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

Project SMOS

Quad 2N2222A transistors (JANS2N6989U)

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CHANGE RECORD

Issue: 1 Revision: 0

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Test Report Number	
Project	SMOS
SCC Component no.	
Component Designation	Quad npn transistor JANS2N6989U
Irradiation Spec. no.	
Family	Integrated Circuits
Group	Silicon Monolithic
Package	LCC-20
Component Specification	
Test House Name	ESA / ESTEC
Irradiation Test Plan Number	
Manufacturer name	
Application type of Acceptance	
Serial Number of samples	Three (3) samples serialised as Ref, 1 and 2
Manufacturing Date Code	
Irradiation Measurement Interval: Biased Unbiased: Circuit Reference: Supply Voltage: Temp ^{o}C: Duration:	1 krad(H20) Yes (2 parts) 1V Room temperature 20 ± 3 days
Electrical Measurement Parameters	
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 7 days at room temperature

1 INTRODUCTION

The following document contains the TID Radiation Test Report for the quad 2N2222A transistors for the SMOS project.

2 APPLICABLE DOCUMENTS

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

3 TEST DESCRIPTION

Three (3) JANS2N6989U, AD devices were selected for TID irradiation testing at the ESTEC ^{60}Co facility. Irradiations were performed at a dose rate of 0.5 rad(Si)/min. Post irradiation annealing measurements were also performed on the devices.

Of the selected devices, one was assigned as a reference device while, two were serialised for radiation exposure. After each exposure-step the components were removed and tested on the SZ-test system for parametric measurements. Each irradiation test-boards can accommodate and bias two quad transistor. The biasing scheme of the quad transistor is illustrated in Figure 1. The operating conditions during irradiation were provided by the SMOS project. The device operating conditions, temperature conditions and applied dose rates are listed in Table 1.

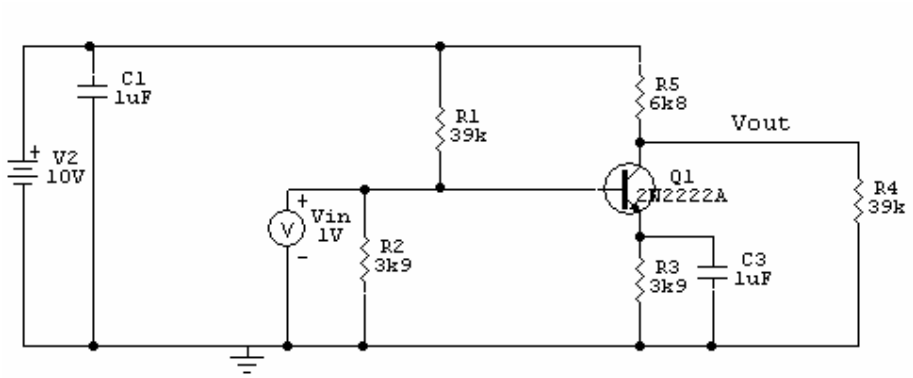

Figure 1: quad transistor biasing conditions for irradiation

Parameter	Ref. Dev.	Dev1	Dev2
Bias During Irradiation	NA	+1V	+1V
Dose Rate	NA	0.5rad(Si)/min	0.5rad(Si)/min
Irradiation Temperature	20 ± 3 ^{o}C	20 ± 3 ^{o}C	20 ± 3 ^{o}C

Table 1 Irradiation Test Conditions

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 TA07T 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
VCE0	Lower 40V Upper 200V
VEB0	Lower 6000V Upper 12000V
ICB0	Upper 10nA
IEB0	Upper 10nA
VBEsat1	Lower 600mV Upper 1200mV
VBEsat2	Lower 0 Upper 2000mV
VCEsat1	Lower 0 Upper 300mV
VCEsat2	Lower 0mV Upper 1000mV
hfe1(DC)	Lower 35 Upper 3000

hfe2	Lower 50 Upper 300
hfe1(DC)	Lower 75 Upper 300
hfe1(DC)	Lower 100 Upper 300
hfe1(DC)	Lower 40 Upper 300
hfe1(DC)	Lower 50 Upper 300
h21e(AC)	Lower 50 Upper 300
H21e(AC)	Lower 75 Upper 375

The time between irradiation stop, performing parametric measurements and starting irradiation for all irradiation steps were less than 30min. 17 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	Ref. Dev.	Dev1 Biased	Dev2 Biased	Dev3 Biased	Dev4 Unbiased
Pre-rad. Par. measurements	Yes	Yes	Yes	Yes	Yes
0.664 krad(water)					
par. measurements	Yes	Yes	Yes	Yes	Yes
1.497 krad(water)					
par. measurements	Yes	Yes	Yes	Yes	Yes
2.271 krad(water)					
par. measurements	Yes	Yes	Yes	Yes	Yes
4.74 krad(water)					
Par. Measurements	Yes	Yes	Yes	Yes	Yes
5.635 krad(water)					
Par Measurements	Yes	Yes	Yes	Yes	Yes
6.638 krad(water)					
par. measurements	Yes	Yes	Yes	Yes	Yes
7.498 krad(water)					
par. measurements	Yes	Yes	Yes	Yes	Yes
11.53 krad(water)					

par. measurements	Yes	Yes	Yes	Yes	Yes
12.299 krad(water)					
Par. Measurements	Yes	Yes	Yes	Yes	Yes
13.084 krad(water)					
Par Measurements	Yes	Yes	Yes	Yes	Yes
13.873 krad(water)					
par. measurements	Yes	Yes	Yes	Yes	Yes
16.205 krad(water)					
par. measurements	Yes	Yes	Yes	Yes	Yes
17.007 krad(water)					
par. measurements	Yes	Yes	Yes	Yes	Yes
17795 krad(water)					
Par. Measurements	Yes	Yes	Yes	Yes	Yes
18705 krad(water)					
Par Measurements	Yes	Yes	Yes	Yes	Yes
19686 krad(water)					
par. measurements	Yes	Yes	Yes	Yes	Yes
22140 krad(water)					
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

Results for a device for each part are presented for all the parameters: the curves show the variation of the parameters as a function of dose. The last point plotted corresponds to the measurement done after the one-week annealing period.

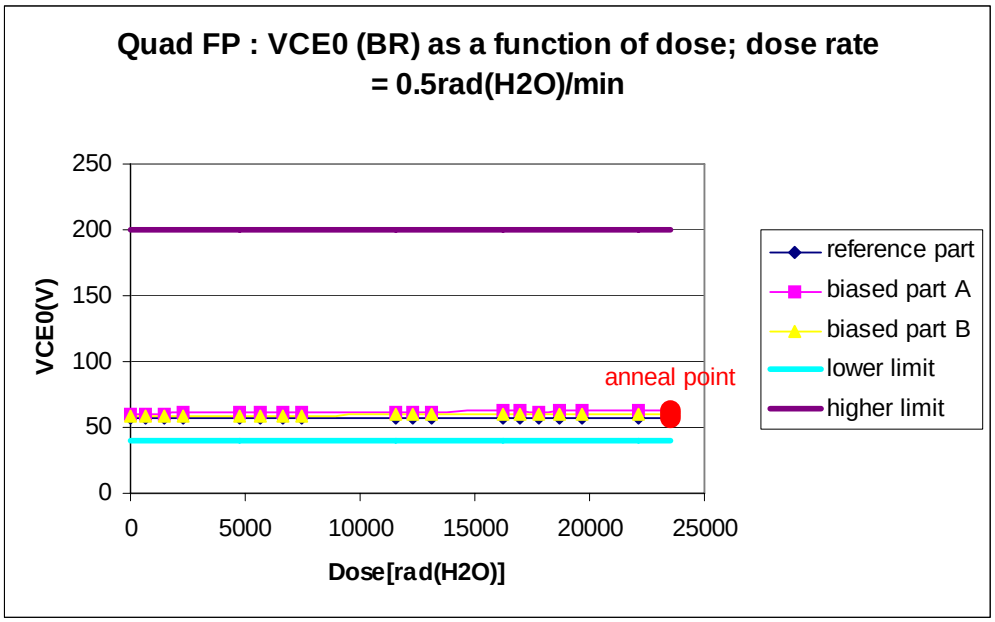

Figure 2: Quad FP collector-emitter voltage, open base, as a function of dose; gamma 0.5 rad(water)/min

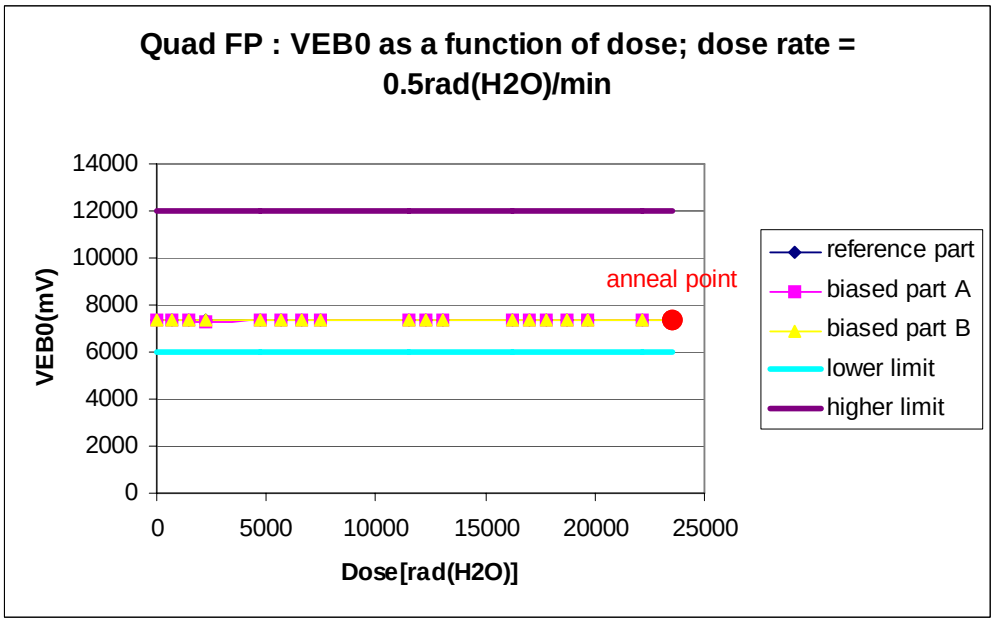

Figure 3: Quad FP emitter-base voltage, open collector, as a function of dose; gamma 0.5 rad(water)/min

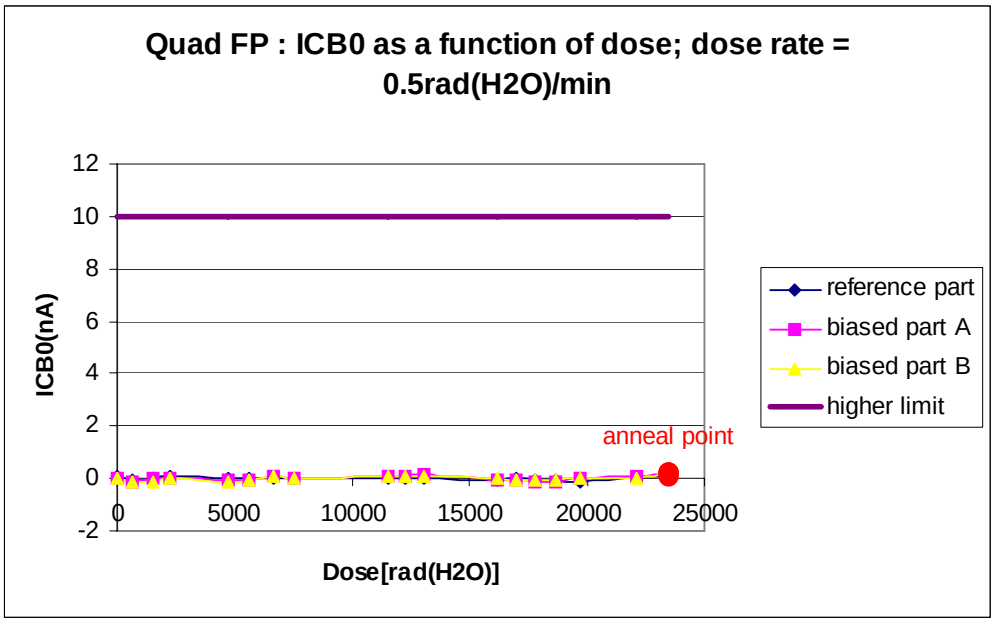

Figure 4: Quad FP collector cut-off current as a function of dose; gamma 0.5 rad(water)/min

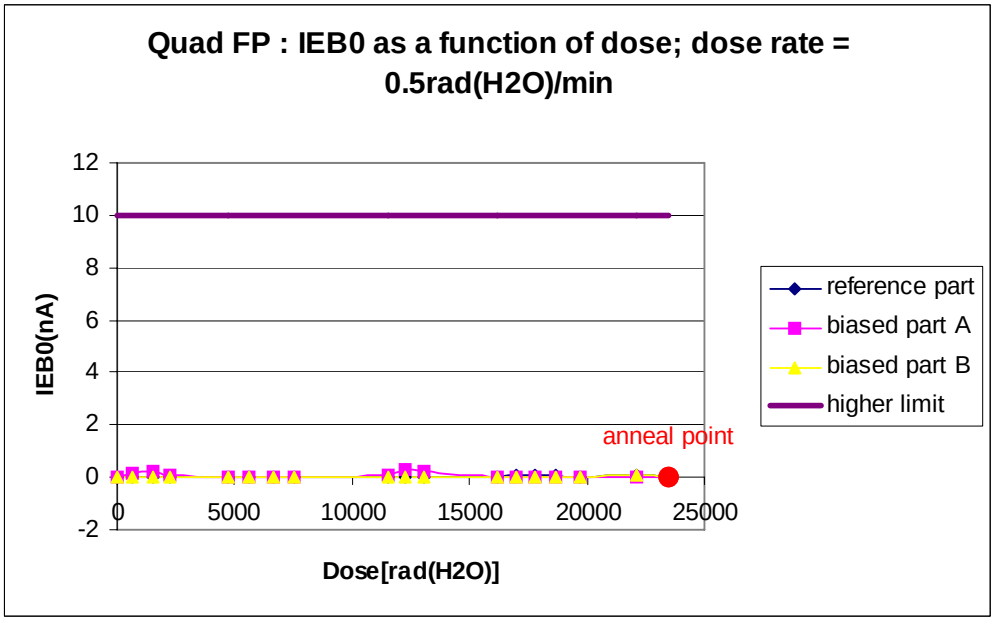

Figure 5: Quad FP emitter cut-off current as a function of dose; gamma 0.5 rad(water)/min

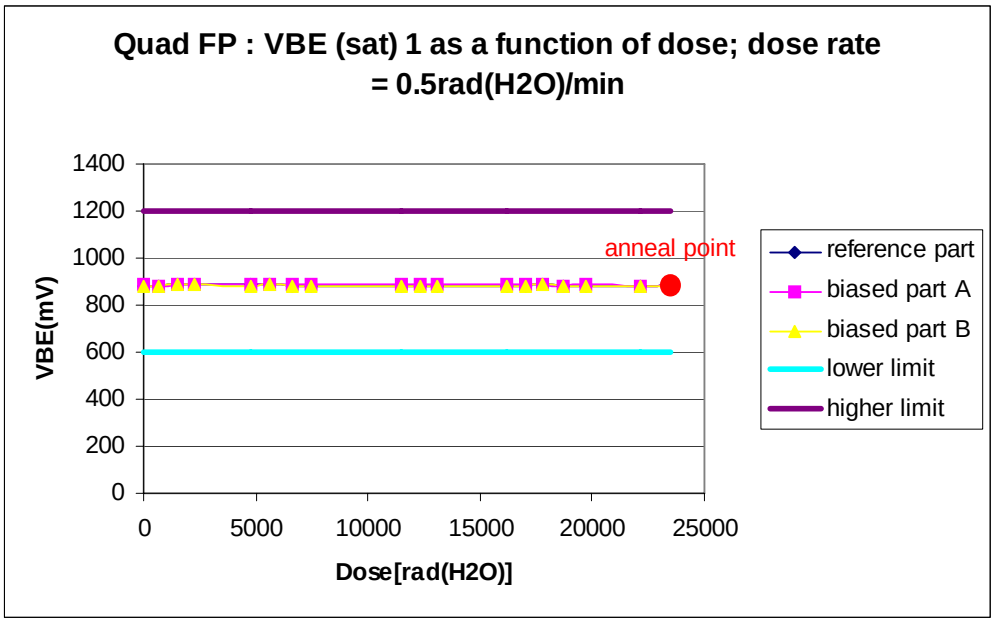

Figure 6: Quad FP base-emitter saturation voltage 1 as a function of dose; gamma 0.5 rad(water)/min

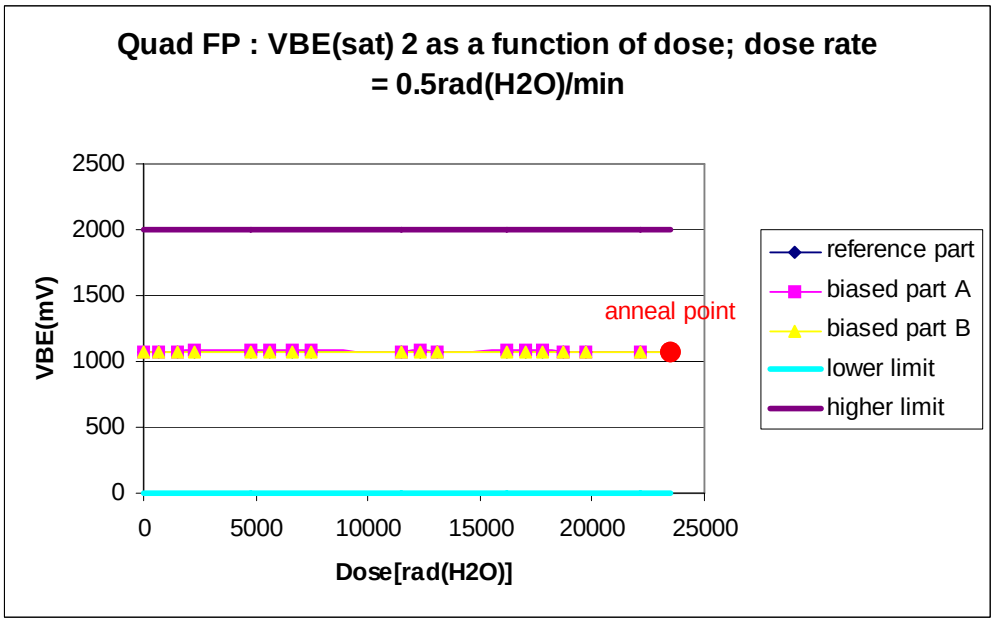

Figure 7: Quad FP base-emitter saturation voltage 2 as a function of dose; gamma 0.5 rad(water)/min

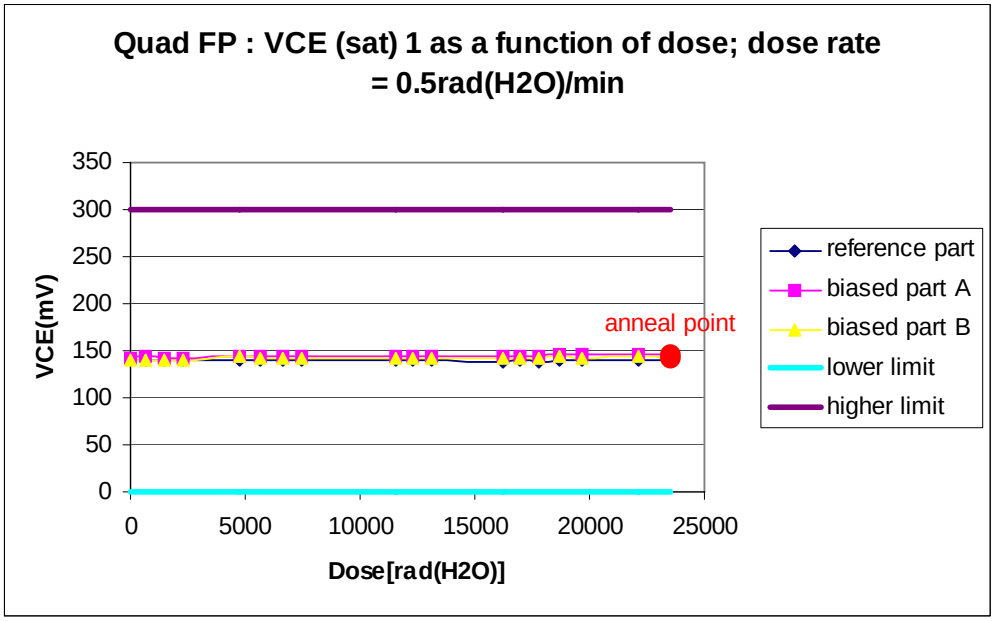

Figure 8: Quad FP collector-emitter saturation voltage 1 as a function of dose; gamma 0.5 rad(water)/min

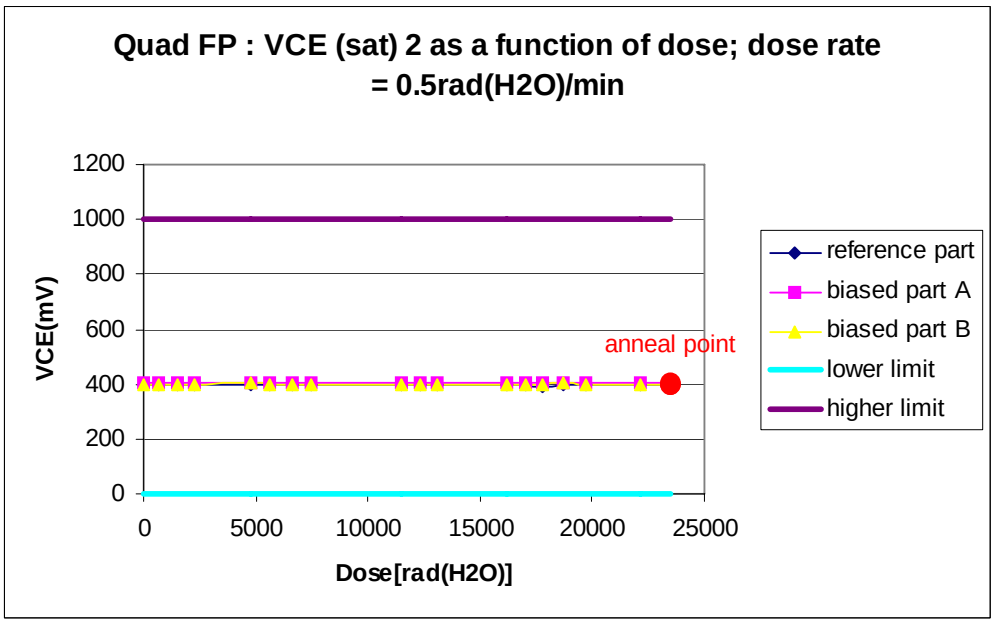

Figure 9: Quad FP collector-emitter saturation voltage 2 as a function of dose; gamma 0.5 rad(water)/min

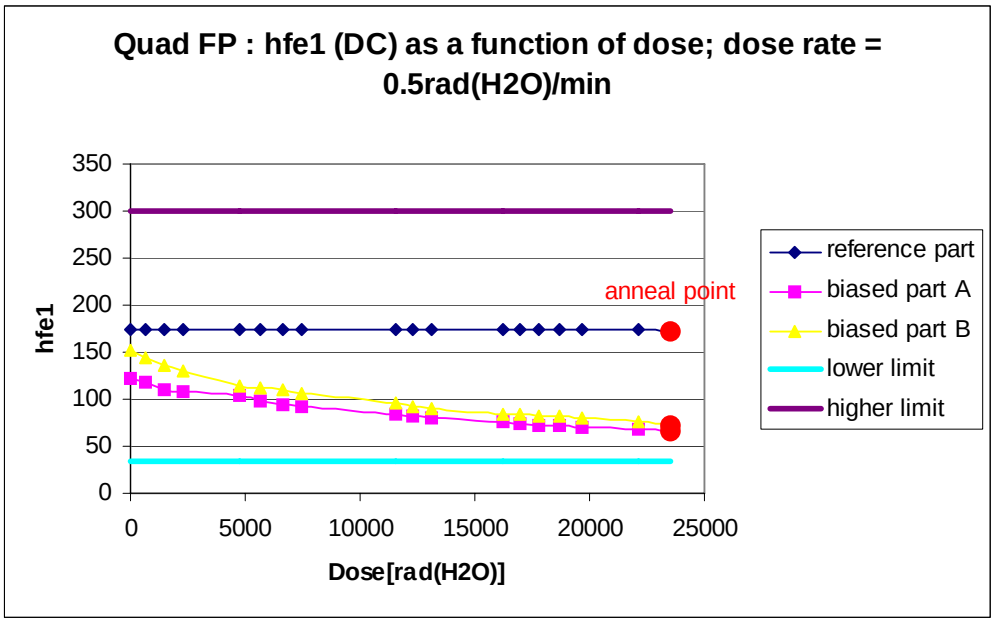

Figure 10: Quad FP DC current gain as a function of dose; gamma 0.5 rad(water)/min

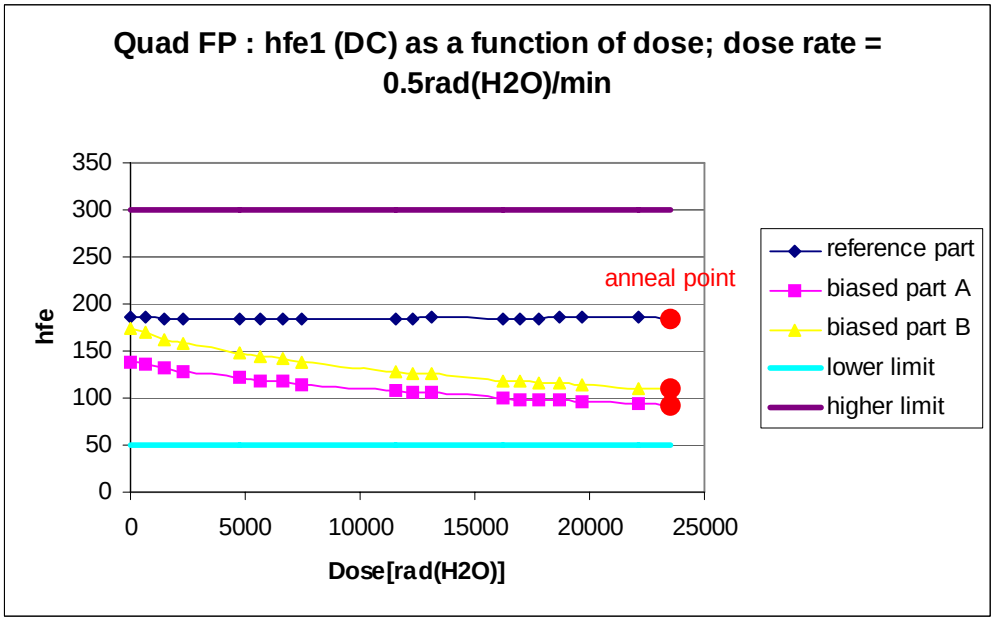

Figure 11: Quad FP DC current gain as a function of dose; gamma 0.5 rad(water)/min

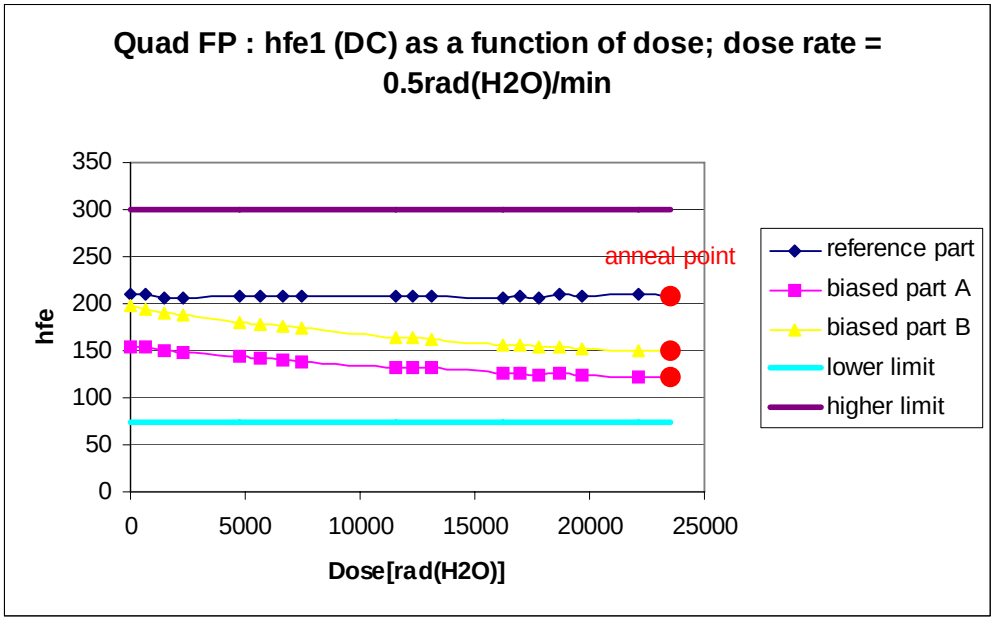

Figure 12: Quad FP DC current gain as a function of dose; gamma 0.5 rad(water)/min

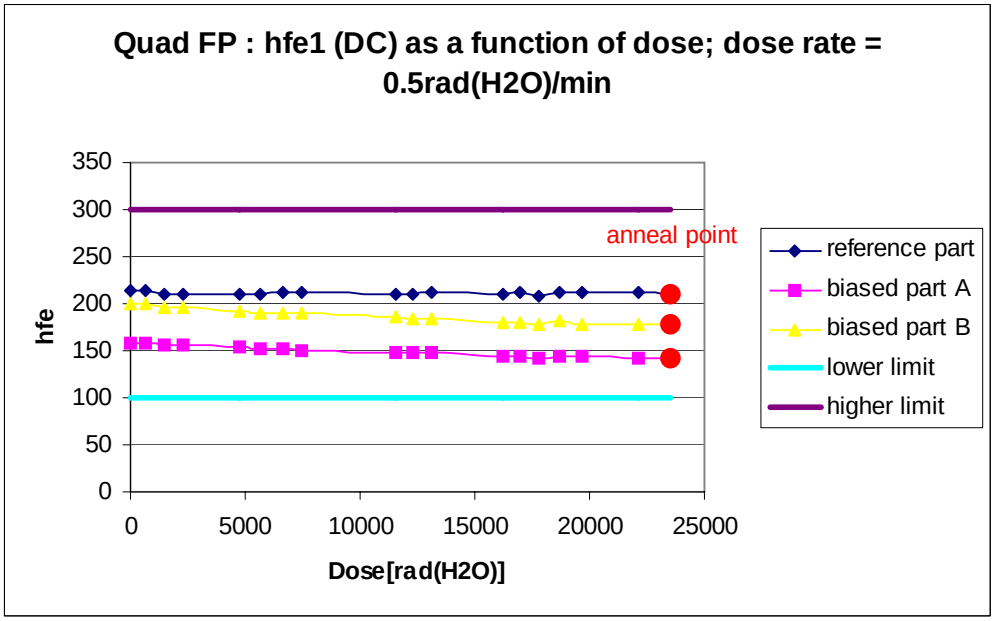

Figure 13: Quad FP DC current gain as a function of dose; gamma 0.5 rad(water)/min

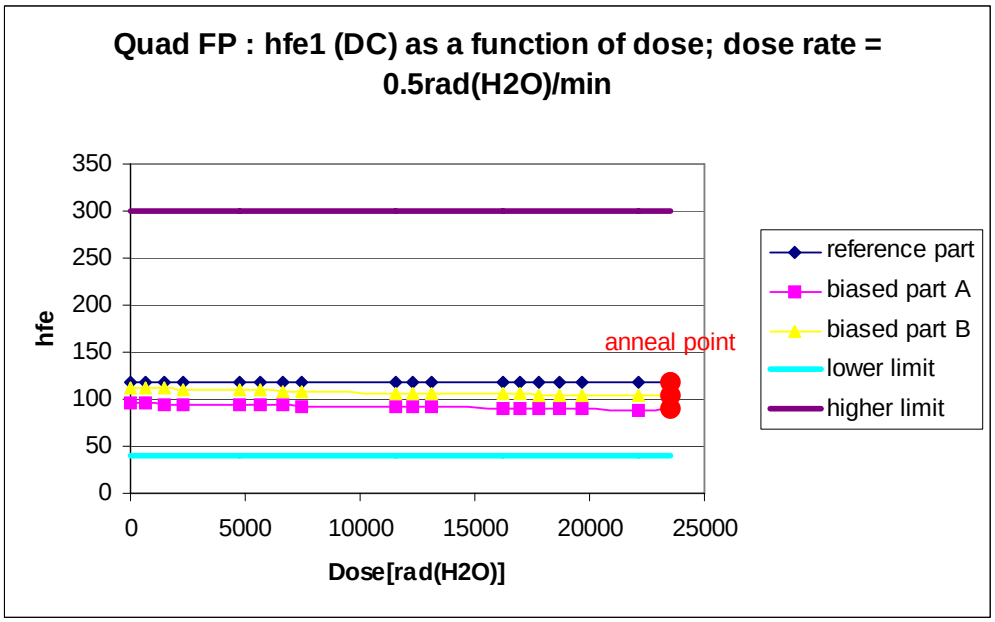

Figure 14: Quad FP DC current gain as a function of dose; gamma 0.5 rad(water)/min

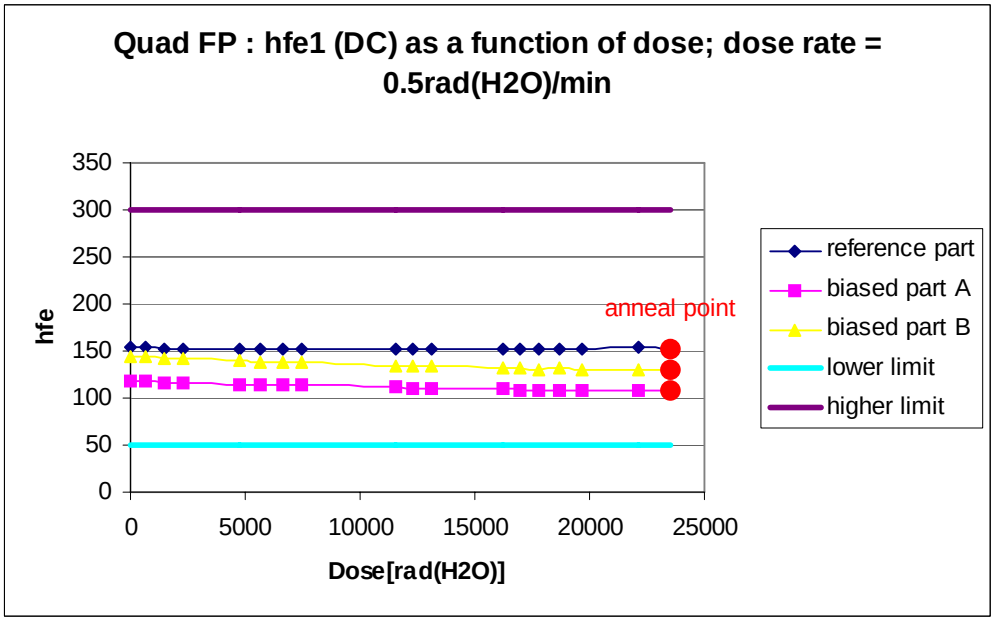

Figure 15: Quad FP DC current gain as a function of dose; gamma 0.5 rad(water)/min

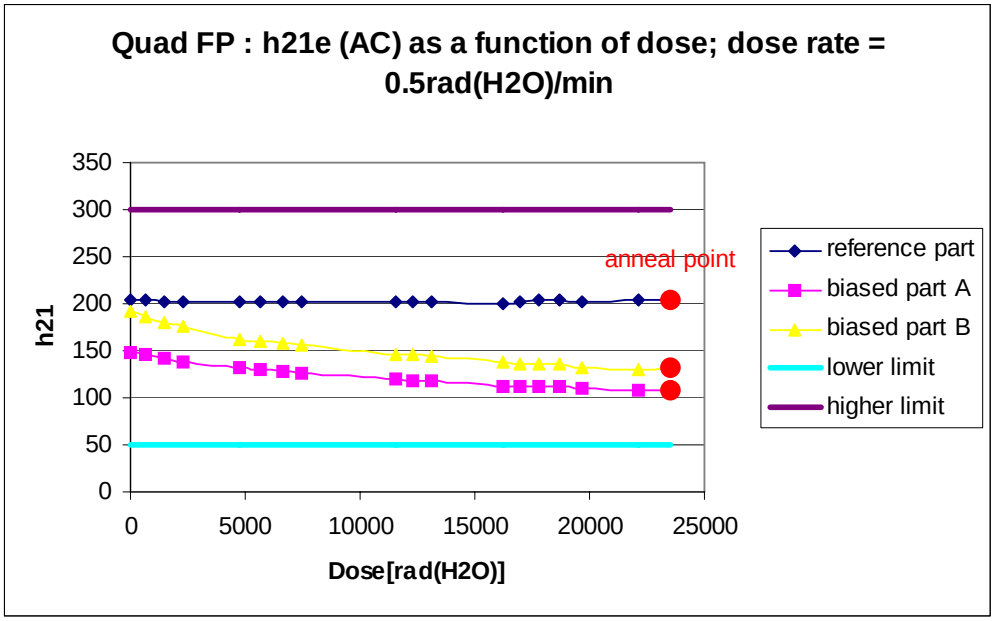

Figure 16: Quad FP AC current gain as a function of dose; gamma 0.5 rad(water)/min

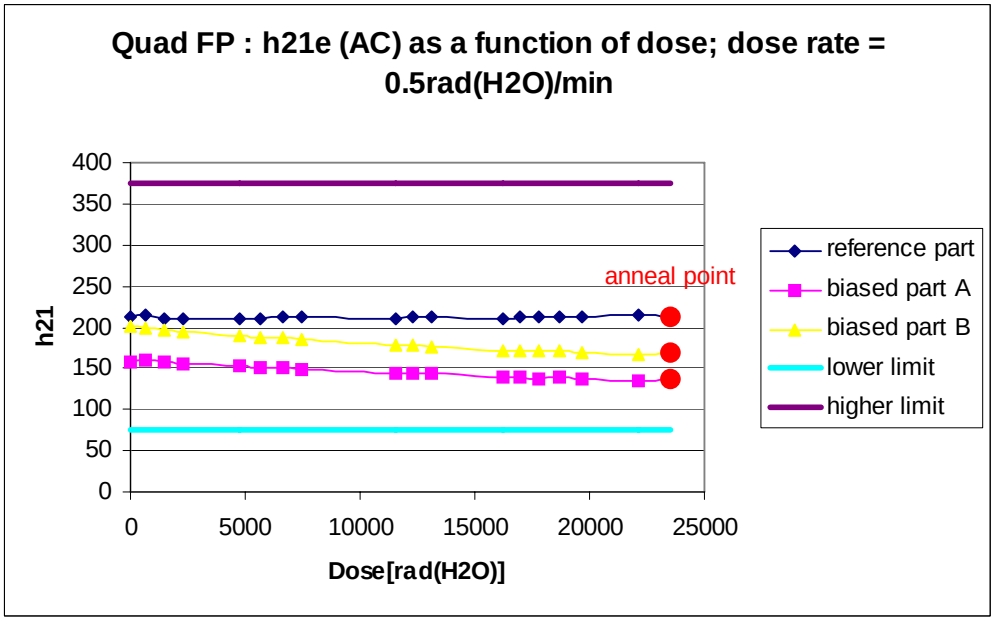

Figure 17: Quad FP AC current gain as a function of dose; gamma 0.5 rad(water)/min