223E+0	-1.150E-2	-1.923E-2
N° 6 (Bias1)	---	-1.104E-2	4.388E-2	2.780E-2	-2.100E-4	4.136E+0	4.593E+0	-1.780E-2	2.090E-2
N° 7 (OFF)	---	6.773E-2	2.705E-2	1.394E-2	1.458E-2	-2.276E-2	-1.101E-1	9.483E-2	8.030E-3
N° 8 (OFF)	---	7.590E-2	4.996E-2	2.857E-2	2.321E-2	-5.106E-2	-3.206E-1	8.960E-3	1.764E-2
N° 9 (OFF)	---	-2.706E-2	-6.930E-3	1.111E-2	-1.041E-2	-9.827E-2	-4.120E-1	-4.164E-2	-3.669E-2
N° 10 (OFF)	---	-7.210E-3	1.503E-2	1.950E-2	1.248E-2	-7.273E-2	-3.209E-1	5.280E-2	5.191E-2
N° 11 (OFF)	---	5.100E-3	-5.700E-3	-5.971E-2	-5.024E-2	-2.097E-1	-1.009E+0	-7.541E-2	-4.773E-2
Average (OFF)	---	-4.796E-3	2.496E-2	4.608E-3	-2.352E-3	3.861E+0	4.810E+0	-2.655E-2	1.341E-2
s (OFF)	---	2.107E-2	1.531E-2	2.762E-2	3.841E-2	1.990E-1	3.726E-1	2.103E-2	3.721E-2
Average+3s (OFF)	---	5.841E-2	7.089E-2	8.746E-2	1.129E-1	4.458E+0	5.928E+0	3.653E-2	1.250E-1
Average-3s (OFF)	---	-6.800E-2	-2.096E-2	-7.824E-2	-1.176E-1	3.264E+0	3.693E+0	-8.963E-2	-9.822E-2
Average (Bias1)	---	2.289E-2	1.588E-2	2.682E-3	-2.076E-3	-9.091E-2	-4.345E-1	7.908E-3	-1.368E-3
s (Bias1)	---	4.620E-2	2.384E-2	3.551E-2	2.966E-2	7.199E-2	3.397E-1	6.886E-2	4.088E-2
Average+3s (Bias1)	---	1.615E-1	8.739E-2	1.092E-1	8.689E-2	1.251E-1	5.846E-1	2.145E-1	1.213E-1
Average-3s (Bias1)	---	-1.157E-1	-5.563E-2	-1.038E-1	-9.104E-2	-3.069E-1	-1.454E+0	-1.987E-1	-1.240E-1

7. Rka

Ta=25°C ; DIk = 10µA to 10 mA



Rka . (Ohm) **Max = 0.3**

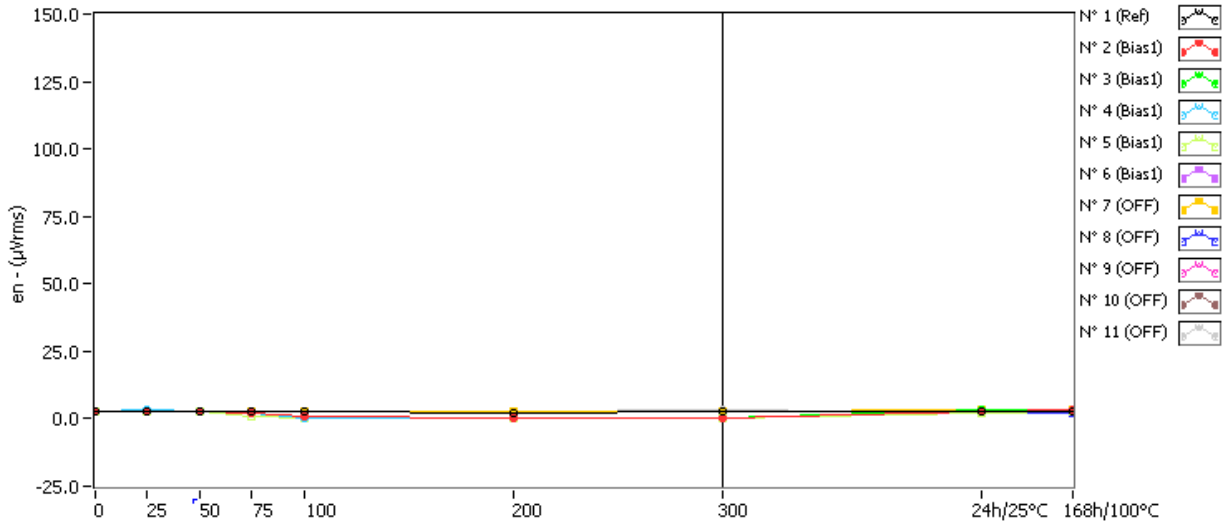
	0krad(Si)	25krad(Si)	50krad(Si)	75krad(Si)	100krad(Si)	200krad(Si)	300krad(Si)	24h/25°C	168h/100°C
N° 1 (Ref)	0.256	0.253	0.254	0.256	0.253	0.252	0.253	0.252	0.252
N° 2 (Bias1)	0.254	0.256	0.256	0.255	0.256	4.556	6.852	0.234	0.259
N° 3 (Bias1)	0.262	0.260	0.265	0.259	0.256	9.108	5.089	0.253	0.265
N° 4 (Bias1)	0.261	0.258	0.262	0.262	0.263	4.475	4.808	0.247	0.263
N° 5 (Bias1)	0.257	0.256	0.257	0.258	0.263	8.578	5.061	0.247	0.257
N° 6 (Bias1)	0.251	0.249	0.253	0.252	0.253	5.905	5.325	0.224	0.254
N° 7 (OFF)	0.252	0.258	0.257	0.256	0.257	0.245	0.076	0.257	0.253
N° 8 (OFF)	0.255	0.261	0.259	0.257	0.255	0.233	0.053	0.252	0.259
N° 9 (OFF)	0.259	0.258	0.259	0.259	0.260	0.231	0.025	0.260	0.260
N° 10 (OFF)	0.255	0.255	0.258	0.258	0.255	0.233	0.079	0.257	0.261
N° 11 (OFF)	0.260	0.261	0.261	0.257	0.260	0.203	0.171	0.254	0.258

Delta [Rka]

	0krad(Si)	25krad(Si)	50krad(Si)	75krad(Si)	100krad(Si)	200krad(Si)	300krad(Si)	24h/25°C	168h/100°C
N° 1 (Ref)	---	-2.754E-3	-2.448E-3	1.271E-4	-2.605E-3	-3.587E-3	-3.107E-3	-3.612E-3	-4.345E-3
N° 2 (Bias1)	---	1.237E-3	1.555E-3	8.208E-4	1.941E-3	4.302E+0	6.598E+0	-2.022E-2	4.962E-3
N° 3 (Bias1)	---	-1.507E-3	2.827E-3	-3.186E-3	-5.546E-3	8.846E+0	4.827E+0	-9.152E-3	2.654E-3
N° 4 (Bias1)	---	-2.146E-3	1.089E-3	1.903E-3	1.997E-3	4.215E+0	4.547E+0	-1.329E-2	2.248E-3
N° 5 (Bias1)	---	-4.685E-4	-4.425E-4	1.448E-3	6.153E-3	8.321E+0	4.804E+0	-1.026E-2	1.571E-4
N° 6 (Bias1)	---	-1.573E-3	1.835E-3	1.121E-3	2.270E-3	5.654E+0	5.074E+0	-2.684E-2	2.791E-3
N° 7 (OFF)	---	5.344E-3	4.725E-3	3.530E-3	4.344E-3	-6.972E-3	-1.759E-1	5.194E-3	1.212E-3
N° 8 (OFF)	---	5.912E-3	4.682E-3	2.647E-3	2.200E-5	-2.175E-2	-2.013E-1	-2.487E-3	4.219E-3
N° 9 (OFF)	---	-6.796E-4	1.392E-4	-4.524E-4	1.259E-3	-2.805E-2	-2.340E-1	6.367E-4	9.360E-4
N° 10 (OFF)	---	-2.242E-4	2.567E-3	2.513E-3	1.700E-5	-2.242E-2	-1.757E-1	2.236E-3	5.691E-3
N° 11 (OFF)	---	8.208E-4	4.975E-4	-2.781E-3	-4.875E-4	-5.654E-2	-8.868E-2	-5.783E-3	-1.572E-3
Average (OFF)	---	-8.915E-4	1.373E-3	4.214E-4	1.363E-3	6.268E+0	5.170E+0	-1.595E-2	2.562E-3
s (OFF)	---	1.335E-3	1.198E-3	2.056E-3	4.249E-3	2.198E+0	8.195E-1	7.459E-3	1.710E-3
Average+3s (OFF)	---	3.113E-3	4.965E-3	6.590E-3	1.411E-2	1.286E+1	7.629E+0	6.425E-3	7.694E-3
Average-3s (OFF)	---	-4.896E-3	-2.220E-3	-5.747E-3	-1.139E-2	-3.251E-1	2.711E+0	-3.833E-2	-2.569E-3
Average (Bias1)	---	2.235E-3	2.522E-3	1.091E-3	1.031E-3	-2.715E-2	-1.751E-1	-4.044E-5	2.097E-3
s (Bias1)	---	3.152E-3	2.196E-3	2.635E-3	1.961E-3	1.819E-2	5.390E-2	4.243E-3	2.873E-3
Average+3s (Bias1)	---	1.169E-2	9.111E-3	8.996E-3	6.914E-3	2.742E-2	-1.341E-2	1.269E-2	1.072E-2
Average-3s (Bias1)	---	-7.220E-3	-4.067E-3	-6.813E-3	-4.852E-3	-8.171E-2	-3.368E-1	-1.277E-2	-6.521E-3

8. en

Ta=25°C ; Ik = 10 µA ; f = 1 kHz



en . (µVrms)

	0krad(Si)	25krad(Si)	50krad(Si)	75krad(Si)	100krad(Si)	200krad(Si)	300krad(Si)	24h/25°C	168h/100°C
N° 1 (Ref)	2.565	2.421	2.421	2.449	2.506	2.366	2.449	2.979	2.686
N° 2 (Bias1)	2.449	2.686	2.625	1.968	0.723	0.141	0.144	2.780	3.623
N° 3 (Bias1)	2.625	2.625	2.717	1.858	0.637	0.088	0.148	3.084	2.812
N° 4 (Bias1)	2.945	3.048	2.945	2.133	0.555	0.117	0.107	2.945	2.911
N° 5 (Bias1)	2.449	2.478	2.506	1.120	0.251	0.112	0.190	2.109	2.655
N° 6 (Bias1)	2.594	2.506	2.449	2.037	0.456	0.069	0.077	2.286	2.748
N° 7 (OFF)	2.945	2.979	2.945	2.812	3.013	2.979	3.013	3.192	3.229
N° 8 (OFF)	2.535	2.625	2.506	2.449	2.655	2.625	2.845	2.625	2.312
N° 9 (OFF)	2.845	2.878	2.845	2.780	2.812	2.748	2.911	3.304	2.565
N° 10 (OFF)	2.594	2.535	2.478	2.506	2.506	2.625	2.655	2.394	2.339
N° 11 (OFF)	2.449	2.506	2.506	2.717	2.625	2.506	3.155	2.312	2.339

Delta [en]

	0krad(Si)	25krad(Si)	50krad(Si)	75krad(Si)	100krad(Si)	200krad(Si)	300krad(Si)	24h/25°C	168h/100°C
N° 1 (Ref)	---	-1.435E-1	-1.435E-1	-1.154E-1	-5.838E-2	-1.986E-1	-1.154E-1	4.141E-1	1.209E-1
N° 2 (Bias1)	---	2.363E-1	1.752E-1	-4.812E-1	-1.726E+0	-2.308E+0	-2.305E+0	3.307E-1	1.174E+0
N° 3 (Bias1)	---	0.000E+0	9.223E-2	-7.665E-1	-1.988E+0	-2.537E+0	-2.477E+0	4.590E-1	1.877E-1
N° 4 (Bias1)	---	1.035E-1	0.000E+0	-8.115E-1	-2.390E+0	-2.828E+0	-2.838E+0	0.000E+0	-3.371E-2
N° 5 (Bias1)	---	2.836E-2	5.705E-2	-1.330E+0	-2.199E+0	-2.337E+0	-2.259E+0	-3.405E-1	2.056E-1
N° 6 (Bias1)	---	-8.808E-2	-1.451E-1	-5.572E-1	-2.138E+0	-2.525E+0	-2.517E+0	-3.086E-1	1.537E-1
N° 7 (OFF)	---	3.410E-2	0.000E+0	-1.325E-1	6.859E-2	3.410E-2	6.859E-2	2.471E-1	2.841E-1
N° 8 (OFF)	---	8.910E-2	-2.902E-2	-8.608E-2	1.195E-1	8.910E-2	3.094E-1	8.910E-2	-2.231E-1
N° 9 (OFF)	---	3.294E-2	0.000E+0	-6.476E-2	-3.256E-2	-9.658E-2	6.626E-2	4.593E-1	-2.800E-1
N° 10 (OFF)	---	-5.906E-2	-1.168E-1	-8.808E-2	-8.808E-2	3.004E-2	6.043E-2	-2.009E-1	-2.554E-1
N° 11 (OFF)	---	5.705E-2	5.705E-2	2.674E-1	1.752E-1	5.705E-2	7.060E-1	-1.370E-1	-1.102E-1
Average (OFF)	---	5.602E-2	3.587E-2	-7.892E-1	-2.088E+0	-2.507E+0	-2.479E+0	2.812E-2	3.374E-1
s (OFF)	---	1.219E-1	1.195E-1	3.324E-1	2.484E-1	2.075E-1	2.285E-1	3.631E-1	4.771E-1
Average+3s (OFF)	---	4.217E-1	3.942E-1	2.079E-1	-1.343E+0	-1.885E+0	-1.794E+0	1.117E+0	1.769E+0
Average-3s (OFF)	---	-3.096E-1	-3.225E-1	-1.786E+0	-2.833E+0	-3.129E+0	-3.165E+0	-1.061E+0	-1.094E+0
Average (Bias1)	---	3.083E-2	-1.775E-2	-2.081E-2	4.852E-2	2.274E-2	2.421E-1	9.153E-2	-1.169E-1
s (Bias1)	---	5.518E-2	6.356E-2	1.630E-1	1.081E-1	7.071E-2	2.801E-1	2.726E-1	2.334E-1
Average+3s (Bias1)	---	1.964E-1	1.729E-1	4.682E-1	3.727E-1	2.349E-1	1.082E+0	9.093E-1	5.833E-1
Average-3s (Bias1)	---	-1.347E-1	-2.084E-1	-5.098E-1	-2.757E-1	-1.894E-1	-5.981E-1	-7.262E-1	-8.171E-1