esa DOCUMENT

document title/ titre du document

Radiation Test Report for Enhanced Low Dose Rate Sensitivity (ELDRS) testing

OP400

prepared by/*préparé par* Ali Mohammadzadeh / Cécile Renaudie

reference/*réference* ESA_QCA0502T_I
issue/*édition* 1
revision/*révision* 2
date of issue/*date d'édition* 24 octobre 2006
status/*état*
Document type/*type de document* Radiation Test Report
Distribution/*distribution*

European Space Agency
Agence spatiale européenne

ESTEC
Keplerlaan 1 - 2201 AZ Noordwijk - The Netherlands
Tel. (31) 71 5656565 - Fax (31) 71 5656040

APPROVAL

author *auteur*		date *date*

approved by *approuvé by*	date *date*

CHANGE LOG

reason for change */raison du changement*	issue/*issue*	revision/*revision*	date/*date*

CHANGE RECORD

Issue: 1 Revision: 1

reason for change/*raison du changement*	page(s)/*page(s)*	paragraph(s)/*paragraph(s)*

Table Of Contents

Test Report Number	ESA_QCA0502T_I
Project	
SCC Component no.	
Component Designation	Quad low offset low power op-amp OP400
Irradiation Spec. no.	
Family	Operational amplifiers
Group	Silicon Monolithic
Package	CERDIP-14
Component Specification	
Test House Name	ESA / ESTEC
Irradiation Test Plan Number	
Manufacturer name	Analog Devices
Application type of Acceptance	
Serial Number of samples	Five (5) samples serialised as Ref, 1, 2, 3 and 4
Manufacturing Date Code	0304
Irradiation Measurement Interval: Biased Unbiased: Circuit Reference: Supply Voltage: Temp ^{o}C: Duration:	 Yes (3 parts) Yes (1 part) ±5V Room temperature 20 ± 3 29 days
Electrical Measurement Parameters	IOS, Ib, IS, AV0, Vo, SR, VOS
Facility Source: Energy: Dose Rate: Absorbed Material: Thickness: Temperature ^{o}C:	 60Co 0.5 rad(Si)/min N/A N/A 20 ± 3
Dosimetry / Calibration method.	A calibrated NE2571, 0.6cc air ionisation chamber read by a calibrated Farmer 2670 dosimeter.
Anneal Test Biased Unbiased Bias Circuit Reference Supply Voltage Duration	 No Yes 29 days and 3 months at room temperature followed by 6 days at 100°C

1 INTRODUCTION

The following document contains the TID Radiation Test Report for OP400 quad low offset low power operational amplifier.

2 APPLICABLE DOCUMENTS

AD1- ESA/SCC 22900 “Total Dose Steady-State Irradiation Test Method”

3 TEST DESCRIPTION

Five (5) OP400, AD devices were selected for TID irradiation testing at the ESTEC ^{60}Co facility. Irradiations were performed at a dose rate of 0.5rad(Si)/min. Post irradiation annealing measurements were also performed on the devices.

Of the selected devices, one was assigned as a reference device while, four were serialised for radiation exposure (three biased and one unbiased). After each exposure-step the components were removed and tested on the SZ-test system for parametric measurements. Each irradiation test-boards accommodated and biased one OP400. The biasing scheme of the operational amplifiers is illustrated in Figure 1. The device operating conditions, temperature conditions and applied dose rates are listed in Table 1.

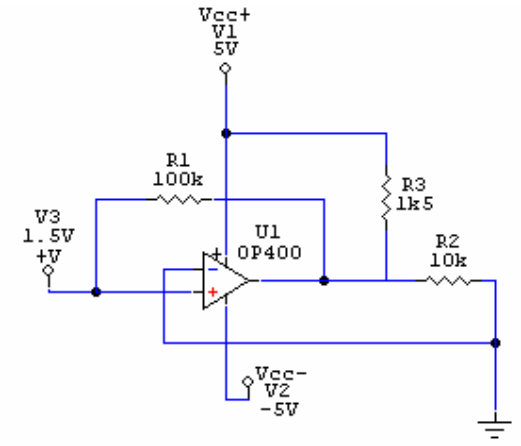

Figure 1: OP400 irradiation biasing conditions

Table 1: irradiation Test Conditions

Parameter	Dev 544	Dev 539	Dev 540	Dev 542	Dev 541
Bias During Irradiation	NA	+1.5V	+1.5V	+1.5V	NO
Dose Rate	NA	0.5rad(Si)/min	0.5rad(Si)/min	0.5rad(Si)/min	0.5rad(Si)/min
Irradiation Temperature	20 ± 3 ^{o}C	20 ± 3 ^{o}C	20 ± 3 ^{o}C	20 ± 3 ^{o}C	20 ± 3 ^{o}C

3.1 Measurement set-up

Two sets of measurements were performed one set of continuous measurements (in 10 min intervals) during the irradiation runs and one set of parametric measurement at regular intervals between irradiation steps. Continuous measurements were performed employing a HP-VEE system consisting of:

- HP 6626A System DC Power Supply
- HP 34970A Data Acquisition / Switch Unit

Parametric measurements were performed employing a SZ parametric tests system:

- SZ M3000 Test Station Sm02B
- M3000 TA09B Test Adapter
- Software UTS-Version 2.5.1

Table 2 lists all parametric measurements performed and their limit values.

Table 2: parameters measured by the SZ parametric Test System

Test Parameter	Limit
Input offset voltage VOS	Upper 0.15mV
Input offset current IOS	Upper 1nA
Input bias current IB	Upper 3nA
Supply Current IS	Lower 0mA Upper 2.9mA
Large signal voltage gain AV0	Lower 73dB
Positive supply voltage V0+	Lower 12V
Negative supply voltage V0-	Upper -12V
Slew rate SR	Lower 0.05V/μs

The time between irradiation stop, performing parametric measurements and starting irradiation for all irradiation steps were less than 30min. 21 irradiation steps were performed and parametric measurements performed after each step (parametric also performed for the reference device). Pre-

irradiation measurements were performed on all devices. Table 3 illustrates the irradiation and measurement history.

Table 3: irradiation and measurement history

Irradiation steps	Dev 544	Dev 539 Biased	Dev 540 Biased	Dev 542 Biased	Dev 541 Unbiased
Pre-rad. Par. measurements	Yes	Yes	Yes	Yes	Yes
0.72 krad(Si)					
par. measurements	Yes	Yes	Yes	Yes	Yes
1.34 krad(Si)					
par. measurements	Yes	Yes	Yes	Yes	Yes
2.02 krad(Si)					
par. measurements	Yes	Yes	Yes	Yes	Yes
3.94 krad(Si)					
Par. Measurements	Yes	Yes	Yes	Yes	Yes
4.6 krad(Si)					
Par Measurements	Yes	Yes	Yes	Yes	Yes
5.27 krad(Si)					
par. measurements	Yes	Yes	Yes	Yes	Yes
5.94 krad(Si)					
par. measurements	Yes	Yes	Yes	Yes	Yes
6.59 krad(Si)					
par. measurements	Yes	Yes	Yes	Yes	Yes
8.66 krad(Si)					
Par. Measurements	Yes	Yes	Yes	Yes	Yes
9.34 krad(Si)					
Par Measurements	Yes	Yes	Yes	Yes	Yes
10.03 krad(Si)					
par. measurements	Yes	Yes	Yes	Yes	Yes
11.03 krad(Si)					
par. measurements	Yes	Yes	Yes	Yes	Yes
11.78 krad(Si)					
par. measurements	Yes	Yes	Yes	Yes	Yes
13.77 krad(Si)					
Par. Measurements	Yes	Yes	Yes	Yes	Yes
14.42 krad(Si)					
Par Measurements	Yes	Yes	Yes	Yes	Yes
15.21 krad(Si)					
par. measurements	Yes	Yes	Yes	Yes	Yes
15.95 krad(Si)					
par. measurements	Yes	Yes	Yes	Yes	Yes

16.68 krad(Si)					
par. measurements	Yes	Yes	Yes	Yes	Yes
18.86 krad(Si)					
Par. Measurements	Yes	Yes	Yes	Yes	Yes
19.56 krad(Si)					
Par Measurements	Yes	Yes	Yes	Yes	Yes
20.02 krad(Si)					
Par Measurements	Yes	Yes	Yes	Yes	Yes

3.2 Thermal conditions

All irradiations and measurements were performed at room temperature (20 ± 3 ^{o}C).

3.3 Dosimetry

A calibrated NE2571, 0.6cc air ionisation chamber read by a calibrated Farmer 2670 dosimeter was used to measure the Total Ionising Dose.

3.4 Test Results

The irradiation test results for OP400 are presented in Figure 2 to 12. For ease of visualization the average of the three biased parts are illustrated. This is also the case for the unbiased part (the average of the quad op-amp).

The following parameters (for biased devices) were out of spec between 5.4 to 7.2krad(Si): Ios, -Ib and +Ib. Ios recovers after +100^{o}C anneal.

The following parameters (for unbiased devices) were out of spec between 5.4 to 7.2krad(Si): -Ib and +Ib.

+Vo (for unbiased device) goes out of specification between 18.9 and 19.6krad(Si), this value recovers after the second room temperature anneal.

+SR (for unbiased device) out of specification after the second room temperature anneal. For biased devices +SR out of specification after +100^{o}C anneal.

SR (unbiased device) out of specification between 8.6 and 9.3 krad(Si). Recovery is seen after 13.7krad(Si) but out of specification again after +100^{o}C anneal.

SR (biased devices) out of specification at 10krad(Si)

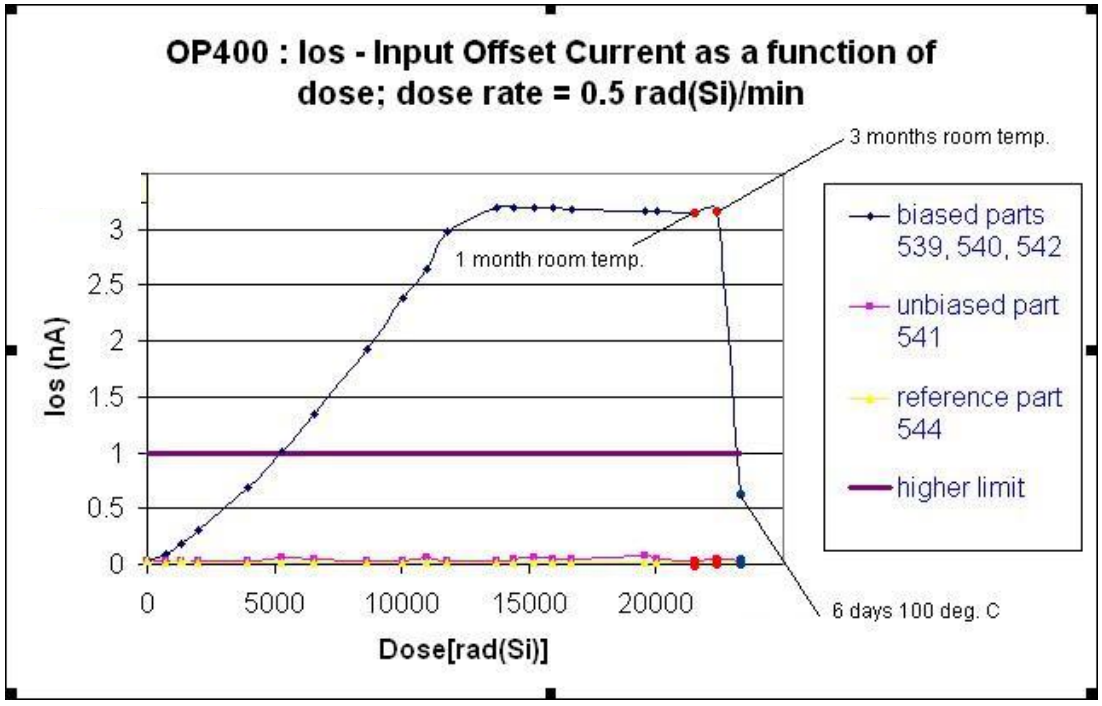

Figure 2: OP400 input offset current as a function of dose; gamma 0.5 rad(Si)/min

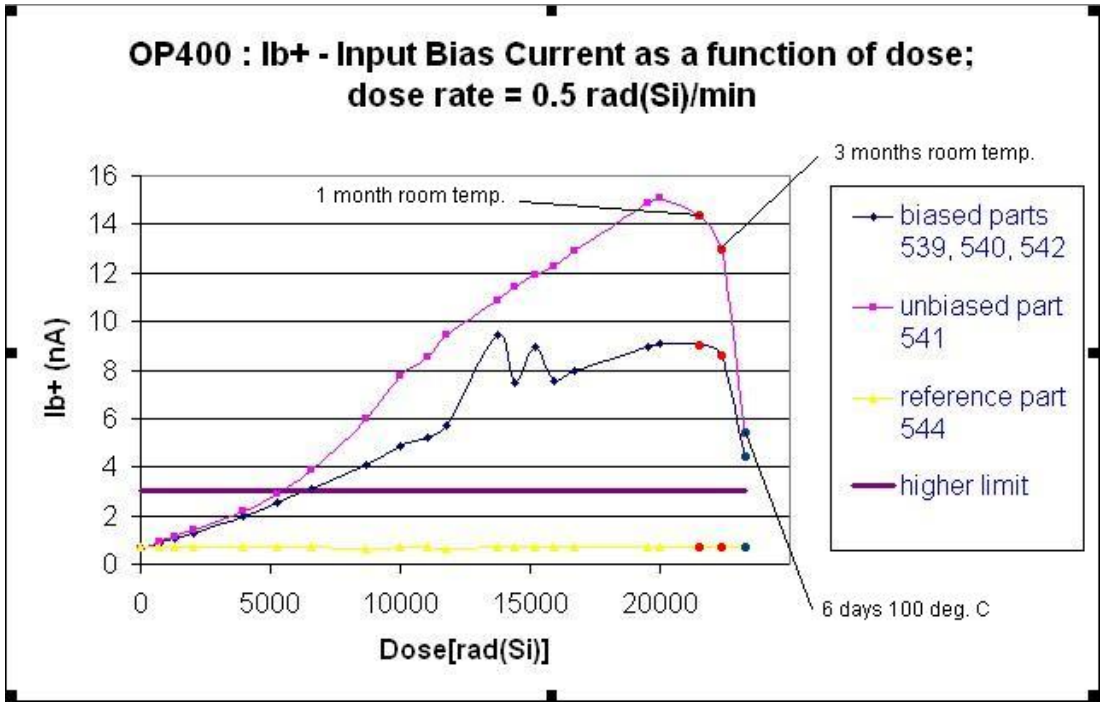

Figure 3: OP400 positive input bias current as a function of dose; gamma 0.5 rad(Si)/min

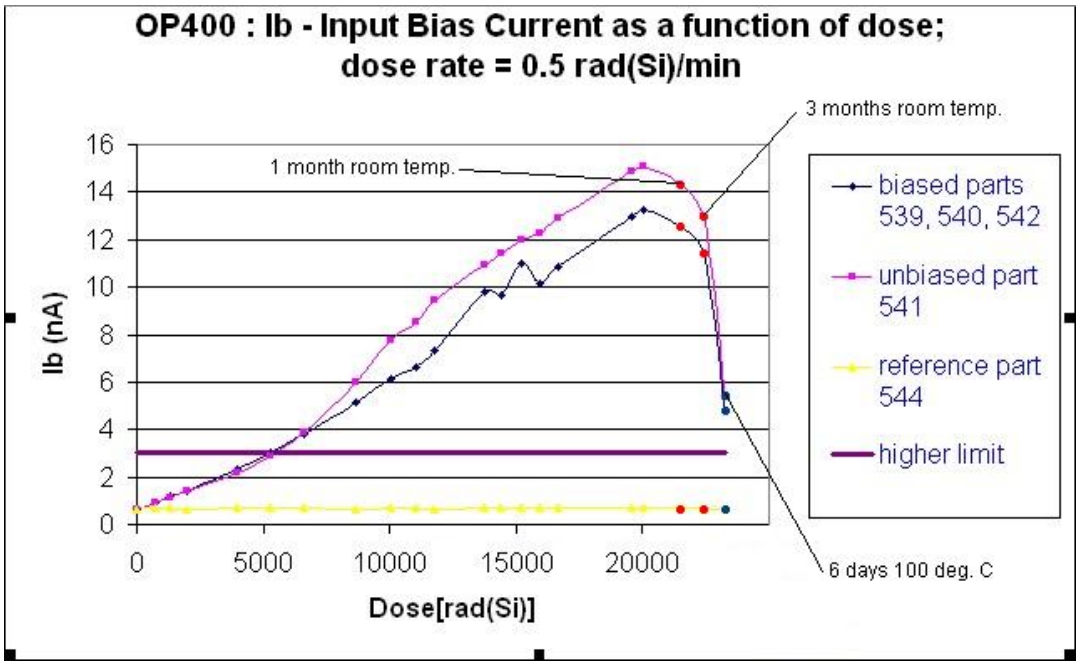

Figure 4: OP400 input bias current as a function of dose; gamma 0.5 rad(Si)/min

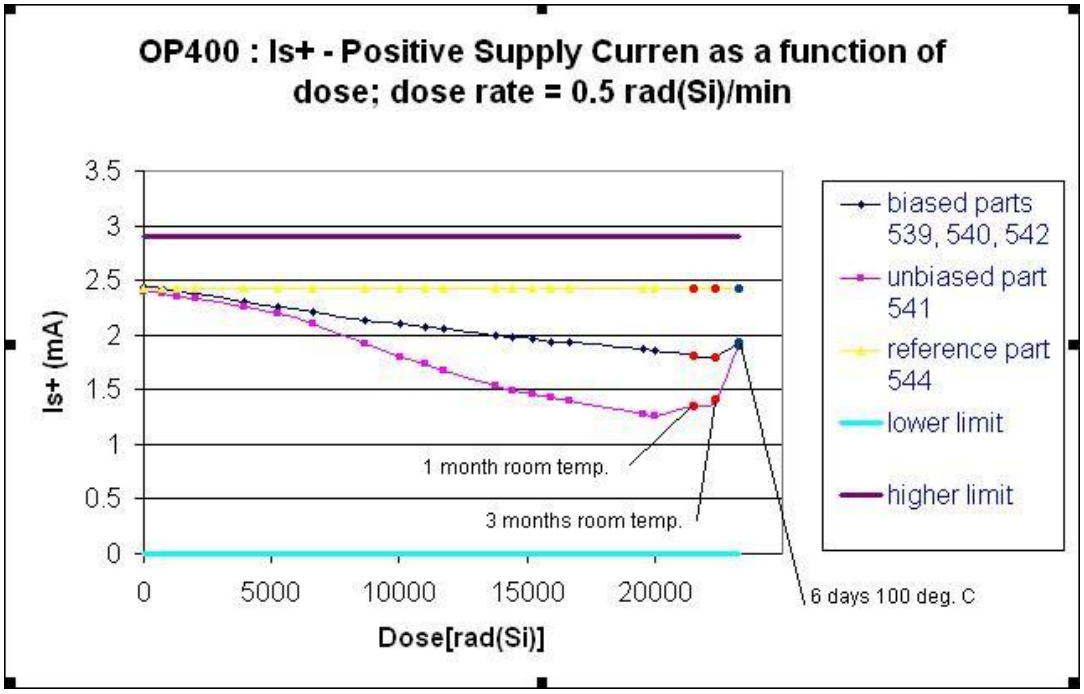

Figure 5: OP400 positive supply current as a function of dose; gamma 0.5 rad(Si)/min

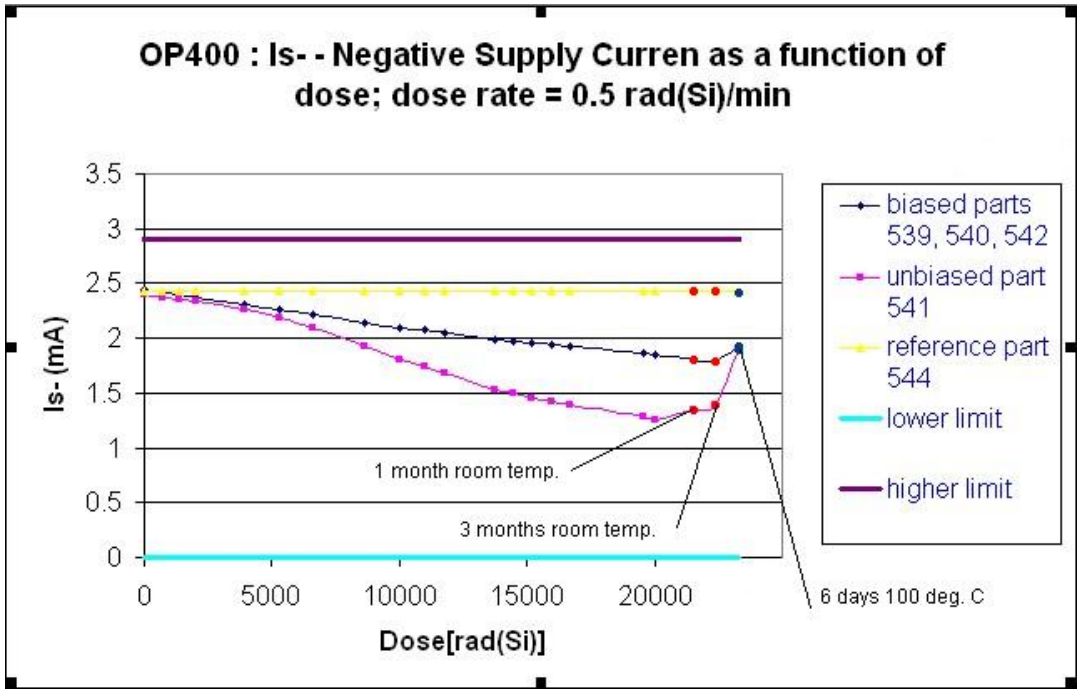

Figure 6: OP400 negative supply current as a function of dose; gamma 0.5 rad(Si)/min

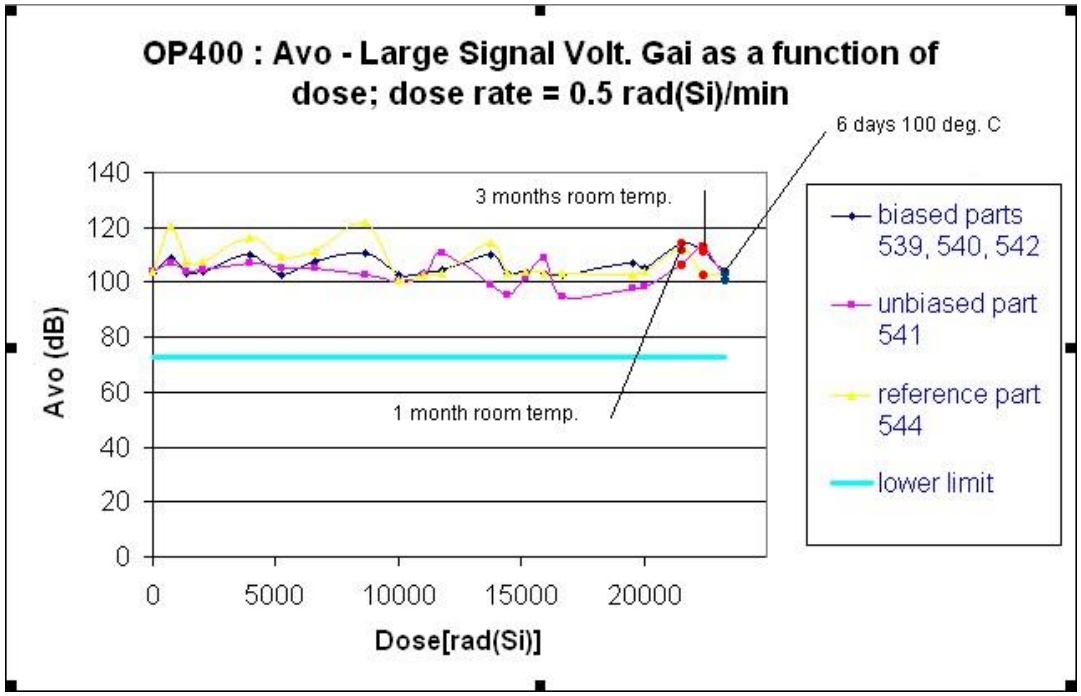

Figure 7: OP400 large signal voltage gain as a function of dose; gamma 0.5 rad(Si)/min

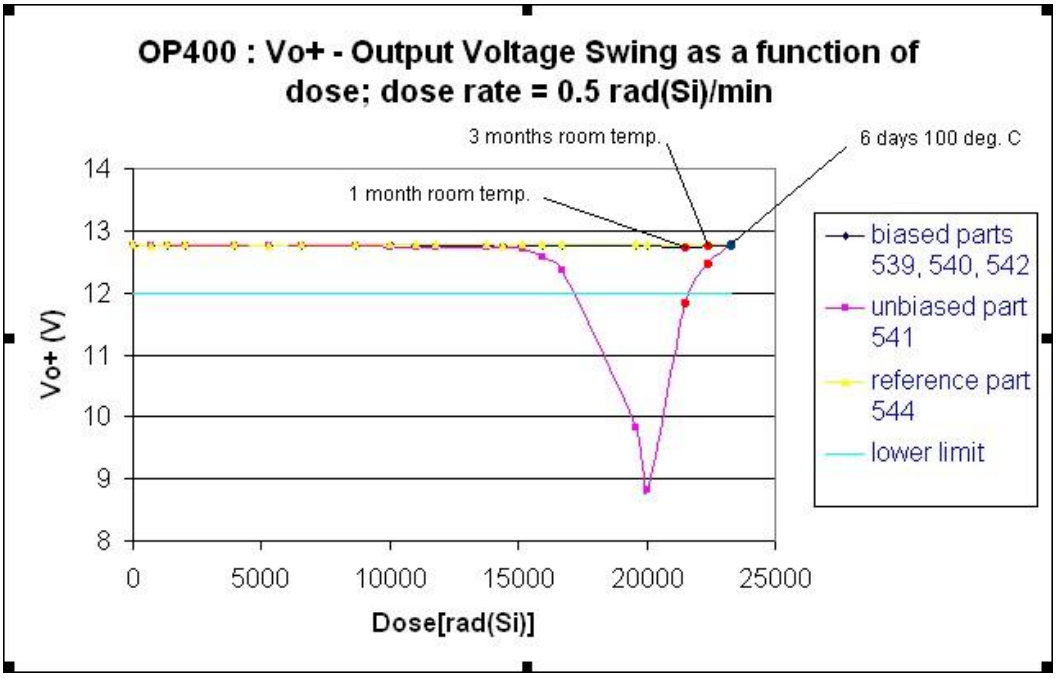

Figure 8: OP400 output voltage swing as a function of dose; gamma 0.5 rad(Si)/min

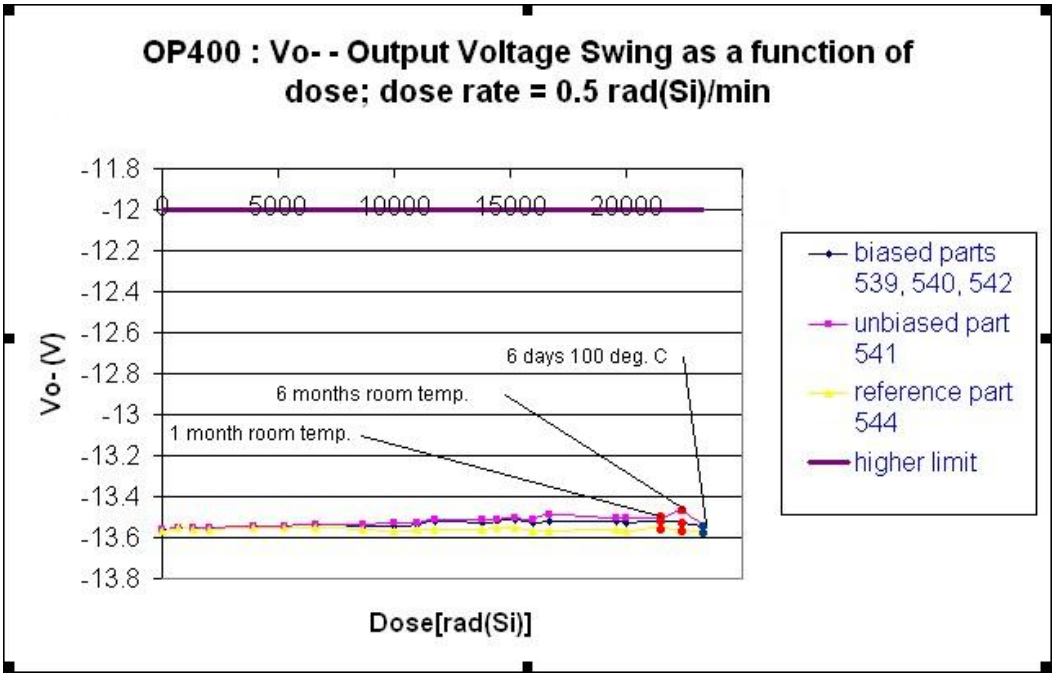

Figure 9: OP400 negative output voltage gain as a function of dose; gamma 0.5 rad(Si)/min

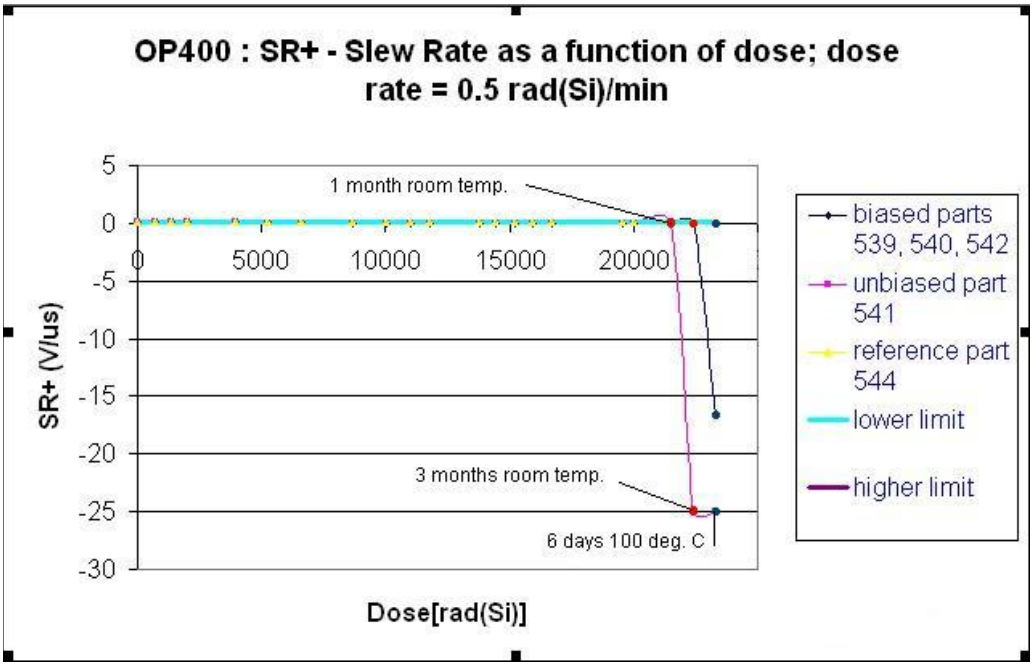

Figure 10: OP400 positive slew rate as a function of dose; gamma 0.5 rad(Si)/min

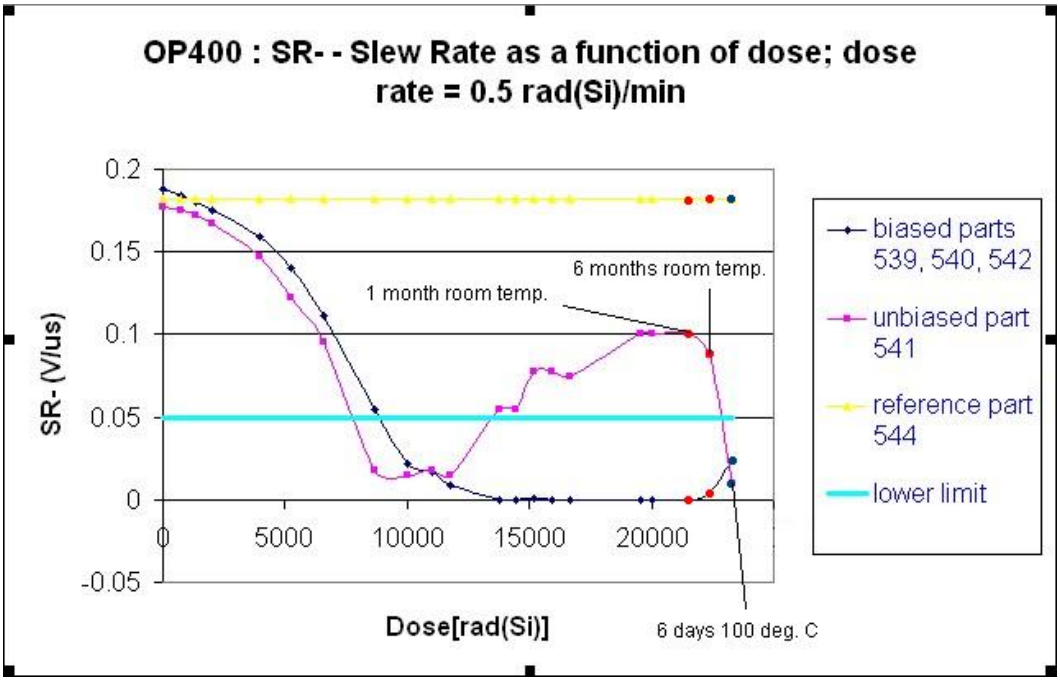

Figure 11: OP400 negative slew rate as a function of dose; gamma 0.5 rad(Si)/min

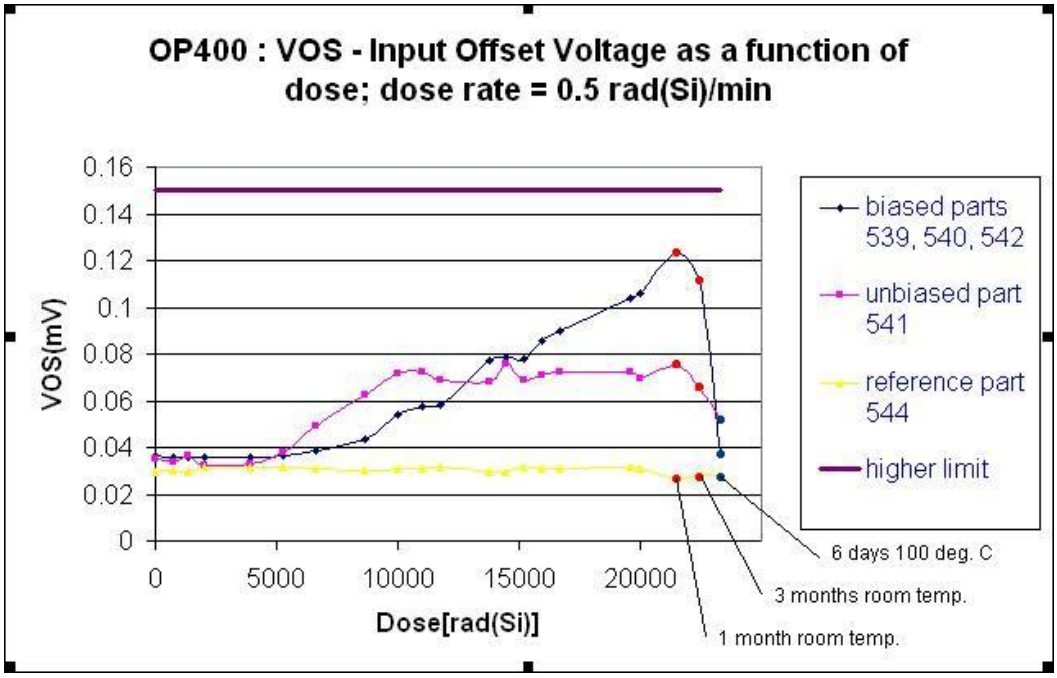

Figure 12: OP400 input offset voltage as a function of dose; gamma 0.5 rad(Si)/min

4 CONCLUSION

Irradiation tests on the OP400 devices were performed to investigate the component's susceptibility to ELDRS. Most device parameters were within specification up to a level of 20krad(Si) even though many of them degraded. However, parameters such as Ios, -Ib and +Ib (for biased devices) were out of specification already between 5.4 to 7.2krad(Si). The results indicate a bias dependency for some of the parameters. Most parameters remained unchanged or improved with room temperature annealing, however, some parameters degraded. This was also the case for the +100^{o}C anneal period.