estec

European Space Research
and Technology Centre
Keplerlaan 1
2201 AZ Noordwijk
The Netherlands
Tel. (31) 71 5656565
Fax (31) 71 5656040
www.esa.int

DOCUMENT

RA0583 CO60 TID Test Results on Part Type OP27A

RA0583.doc

Prepared by **Michele Muschitiello TEC-QEC**
Reference **RA 0583**
Issue **1**
Revision **0**
Date of Issue **19 May 2011**
Status **Issued**
Document Type **Test Report**
Distribution **ESCIES Library**

APPROVAL

Title RA0583 CO60 TID Test Results on Part Type OP27ATID test on OP 27A for Alphasat	
Issue 1	**Revision** 0
Author Michele Muschitiello TEC-QEC	**Date 18 May 2011**
Approved by Christian Poivey TEC-QEC	**Date 18 May 2011**
Authorised by	**Date**

CHANGE LOG

Reason for change	Issue	Revision	Date
issued for first release	1	0	19 May 2011

CHANGE RECORD

Issue 1	**Revision** 0		
Reason for change	**Date**	**Pages**	**Paragraph(s)**

Table of contents:

1 ACRONYMS

TID Total Irradiation Dose

2 REFERENCES

REF1 ESA/SCC 22900 “Total Dose Steady-State Irradiation Test Method”, issue 3

3 PURPOSE

The purpose of this test report is to describe the TID test performed according to REF1 on the devices below specified.

4 SCOPE

This documents reports the test results obtained on Low noise precision operational amplifier based on part type OP27A, Part Identification Number 5962R946002VPA and Lot Date Code Q0940A to be used in the frame of Alphasat ESA Project.

5 TEST DESCRIPTION

5.1 Facility and Dosimetry

The ESTEC Co-60 facility comprises of a Nordion Gammabeam 150C irradiator containing a nominal 74.8 TBq (2000 Ci) Co-60 source at the last reload date in June 2007. The irradiation room is monitored for temperature, relative humidity and pressure.

The dosimetry system is based on Farmer type 2571A 0.6 cc air ionisation chambers linked to Farmer 2670 electrometers. The dosimetry system is compensated against temperature and pressure environmental fluctuation.

All irradiations and measurements were performed at room temperature (22.5 ± 3 °C).

5.2 Devices Under Test

A total of twenty three devices were received from MDA.

Part description:

Component Designation	OP27A
Manufacturer	Analog Device
Family	Op-Amp (bipolar)
Group	Silicon
Package	8 pin, Ceramic Dual in Line
Component Specification	DSCC 5962-94680
Part Identification Number	5962R9468002VPA
Lot date code	Q0940A
Device serial numbers	1134, 1135, 1136, 1137, 1138, 1139, 1140, 1141, 1143, 1144, 1145, 1146, 1149, 1150, 1151, 1152, 1155, 1156, 1157, 1158, 1159, 1160, 1161.

A biasing board was also received to accommodate the DUT's in the irradiation room.

The devices from s/n 1135 to s/n 1139 were irradiated with bias applied according to the schematic in Figure 1.

The devices s/n's: 1140, 1141, 1143, 1144 and 1145, were irradiated with all the pins grounded (un-biased).

Table 1 summarize the sample usage.

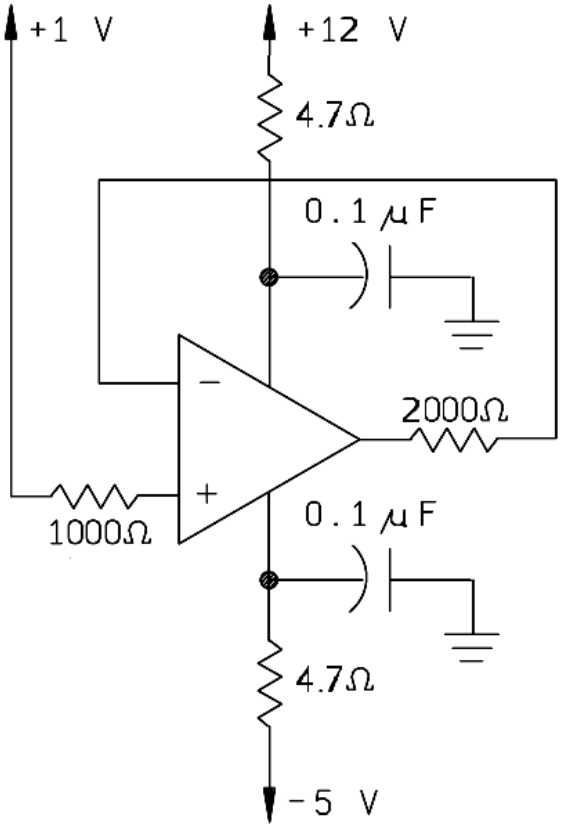

Figure 1 Biasing circuit

Table 1 received samples and their usage.

S/n's	Description
1135, 1136, 1137, 1138, 1139	Biased during ^{60}Co irradiation
1140, 1141, 1143, 1144, 1145	Unbiased during ^{60}Co irradiation
1134	Reference device (not irradiated) - Electrically tested before and after each intermediate measurement run at irradiation step completion
1146, 1149, 1150, 1151, 1152, 1155, 1156, 1157, 1158, 1159, 1160, 1161	Passed initial go/no go electrical measurements. Not Irradiated

5.3 Radiation Test Plan

The actual radiation test steps are reported in Table 2.

Table 2 Irradiation Test Plan

Step	Total Dose (Si) krad	Dose Rate (Si)rad/min
(Pre irradiation) 0	==	==
Irradiation step # 1	2.42	0.61
Irradiation step # 2	5.66	0.59
Irradiation step # 3	7.43	0.60
Irradiation step # 4	9.19	0.59
Irradiation step # 5	12.52	0.61
Irradiation step # 6	15.24	0.59
Irradiation step # 7	20.34	0.60
Irradiation step # 8	30.45	0.59

At the completion of each irradiation step, intermediate electrical measurements were carried out according to the next paragraph.
At the end of the final irradiation run, all devices were electrically measured and annealed for 45 hours at room temperature and subsequently aged at 100°C (for 168 hrs in total), maintaining the same bias conditions applied during the TID test.
Table 3 reports the annealing/ageing sequence detail.

Table 3 Anneal/ageing sequence

Step	Temperature	Duration
Anneal	Room temperature	45 hours
Ageing	100 °C	24 hours
Ageing	100 °C	168 hours

At the completion of each anneal/ageing step, all devices were electrically tested.

5.4 Measurement Set-up

No in-situ measurements were performed during irradiation. The measured parameters and the adopted min-max limits (pass/fail criteria) are listed in Table 4.

Table 4 Measured Parameters, Min-Max Limits and Test conditions

nr.	Parameter ID	Parameter description	Limits		Unit
			Min.	Max.	
0	V_{OS}	Input Offset Voltage	-25.	25	µV
1	I_{OS}	Input Offset Current		35	nA
2	$I_{B\ avg}$	Input Bias Current (average)		40	nA
3	I_B+	Positive Input Bias Current		40	nA
4	I_B-	Negative Input Bias Current		40	nA
5	I_S+	Positive Supply current		4.67	mA
6	I_S-	Negative Supply Current		4.67	mA

All the above parameters have been measured by using the following equipment:

Automatic Test Equipment:	model Unimet M3000	s/n 0639001.
Universal Front Test Adapter:	model FASM02B	s/n 913842
Test Adapter:	model TA09B	s/n 914092
Test Board:	SA_TA_09_OP15	
Test Program:	OP27A_TID_Alphasat	

Last valid calibration date: July 2010

The electrical parameters were tested according to TABLE I of DSCC 5962-94680 and applying a stabilization time of about 4 minutes per device.

6 TEST RESULTS

All measurement results are reported from Table 5 to Table 11. Test ended with a registered Total Dose of 30.45 krad(Si).
At the end of the last irradiation step, electrical measurements were performed. The devices were tested again after 45 hours annealing at room temperature.
After the annealing, the samples went through accelerated ageing, with an intermediate electrical test performed after 24 hours and finale measurement performed after 168 hrs at 100°C.
During the entire annealing, the irradiated devices were biased employing the same test board.

Electrical Measurement uncertainty values, reported in the relevant table header, were estimated by combining the instrument uncertainty for the measured parameter according to the specification of the Unimet M3000 A.T.E. and the variations of the same parameter in the reference device (s/n 1134), observed during the entire test campaign.

Significant data from tables have also been plotted from Figure 3 to Figure 9. The identification of device s/n's and the colour of the relevant trendlines on the graphs is shown in Figure 2.

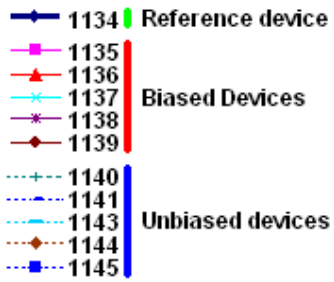

Figure 2

Vos - Input Offset Voltage limits:	-0.025	0.025	mV	Expanded uncertainty (k=2) 0.014 mV							Table 5

	0	2.5krad	5.5krad	7.5krad	9.5krad	12.5krad	15.2krad	20.3krad	30.5krad	Anneal @R.T. 45 h	Ageing @100'C 24 h	Ageing @100'C 168 h
1134	-0.004	-0.001	0.000	-0.003	-0.012	-0.001	-0.003	-0.019	-0.017	-0.008	-0.011	-0.010
1135	0.002	0.000	0.007	-0.003	0.005	0.008	0.009	0.010	0.010	0.007	-0.002	0.007
1136	-0.020	-0.022	-0.017	-0.023	-0.020	-0.018	-0.018	-0.016	-0.018	-0.018	**-0.025**	-0.012
1137	0.002	-0.002	-0.001	-0.003	-0.004	-0.003	-0.004	-0.003	-0.004	-0.004	-0.005	0.012
1138	-0.008	-0.010	-0.011	-0.012	-0.012	-0.011	-0.010	-0.009	-0.006	-0.009	-0.011	-0.001
1139	-0.006	-0.003	0.009	-0.005	-0.004	-0.003	-0.004	-0.002	-0.001	-0.003	-0.003	0.001
1140	-0.017	**-0.033**	-0.019	**-0.037**	**-0.037**	**-0.035**	**-0.035**	**-0.032**	-0.015	**-0.031**	**-0.035**	-0.022
1141	-0.003	-0.019	-0.012	-0.022	-0.024	-0.022	-0.024	-0.020	-0.011	-0.019	-0.020	-0.013
1143	0.001	-0.015	-0.007	-0.019	-0.020	-0.019	-0.014	-0.014	-0.014	-0.016	-0.019	-0.015
1144	0.000	-0.007	-0.005	-0.012	-0.013	-0.012	-0.009	-0.009	-0.007	-0.009	-0.012	-0.001
1145	-0.011	-0.013	-0.013	-0.016	-0.016	-0.014	-0.013	-0.013	-0.010	-0.011	-0.016	-0.008

Note: All values were considered within the limits due to measurement uncertainty related to this parameter (in dark red values below nom. lower limit).

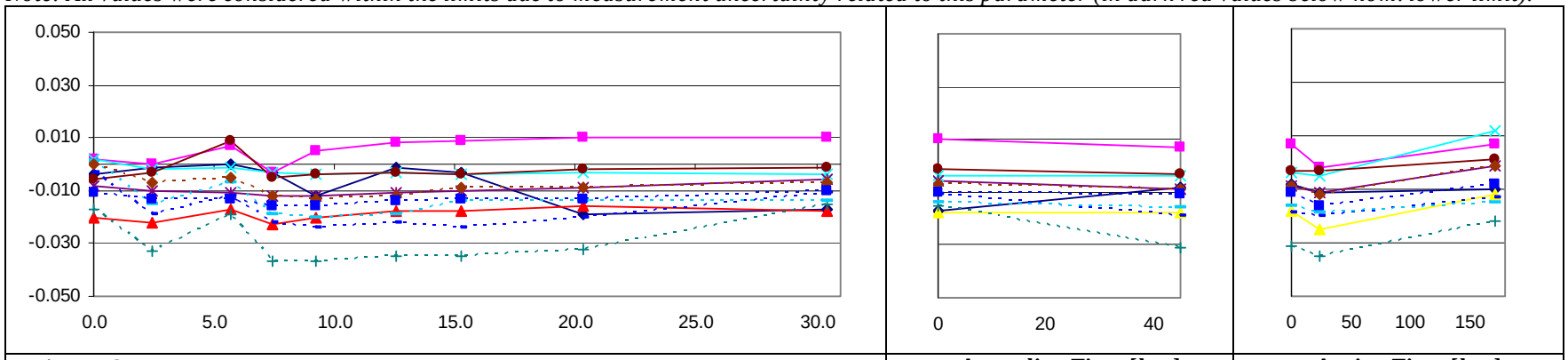

Figure 3 **TID [krad](Si)** **Annealing Time [hrs]** **Ageing Time [hrs]**

Ios - Input Offset Current limits:		35	nA	Expanded uncertainty (k=2) 0.060 nA							Table 6
	0	2.5krad	5.5krad	7.5krad	9.5krad	12.5krad	15.2krad	20.3krad	30.5krad	Anneal @R.T. 45 h	Ageing @100'C 24 h	Ageing @100'C 168 h
1134	0.673	0.639	0.620	0.667	0.698	0.655	0.675	0.750	0.711	0.649	0.654	0.704
1135	4.624	4.861	4.446	4.022	4.378	5.419	5.879	9.452	8.937	8.575	5.259	3.780
1136	1.813	1.620	1.294	1.607	1.381	2.585	2.322	4.262	5.306	5.282	2.713	1.076
1137	2.446	1.630	1.267	0.654	0.433	0.647	0.669	0.881	1.689	1.151	2.196	1.654
1138	0.025	0.910	0.988	1.073	1.063	0.237	0.327	2.135	3.850	3.846	0.052	0.230
1139	2.756	1.815	1.916	1.126	1.872	1.260	1.240	2.784	5.203	3.987	1.511	1.621
1140	0.103	0.699	1.275	2.183	2.787	2.705	0.973	2.499	8.743	8.689	0.374	0.986
1141	0.933	1.009	0.385	0.438	0.630	0.857	3.121	7.627	18.380	18.839	3.086	2.121
1143	0.644	0.005	0.556	0.052	0.550	0.829	2.758	4.730	12.098	12.916	1.192	0.165
1144	0.163	1.004	1.614	1.767	2.602	0.907	0.963	4.565	9.298	8.435	1.154	0.128
1145	1.115	0.692	0.438	0.450	0.585	1.485	3.645	5.751	10.291	10.421	1.229	0.605

Note: All values were within the limits

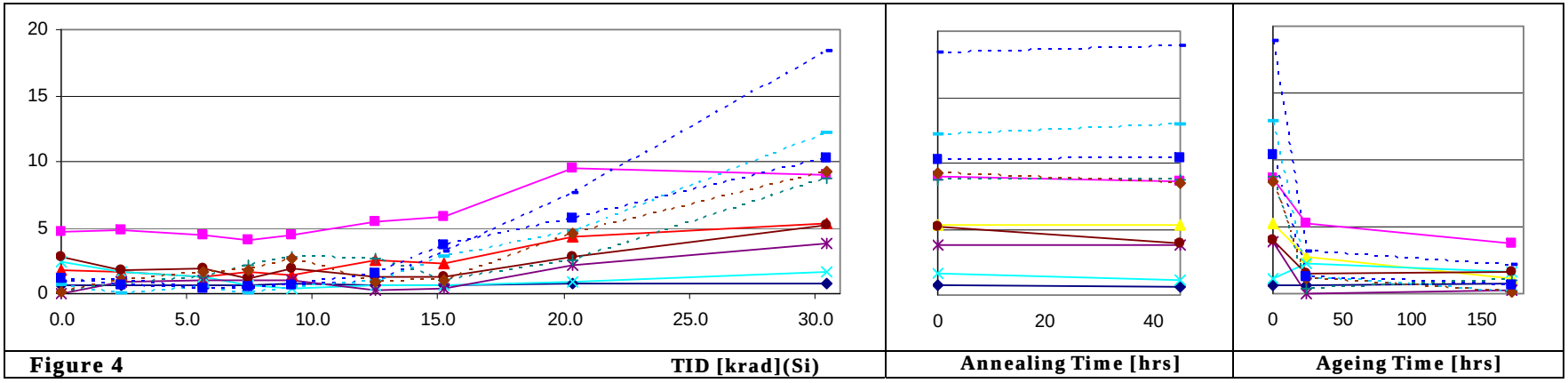

Figure 4 **TID [krad](Si)** **Annealing Time [hrs]** **Ageing Time [hrs]**

$I_{B\ avg}$ - Input bias Curr.(avg) limits:		40	nA	Expanded uncertainty (k=2) 0.320 nA							Table 7
	0	2.5krad	5.5krad	7.5krad	9.5krad	12.5krad	15.2krad	20.3krad	30.5krad	Anneal @R.T. 45 h	Ageing @100'C 24 h	Ageing @100'C 168 h
1134	3.914	4.072	3.990	3.884	3.749	3.992	3.926	3.906	3.757	5.038	4.700	4.877
1135	4.219	3.720	2.188	2.070	2.093	2.902	6.775	34.493	**46.857**	**45.762**	9.181	6.234
1136	3.893	2.568	0.744	1.170	2.437	6.735	10.668	20.868	**41.269**	39.483	7.128	5.468
1137	6.631	5.345	4.140	3.628	4.126	5.970	8.960	16.612	33.991	33.440	8.954	7.236
1138	0.282	1.636	3.390	3.419	2.713	1.936	7.005	18.782	39.189	38.090	1.835	0.438
1139	4.096	2.364	0.925	0.672	1.720	5.160	9.375	18.770	38.750	37.044	6.104	4.819
1140	2.535	2.876	1.919	1.058	1.478	6.404	18.331	**50.391**	**118.218**	**120.577**	4.412	1.060
1141	6.091	7.275	6.828	6.023	6.363	16.267	34.336	**77.693**	**161.997**	**164.107**	19.453	9.333
1143	3.752	3.519	3.329	3.293	2.020	6.521	17.357	38.720	**116.060**	**118.351**	8.073	0.919
1144	0.258	0.447	1.276	2.765	3.637	7.350	20.263	**50.720**	**117.686**	**119.194**	2.093	4.663
1145	2.899	3.476	3.001	2.985	2.799	9.627	24.294	**64.441**	**148.797**	**149.629**	14.775	5.663

Note: values in red were above the specification upper limit.

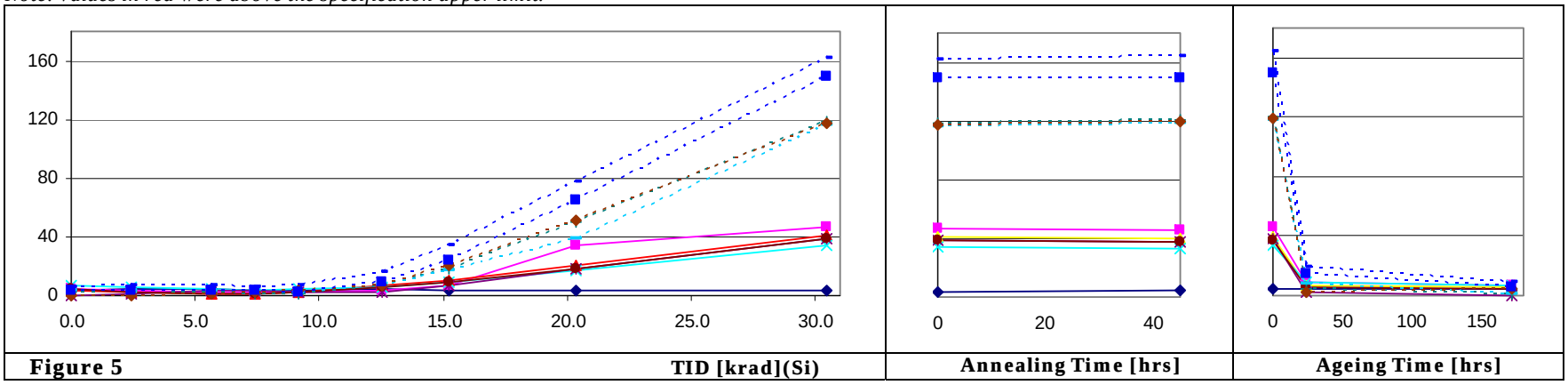

Figure 5 **TID [krad](Si)** **Annealing Time [hrs]** **Ageing Time [hrs]**

I_B +- Input bias Curr.(pos) limits:		40	nA	Expanded uncertainty (k=2) 0.440 nA							Table 8
	0	2.5krad	5.5krad	7.5krad	9.5krad	12.5krad	15.2krad	20.3krad	30.5krad	Anneal @R.T. 45 h	Ageing @100'C 24 h	Ageing @100'C 168 h
1134	3.587	3.763	3.665	3.559	3.397	3.672	3.593	3.519	3.420	5.171	4.796	4.930
1135	1.886	1.261	0.029	1.054	2.107	3.434	3.697	29.593	42.300	43.517	7.010	4.818
1136	2.989	1.763	0.099	0.324	1.753	5.409	9.458	18.530	38.463	38.583	6.120	5.314
1137	5.400	4.476	3.508	3.239	3.879	5.694	8.601	16.122	32.973	34.336	8.159	7.016
1138	0.284	1.204	2.927	2.943	2.268	1.842	6.727	17.650	37.119	37.950	2.043	0.324
1139	2.705	1.489	0.052	0.153	0.709	4.532	8.708	17.325	35.975	36.758	5.793	4.332
1140	2.490	3.214	2.645	1.180	0.515	7.741	18.811	48.812	113.584	120.916	4.544	0.444
1141	5.600	6.797	6.691	6.314	6.651	15.950	32.735	73.249	152.259	161.214	18.686	8.734
1143	3.433	3.421	2.981	3.250	1.735	6.023	15.875	36.301	109.912	116.174	7.976	1.068
1144	0.192	0.608	0.385	1.712	2.335	8.008	19.599	48.296	112.595	119.775	2.816	4.485
1145	2.328	3.080	2.858	2.876	2.459	8.874	22.129	60.989	142.936	150.406	14.808	5.745

Note: values in red were above the specification upper limit.

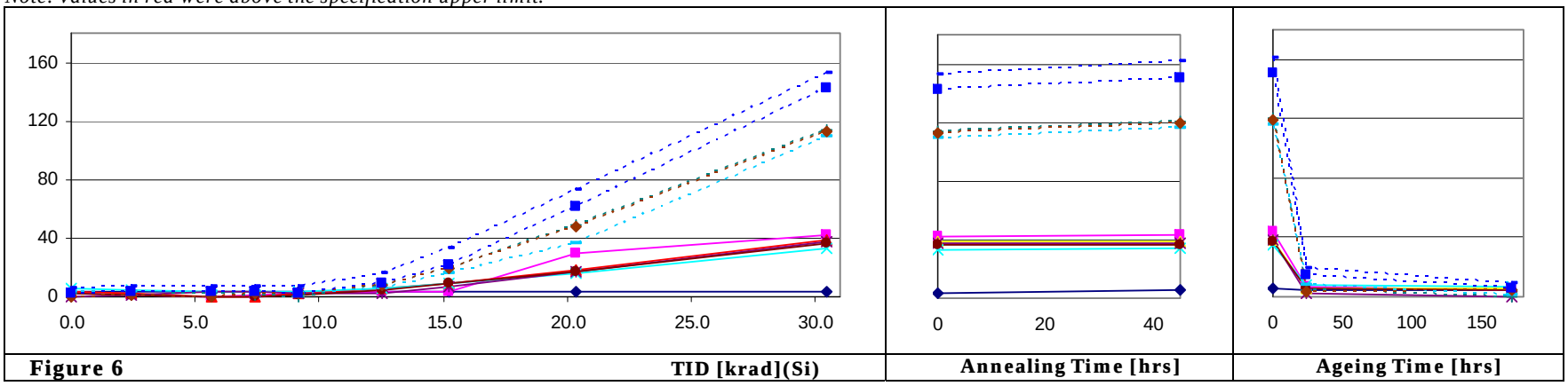

Figure 6 TID [krad](Si) | Annealing Time [hrs] | Ageing Time [hrs]

I_B -- Input bias Curr.(neg) limits:		40	nA	Expanded uncertainty (k=2) 0.260 nA						Table 9	
	0	2.5krad	5.5krad	7.5krad	9.5krad	12.5krad	15.2krad	20.3krad	30.5krad	Anneal @R.T. 45 h	Ageing @100'C 24 h	Ageing @100'C 168 h
1134	4.241	4.381	4.314	4.209	4.101	4.312	4.260	4.292	4.094	4.906	4.603	4.824
1135	6.553	6.179	4.346	3.086	2.079	2.369	9.853	39.394	**51.414**	**48.008**	11.352	7.649
1136	4.797	3.373	1.389	2.015	3.120	8.060	11.878	23.207	**44.076**	**40.383**	8.135	5.622
1137	7.861	6.215	4.771	4.017	4.373	6.247	9.319	17.103	35.009	32.545	9.749	7.457
1138	0.281	2.068	3.854	3.896	3.158	2.031	7.282	19.914	**41.259**	38.229	1.626	0.552
1139	5.488	3.238	1.798	1.192	2.732	5.789	10.041	20.215	**41.525**	37.330	6.416	5.307
1140	2.581	2.538	1.194	0.935	2.441	5.066	17.852	**51.970**	**122.852**	**120.238**	4.281	1.677
1141	6.581	7.753	6.965	5.731	6.074	16.584	35.936	**82.137**	**171.734**	**167.000**	20.219	9.932
1143	4.071	3.617	3.677	3.335	2.306	7.019	18.838	**41.139**	**122.207**	**120.528**	8.169	0.769
1144	0.325	0.287	2.167	3.818	4.939	6.692	20.927	**53.145**	**122.778**	**118.613**	1.370	4.841
1145	3.470	3.871	3.145	3.094	3.139	10.379	26.458	**67.892**	**154.659**	**148.851**	14.741	5.580

Note: values in red were above the specification upper limit.

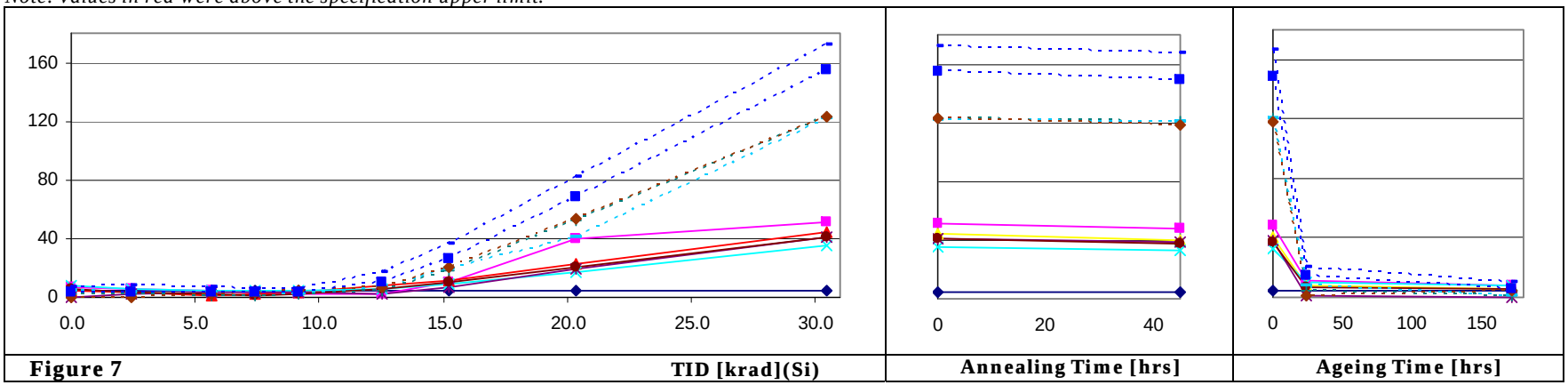

Figure 7 **TID [krad](Si)** **Annealing Time [hrs]** **Ageing Time [hrs]**

I_S +- Supply Curr.(pos) limits:		4.67	mA	Expanded uncertainty (k=2) 0.039 mA							Table 10	
	0	2.5krad	5.5krad	7.5krad	9.5krad	12.5krad	15.2krad	20.3krad	30.5krad	Anneal @R.T. 45 h	Ageing @100'C 24 h	Ageing @100'C 168 h
1134	3.661	3.647	3.654	3.668	3.682	3.649	3.658	3.672	3.679	3.653	3.670	3.656
1135	3.568	3.509	3.460	3.426	3.392	3.277	3.215	3.094	3.148	3.165	3.377	3.439
1136	3.636	3.554	3.492	3.460	3.430	3.352	3.328	3.265	3.191	3.210	3.441	3.505
1137	3.684	3.604	3.542	3.516	3.487	3.415	3.386	3.324	3.247	3.265	3.486	3.552
1138	3.659	3.577	3.507	3.468	3.444	3.363	3.336	3.271	3.200	3.217	3.450	3.525
1139	3.612	3.528	3.463	3.427	3.402	3.321	3.295	3.232	3.163	3.181	3.411	3.484
1140	3.653	3.584	3.520	3.474	3.432	3.301	3.239	3.112	2.929	2.951	3.320	3.407
1141	3.641	3.575	3.520	3.483	3.444	3.321	3.259	3.130	2.945	2.966	3.313	3.398
1143	3.624	3.557	3.505	3.470	3.431	3.314	3.253	3.160	2.950	2.968	3.300	3.383
1144	3.687	3.615	3.548	3.494	3.442	3.310	3.246	3.120	2.935	2.958	3.342	3.438
1145	3.602	3.534	3.484	3.453	3.417	3.304	3.244	3.119	2.933	2.958	3.279	3.358

Note: All values were within the limits

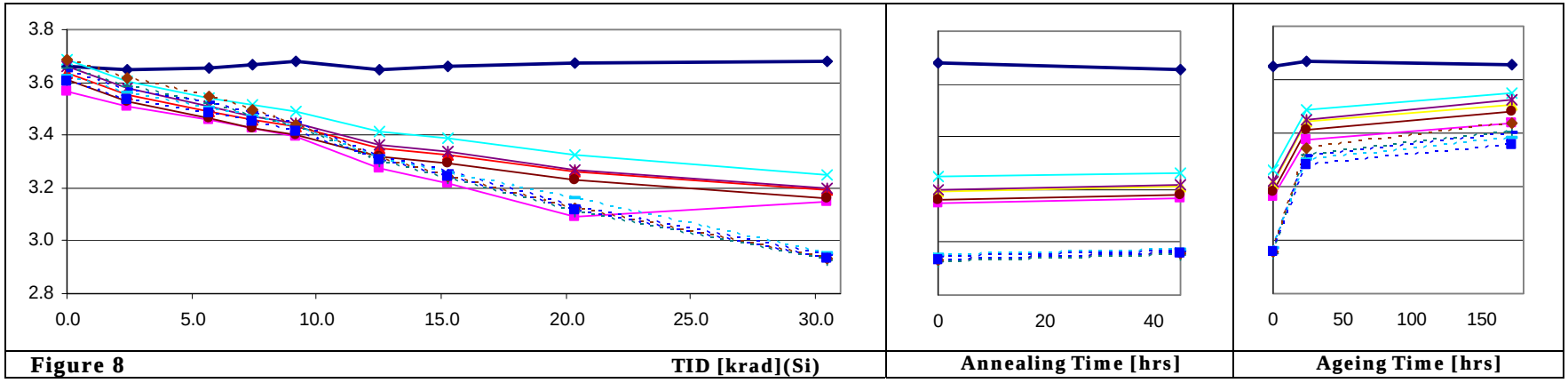

Figure 8 **TID [krad](Si)** **Annealing Time [hrs]** **Ageing Time [hrs]**

I_S -- Supply Curr.(neg) limits:		4.67	mA	Expanded uncertainty (k=2) 0.039 mA							Table 11	
	0	2.5krad	5.5krad	7.5krad	9.5krad	12.5krad	15.2krad	20.3krad	30.5krad	Anneal @R.T. 45 h	Ageing @100'C 24 h	Ageing @100'C 168 h
1134	3.656	3.643	3.654	3.663	3.676	3.647	3.658	3.668	3.679	3.651	3.665	3.654
1135	3.564	3.501	3.456	3.429	3.391	3.278	3.215	3.092	3.148	3.165	3.374	3.439
1136	3.636	3.554	3.490	3.457	3.429	3.352	3.327	3.265	3.192	3.210	3.438	3.505
1137	3.679	3.600	3.542	3.515	3.485	3.409	3.386	3.323	3.247	3.265	3.487	3.556
1138	3.657	3.574	3.505	3.468	3.445	3.364	3.332	3.272	3.199	3.217	3.448	3.523
1139	3.609	3.528	3.461	3.424	3.400	3.320	3.294	3.232	3.163	3.181	3.410	3.483
1140	3.651	3.582	3.520	3.476	3.428	3.301	3.240	3.110	2.928	2.951	3.317	3.408
1141	3.639	3.576	3.520	3.480	3.444	3.321	3.259	3.130	2.944	2.965	3.311	3.397
1143	3.623	3.555	3.504	3.469	3.428	3.312	3.252	3.161	2.949	2.968	3.298	3.380
1144	3.685	3.614	3.546	3.490	3.439	3.309	3.246	3.119	2.936	2.958	3.341	3.434
1145	3.600	3.534	3.485	3.452	3.414	3.303	3.243	3.119	2.932	2.957	3.278	3.356

Note: All values were within the limits

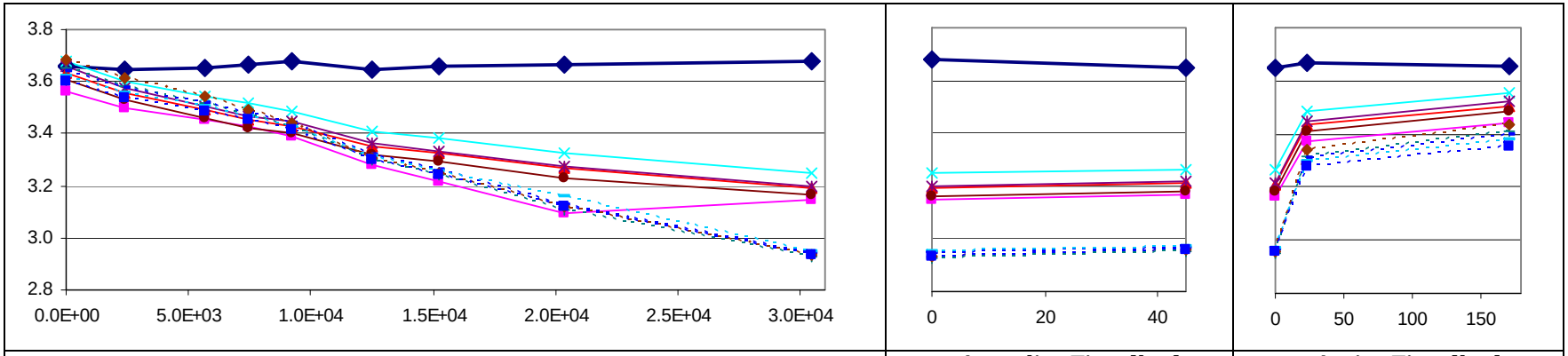

Figure 9 **TID [krad](Si)** **Annealing Time [hrs]** **Ageing Time [hrs]**

7 SUMMARY OF RESULT AND CONCLUSION

No catastrophic failures were observed during the entire test.
The parameter degradations induced by gamma radiation is summarized in: Table 12, Table 13 and Table 14.

Table 12 reports the total doses, recorded before and after the *out of limit* condition, aggregated by the bias condition applied.

Table 12 TID levels, in [krad(Si)], before and after out of limit conditions per different BIAS conditions

nr.	Parameter	Biased		Unbiased	
		pass	*fail*	*pass*	*fail*
0	**V_{OS}**	30.5	-	30.5	-
1	**I_{OS}**	30.5	-	30.5	-
2	**$I_{B\ avg}$**	20.3	30.5	**15.2**	20.3
3	**I_{B}+**	20.3	30.5	**15.2**	20.3
4	**I_{B}-**	20.3	30.5	**15.2**	20.3
5	**I_{S}+**	30.5	-	30.5	-
6	**I_{S}-**	30.5	-	30.5	-

Table 13 Detail of Failures

nr.	Parameter	Bias conditions	Remarks	Table	Fig.
2	$I_{B\ avg}$	Biased	S/n's 1135 and 1136 pass at 20.3 krad(Si). S/n 1136 recovered after 24 hrs R.T. annealing. S/n 1135 recovered after 24 hrs H.T. ageing.	7	5
		Unbiased	S/n's 1140, 1141, 1144 and 1145 pass at 15.2 krad(Si). S/n 1143 pass at 20.3 krad(Si). All Failures recovered after 24 hrs H.T. ageing		
3	I_{B}+	Biased	S/n's 1135 pass at 20.3 krad(Si). S/n 1135 recovered after 24 hrs H.T. ageing	8	6
		Unbiased	S/n's 1140, 1141, 1144 and 1145 pass at 15.2 krad(Si). S/n 1143 pass at 20.3 krad(Si). All Failures recovered after 24 hrs H.T. ageing		
4	I_{B}-	Biased	S/n's 1135, 1136, 1138 and 11396 pass at 20.3 krad(Si). S/n 1138 and s/n 1139 recovered after 24 hrs R.T. annealing. S/n's 1135, 1136 recovered after 24 hrs H.T. ageing	9	7
		Unbiased	S/n's 1140, 1141, 1144 and 1145 pass at 15.2 krad(Si). S/n 1143 pass at 20.3 krad(Si). All Failures recovered after 24 hrs H.T. ageing		

Table 14 Summary of TID test results

nr.	Parameter	Remarks	Worst Case Bias Condition	Table	Fig.
0	V_{OS}	No evidence of TID dependence. No evidence of Bias condition dependence. All devices still within the limits.	n/a	5	3
1	I_{OS}	Evidence of TID dependence. Evidence of Bias condition dependence. All devices still within the limits.	Unbiased	6	4
(a)(d) 2	$I_{B\ avg}$	Evidence of TID dependence. Evidence of Bias condition dependence.	Unbiased	7	5
(a) 3	$I_{B}+$	Evidence of TID dependence. Evidence of Bias condition dependence.	Unbiased	8	6
(b)4	$I_{B}-$	Evidence of TID dependence. Evidence of Bias condition dependence.	Unbiased	9	7
(a)(d) 5	$I_{S}+$	Evidence of TID dependence. Weak Bias condition dependence. All devices still within the limits.	Unbiased	10	8
(a)(d) 6	$I_{S}-$	Evidence of TID dependence. Weak Bias condition dependence. All devices still within the limits.	Unbiased	11	9

All the observations indicate the Input Bias Currents are the most affected parameters with the unbiased test condition as worst case.

APPENDIX A RADIATION SUMMARY

ESTEC ^{60}Co Facility

Keplerlaan, 1 2200AG Noordwijk Zh (NL)

RADIATION TEST SUMMARY

Irradiation Test Report Number : **20070** *Date :* **09 May 2011**

Test Requester : Name	Astrium Satellites
Address	Anchorage Road Portsmouth PO3 5PU - United Kingdom
Personnel present :	Francisco Javier Hernandez Suarez
Project/Cost Code :	ALPHASAT - E/0508-02-01047
Devices/Components irradiated :	OP27A - PIN 5962R946002VPA – DC Q0940A
Device/Component details : (conditions and identification)	See TEC-QEC TID Test report nr. RA0583
Dosimetry Chain used :	A
Dosimeter :	Farmer model 2680 – s/n 390
Gas Ionisation Chamber :	NE Type 2571 – s/n 2915
Measured Dosimetry :	Total Ionising Dose in [Gy] (water)
Dosimetry Procedure :	ESCC 22900 section 4.1.1 TEC-QEC/PR001 - Appendix D

(With the exception of the above specified dosimetry equipment, ESTEC ^{60}Co Facility does not assume any liability for the calibration status of any other equipment lent to the requester)

Irradiation Test Campaign Details

Source Activity : 45.93 [TBq] *on date :* 14 Feb 2011

	units	*Min.*	*Max.*	Time-weighted Average
Temperature	°C	*23.3*	*23.8*	*23.60*
Pressure	mbar	*992.8*	*1037.5*	*1018.38*
Relative Humidity	%	*18.5*	*35.6*	*28.65*

Dosimeter position relative to ^{60}Co source		
X	cm	598
Y	cm	40
Z	cm	40

Run	*Start Date & Time (CET)*	*End Date & Time (CET)*	*Total Ionising Dose [Gy] (water)*	*Dose Rate [mGy/h] (water)*
1	14-Feb-2011 18:15	17-Feb-2011 14:51	26.90	404.7
2	17-Feb-2011 16:18	21-Feb-2011 11:52	36.17	395.2
3	21-Feb-2011 13:03	23-Feb-2011 14:52	19.68	398.7
4	23-Feb-2011 15:52	25-Feb-2011 17:42	19.62	393.8
5	25-Feb-2011 18:17	01-Mar-2011 13:33	37.03	406.2
6	01-Mar-2011 13:56	04-Mar-2011 18:40	30.31	395.1
7	04-Mar-2011 19:10	10-Mar-2011 18:03	56.74	398.6
8	10-Mar-2011 18:45	22-Mar-2011 16:04	112.60	395.1

Note: *The uncertainty budget associated with the absorbed dose to water measurements is 4.2 % (k=2) according to TEC-QEC/PR001 paragraph 12*

Notes: no remarks.

Michele Muschitiello
(TEC-QEC Radiation Test Engineer)

Ali Zadeh
(TEC-QEC Section Head)

DISCLAIMER This test summary provided as a courtesy to the receiver, shall neither imply, nor be construed as constituting, any kind of legal contractual relationship between the European Space Agency and the receiver. The receiver may reproduce the summary report only in its entirety. Reproduction of parts of the test summary is subject to the receiver obtaining prior approval by the laboratory. The European Space Agency does not assume any liability, including but not limited to liability for any damage derived from the use of the test results and the test summary.

Irradiation Test Report nr. 20070 *Page 1 of 1*