

RADIATION TEST REPORT  
FOR MOTOROLA LM139A  
(DATE CODE 9447)

PROJECT SMART1

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## A P P R O V A L

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## C H A N G E L O G

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## C H A N G E R E C O R D

Issue: 1 Revision: 0

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Test Report Number	ESA-QCA-RTR-LM139a-00202
Project	SMART1
SCC Component no.	LM139a
Lot Number	T4114451
Packaging Date	26 January 1995
Component Designation	Quad Bipolar Voltage Comparator
Irradiation Spec. no.	
Family	Integrated Circuits
Group	Silicon Monolithic
Package	Ceramic
Component Specification	
Test House Name	ESA / ESTEC
Irradiation Test Plan Number	NA
Manufacturer name	Motorola
Application type of Acceptance	
Serial Number of samples	Three (3) samples serialised as Ref (SN 43), 1(SN 27) and 2(SN 59)
Manufacturing Date Code	9447
Irradiation Measurement Interval: Biased Unbiased: Circuit Reference: Supply Voltage: Temp °C: Duration:	Yes No  Two devices at +20V and one devices at +12V Room temperature $20 \pm 3$
Electrical Measurement Parameters	See section 3.1
Facility Source: Energy: Dose Rate: Absorbed Material: Thickness: Temperature °C:	$^{60}\text{Co}$  46.8 rad/min and 0.9 rad/min N/A N/A $20 \pm 3$
Dosimetry / Calibration method.	A calibrated NE2571, 0.66cc air ionisation chamber read by a calibrated Farmer 2670 dosimeter.
Anneal Test Biased Unbiased Bias Circuit Reference Supply Voltage Duration	Not available

## 1 INTRODUCTION

The following document contains the Radiation Test Report for Motorola LM139a quad voltage comparator for the SMART1 project.

## 2 APPLICABLE DOCUMENTS

AD-2 ESA/SCC Detailed Specification No. 9103/004 "Integrated Circuits, Silicon Monolithic, Quad Bipolar Voltage Comparator, Based on Types LM139 and LM139A"

## 3 TEST DESCRIPTION

Three (3) LM139a, Flight Lot, Motorola devices were earmarked for TID irradiation testing at the ESTEC <sup>60</sup>Co facility. To investigate Enhanced Low Dose Rate Effects, irradiation tests employing two different dose rates (high and low dose rates) were planned. The high dose rate tests were performed at 46.8 rad/min while the low dose rate tests were performed at 0.9 rad/min which is at the lower capability limits of the ESTEC <sup>60</sup>Co facility. As only 3 devices were available, low dose rate tests were performed on the reference device.

Of the devices received, one was employed as a reference device while, two were serialised for use in the irradiation tests. A special test board (figure 1) was manufactured to accommodate two devices during exposure. Each device on the test board was biased independently with operating conditions as provided by the SMART1 project. The device operating / temperature conditions and applied dose rate are listed in table 1.

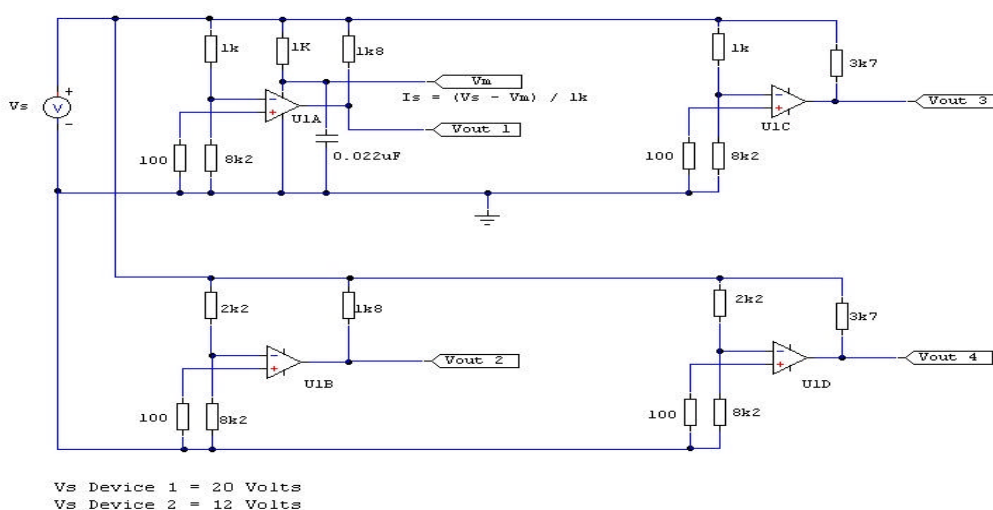


Figure 1 Schematic diagram of LM139a irradiation test circuit.

Parameter	Ref. Dev.	Dev1	Dev2
Bias During Irradiation	NA (+20V)	+20V	+12V
Dose Rate	NA (0.8rad/min)	46.8rad/min	46.8rad/min
Irradiation Temperature	$20 \pm 3$ °C	$20 \pm 3$ °C	$20 \pm 3$ °C

**Table 1 Irradiation Test Conditions**

### 3.1 Measurement set-up

Two sets of measurements were performed with parameters listed in tables 2 and 3. Continuous measurements, during irradiation, were performed employing an 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 2.3.3

Measurement number	Devices 1,2 and Ref
1	Output Voltage Comparator A
2	Output Voltage Comparator B
3	Output Voltage Comparator C
4	Output Voltage Comparator D
5	Device power consumption

**Table 2 Continuous measurements for each device during irradiation.**

Test Parameter
Vos
+Is
Ib
Ib+
Ib-
Ios
Avo
CMRR
PSRR+

**Table 3 Parameters measured by the SZ parametric Test System**

The high dose rate tests were performed first to quickly provide information on the devices behavior when exposed to gamma radiation. The time between irradiation stop, performing parametric measurements and starting irradiation was always less than 30min. 5 irradiation steps were performed and parametric measurements performed after each step. Pre-irradiation measurements were also performed on all devices. Parametric measurements were also performed on a reference device after each irradiation step (with the exception of the low dose rate tests). Table 4 illustrates the high dose rate irradiation and measurement history.

Irradiation steps	Ref. Dev.	Dev1	Dev2
Pre-rad. Par. measurements	Yes	Yes	Yes
1.25 krad (H <sub>2</sub> O)	NA	Yes	Yes
par. measurements	Yes	Yes	Yes
4 krad irrad (H <sub>2</sub> O)	NA	Yes	Yes
par. measurements	Yes	Yes	Yes
9 krad (H <sub>2</sub> O)	NA	Yes	Yes
par. measurements	Yes	Yes	Yes
15.3 krad (H <sub>2</sub> O)	NA	Yes	Yes
Par. measurements	Yes	Yes	Yes

**Table 4 High Dose Rate Irradiation Test procedure**

The low dose rate tests were performed after completed high dose rate irradiation tests. The time between irradiation stop, performing parametric measurements and starting irradiation was always less than 30min. 1 irradiation step was performed including post-irradiation parametric measurements. Pre-irradiation measurements were also performed on the test sample. Table 5 illustrates the low dose rate irradiation and measurement history. The low dose rate measurements were terminated at approximately 8krad due to irradiation facility availability. Due to the limited number of devices available the reference device from the high dose rate tests was used for the low dose rate tests.

Irradiation steps	Ref. Dev.
Pre-rad. Par. measurements	Yes
8.1 krad (H <sub>2</sub> O)	Yes
par. measurements	Yes

**Table 5 Low Dose Rate Irradiation Test procedure**

### **3.2 Thermal conditions**

All irradiations and measurements were performed at room temperature ( $20 \pm 3$  °C).

### **3.3 Dosimetry**

A calibrated NE2571, 0.60cc air ionisation chamber read by a calibrated Farmer 2670 dosimeter was used to measure the Total Ionising Dose.

### **3.4 Test Results (high dose rate)**

Figures 2 to 10 illustrate the parametric results for the reference device and devices 1 to 2. Results from all four outputs of each device has been included. The limit (AD2) for which a parameter is considered out of spec has also been added to each graph.

Figures 11 to 13 illustrate results acquired during the irradiation runs. These include output voltage measurements and power consumption measurements.

Following figure13, a discussion of the results is presented.



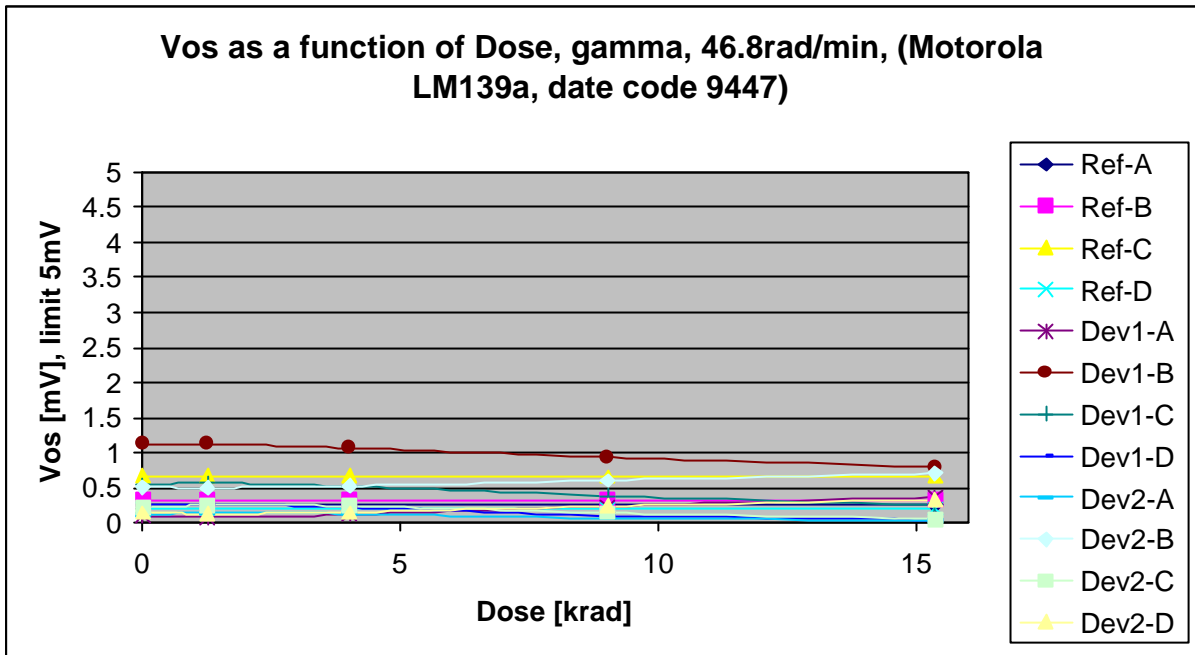


Figure 2 Vos as a function of dose. During irradiation device1 was biased at 20V and device2 at 12V.

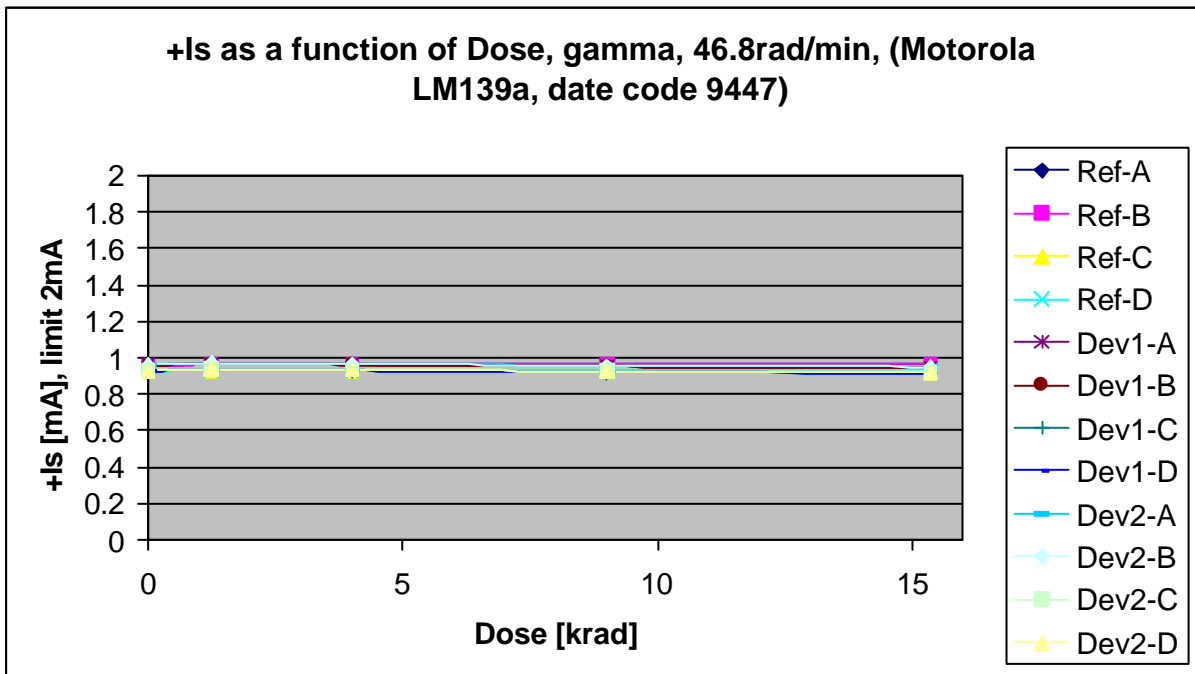


Figure 3 +Is as a function of dose. During irradiation device1 was biased at 20V and device2 at 12V.

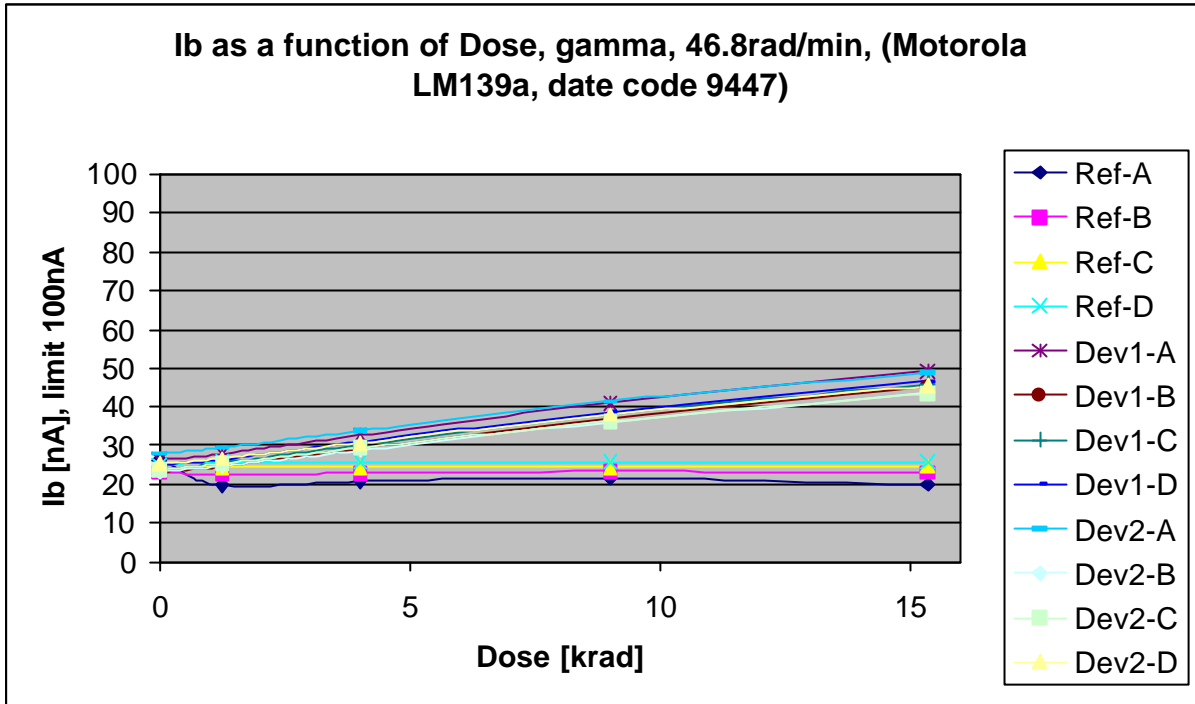


Figure 4 Ib as a function of dose. During irradiation device1 was biased at 20V and device2 at 12V.

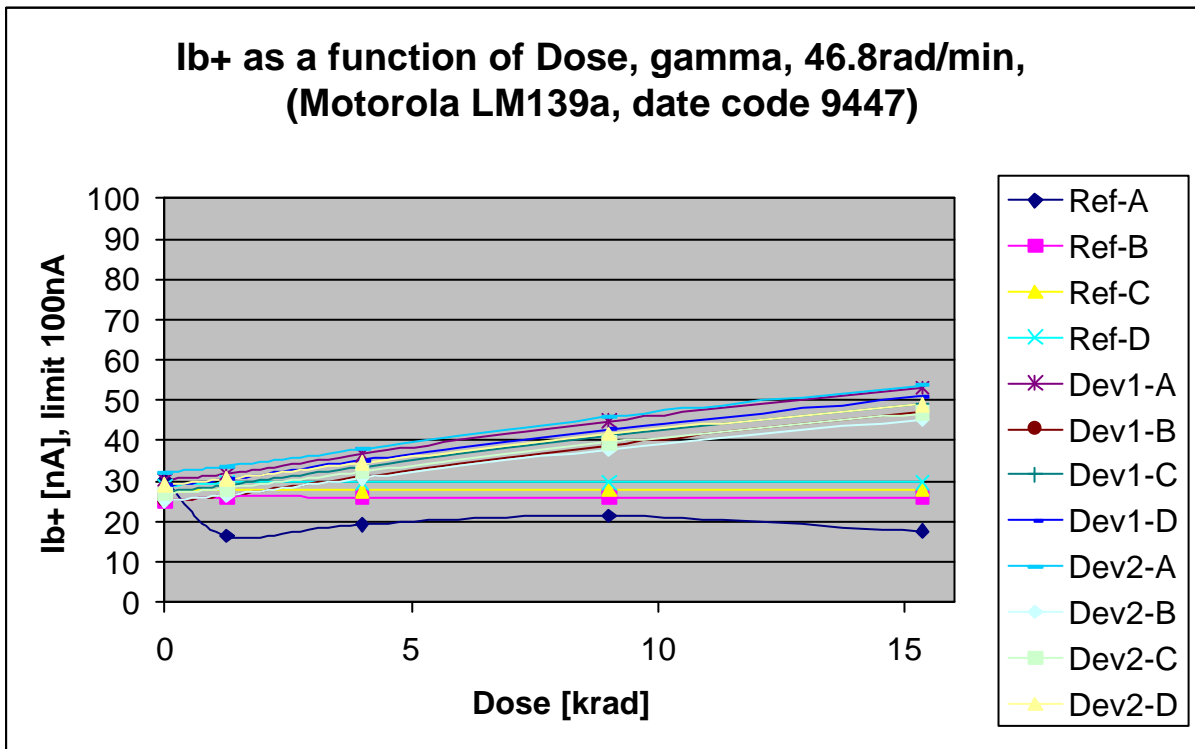


Figure 5 Ib+ as a function of dose. During irradiation device1 was biased at 20V and device2 at 12V.

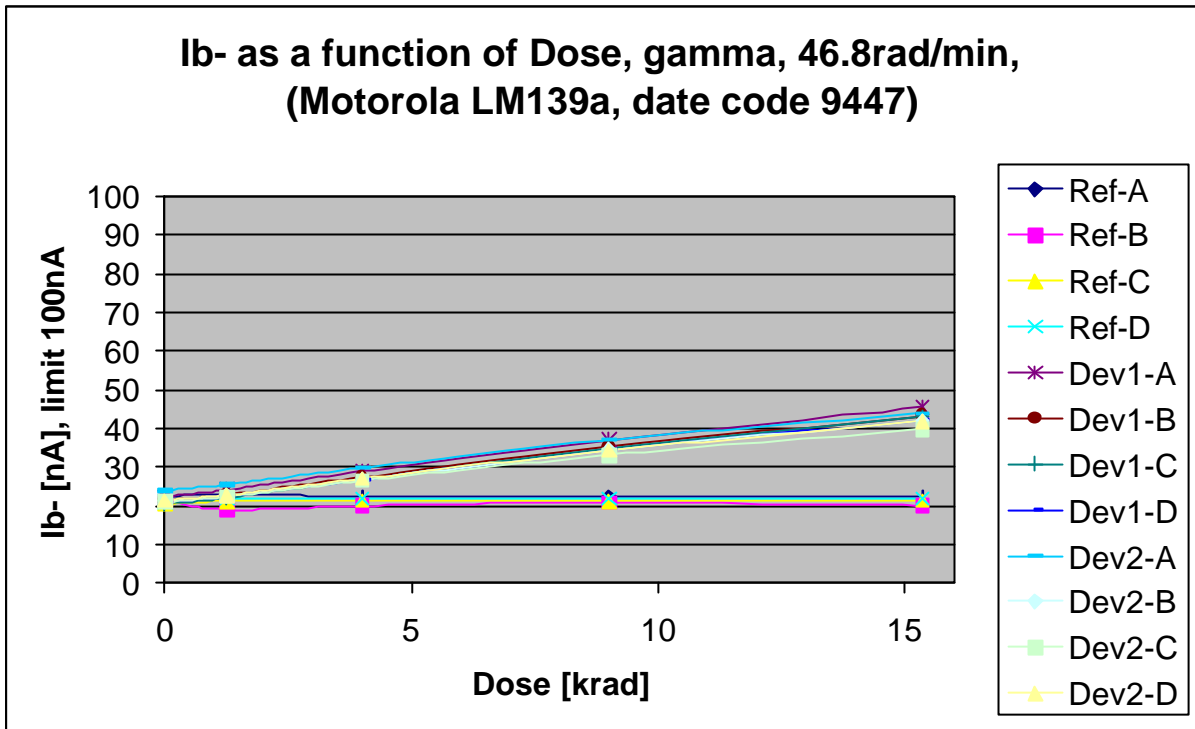


Figure 6 Ib- as a function of dose. During irradiation device1 was biased at 20V and device2 at 12V.

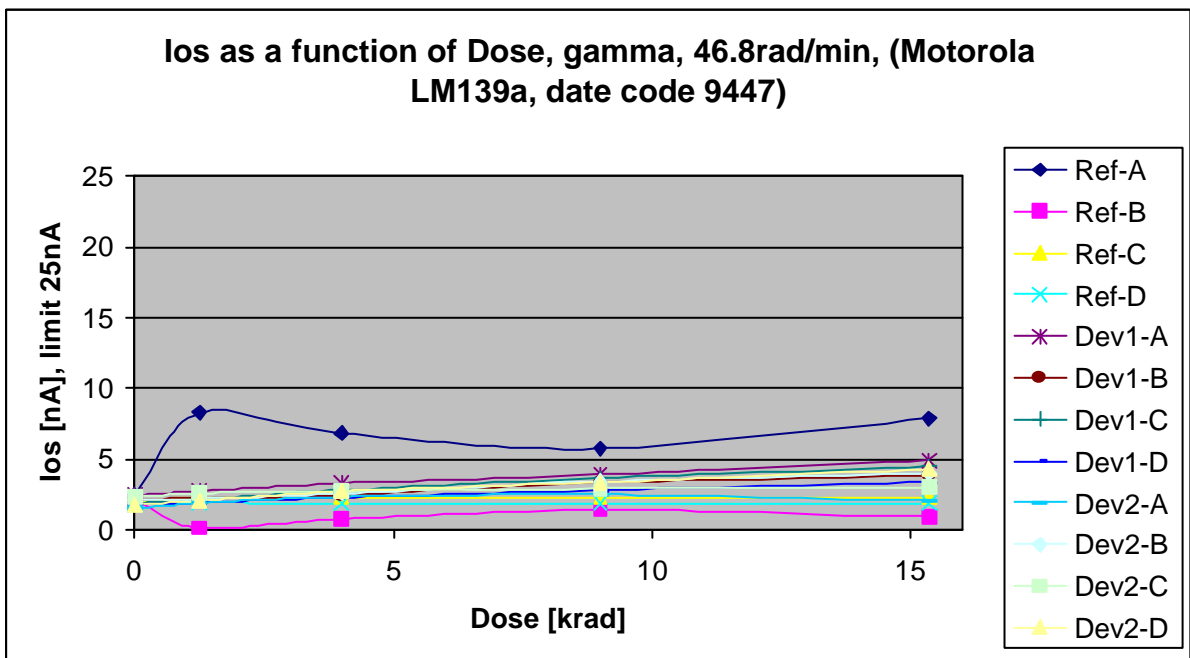


Figure 7 Ios as a function of dose. During irradiation device1 was biased at 20V and device2 at 12V.

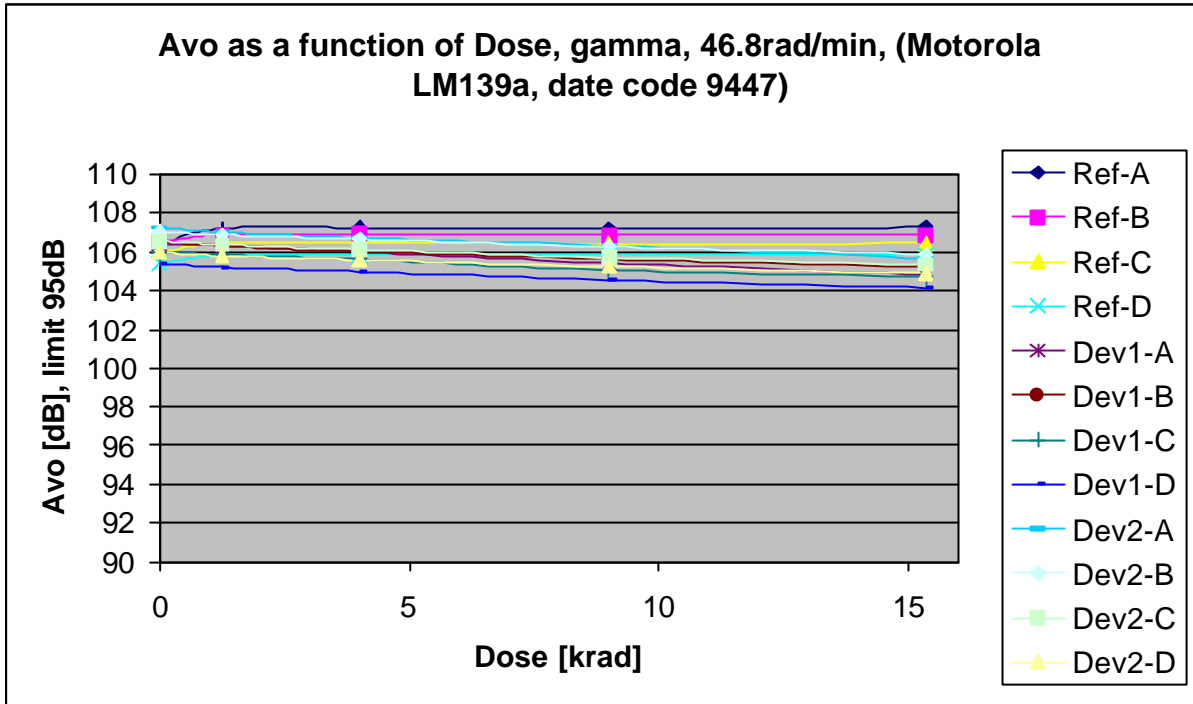


Figure 8 Avo as a function of dose. During irradiation device1 was biased at 20V and device2 at 12V.

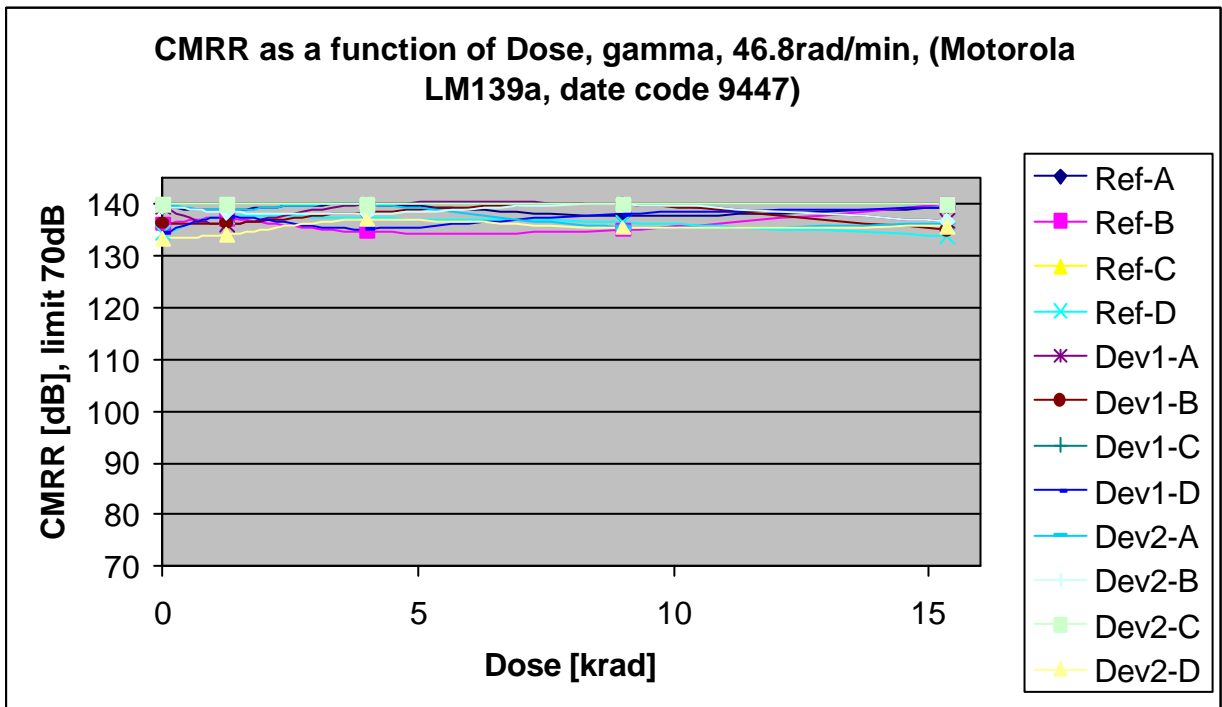


Figure 9 CMRR as a function of dose. During irradiation device1 was biased at 20V and device2 at 12V.

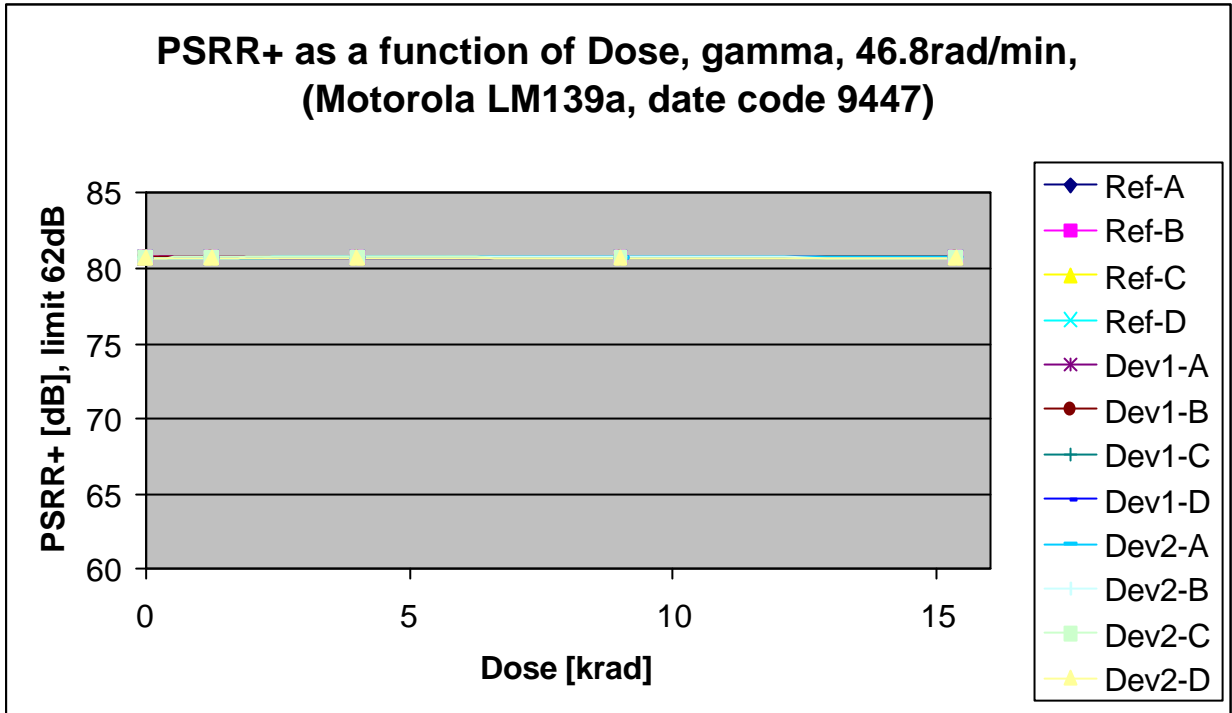


Figure 10 PSRR+ as a function of dose. During irradiation device1 was biased at 20V and device2 at 12V.

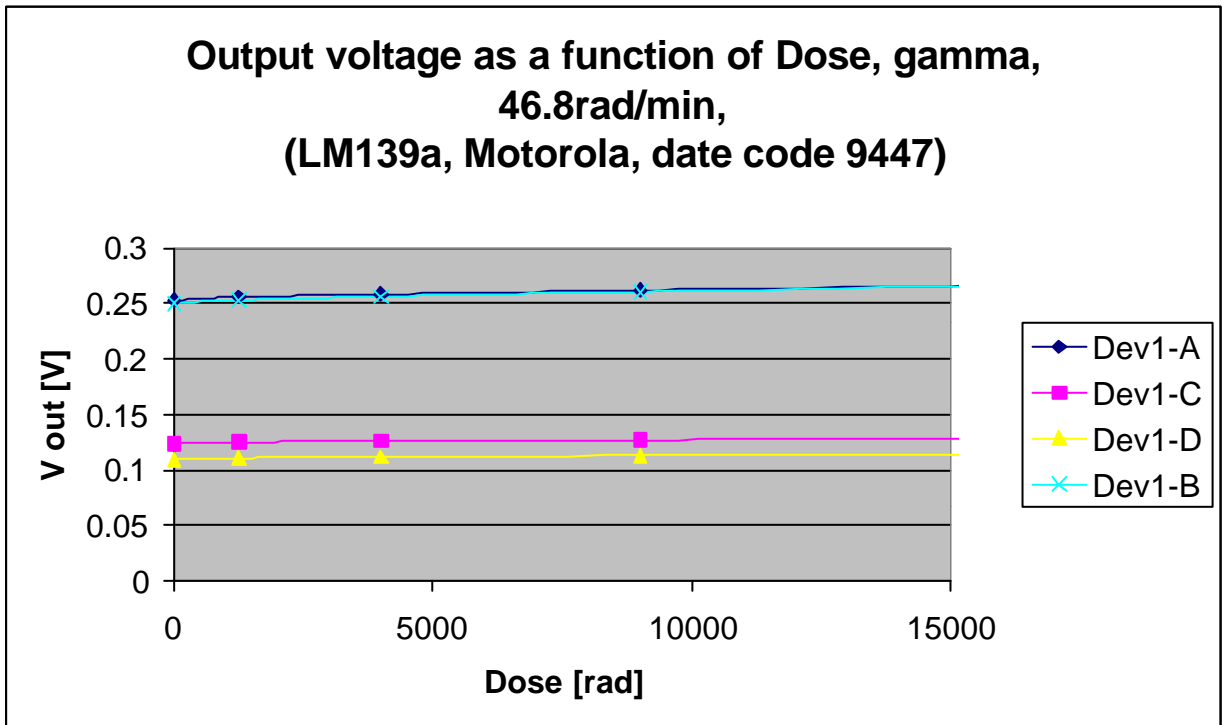


Figure 11 Real time measurement of output voltage during irradiation, device1 biased to 20V.

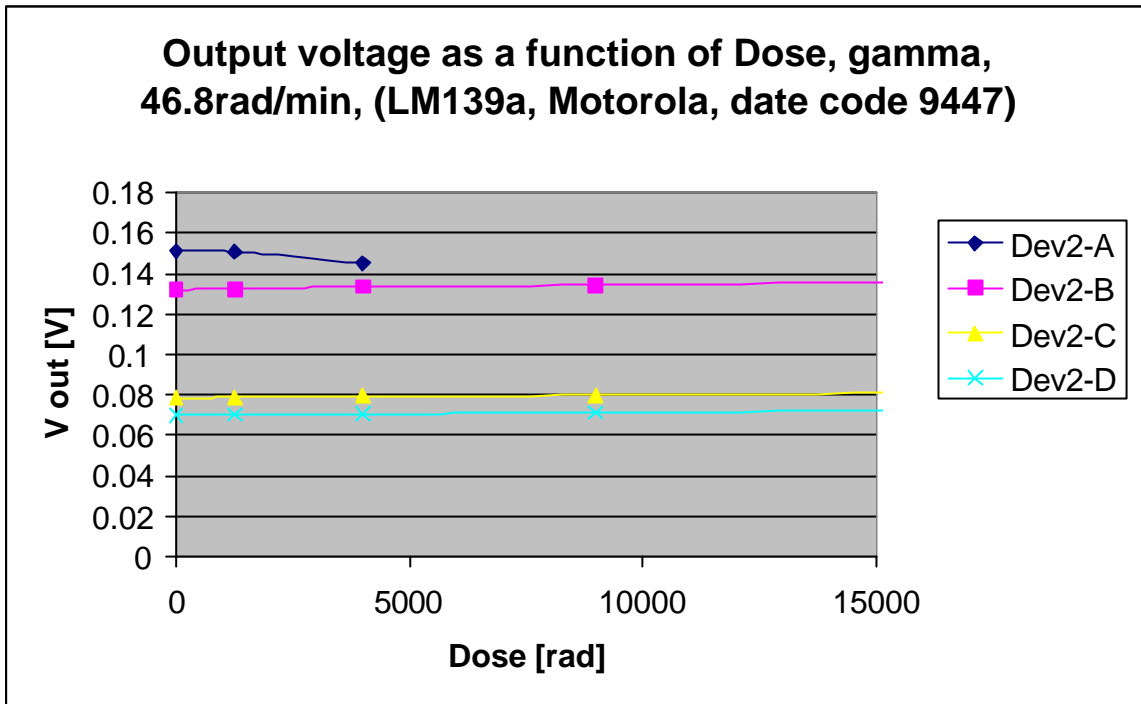


Figure 12 Real time measurement of output voltage during irradiation, device2 biased to 12V.

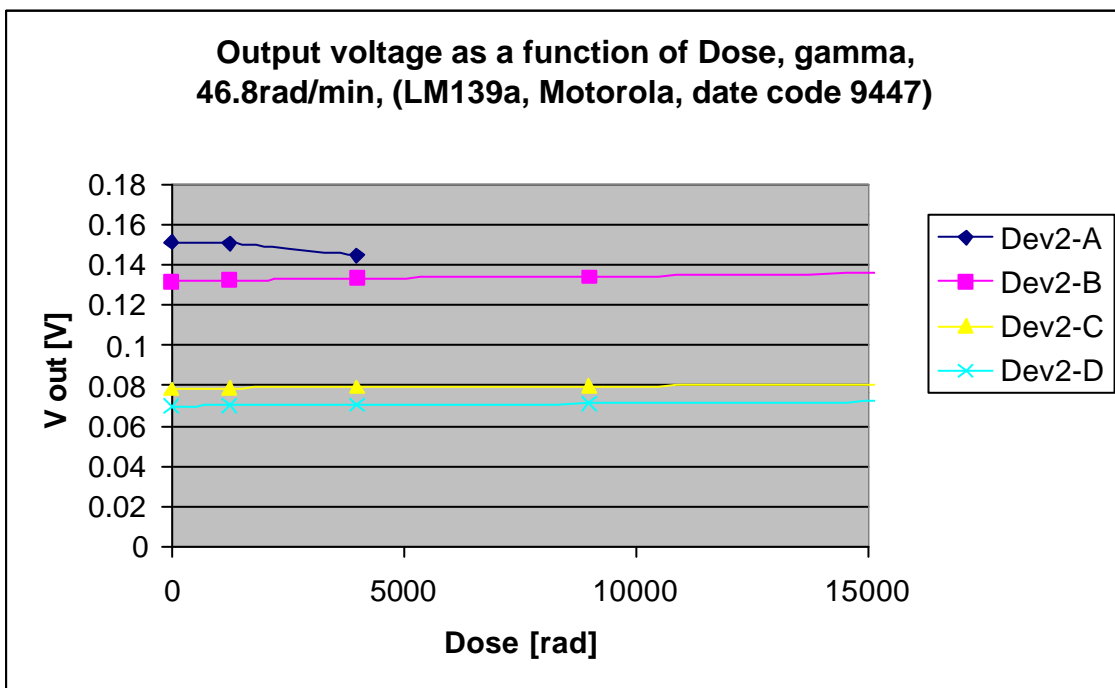


Figure 13 Real time measurement of current consumption during irradiation, device1 biase to 20V and device2 biased to 12V.

Figures 2 to 13 illustrate that the Motorola LM139a (date code 9447) parameters do not significantly change for total doses up to 15krad (H<sub>2</sub>O). The following parameters changed slightly with increasing total dose, however, they were all within the specified values up to 15krad: Ib, Ib+ and Ib-.

Device 2 output-A exhibited anomalous behavior. The cause of this behavior is considered to be a poor electrical connection.

### 3.4.1 CONCLUSION HIGH DOSE RATE TEST

Up to 15krad, only small changes were observed both for parametric and functional measurements, all parameters still within specified values.

### 3.5 Test Results Low Dose Rate

Figures 14 to 22 illustrate the parametric results for the reference device. Results from all four outputs of each device has been included. The limit (AD2) for which a parameter is considered out of spec has also been added to each graph.

Figures 23 to 24 illustrate results acquired during the irradiation runs. These include output voltage measurements and power consumption measurements.

Following figure24, a discussion of the results is presented.

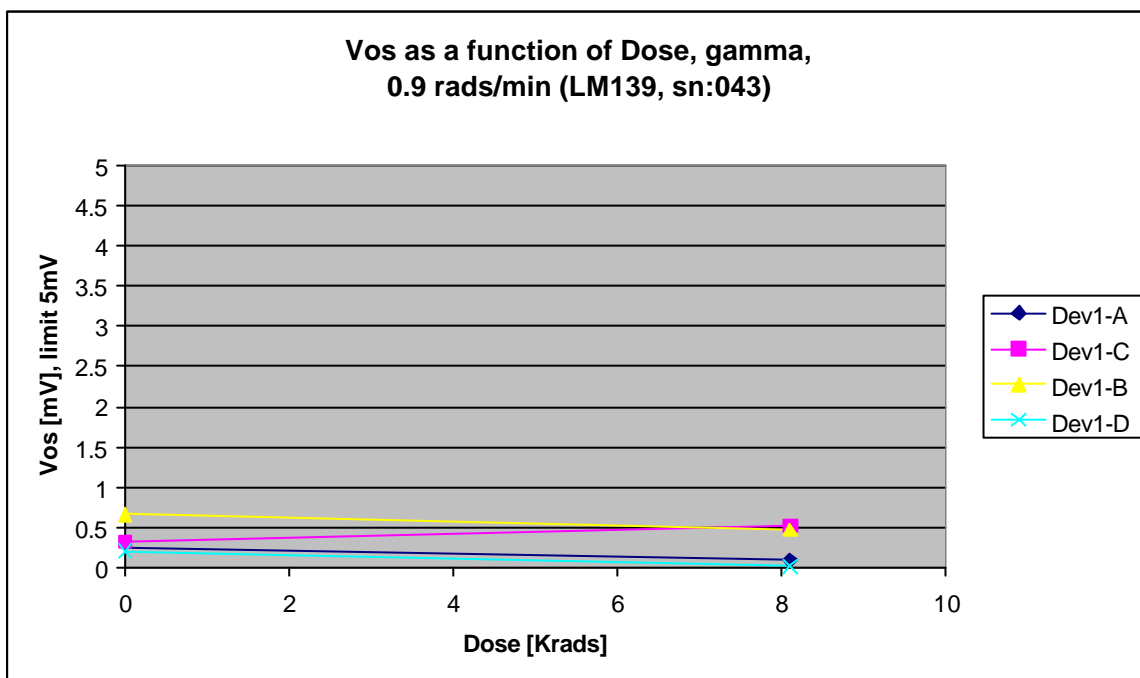


Figure 14 Vos as a function of dose. During irradiation device1 was biased at 20V.



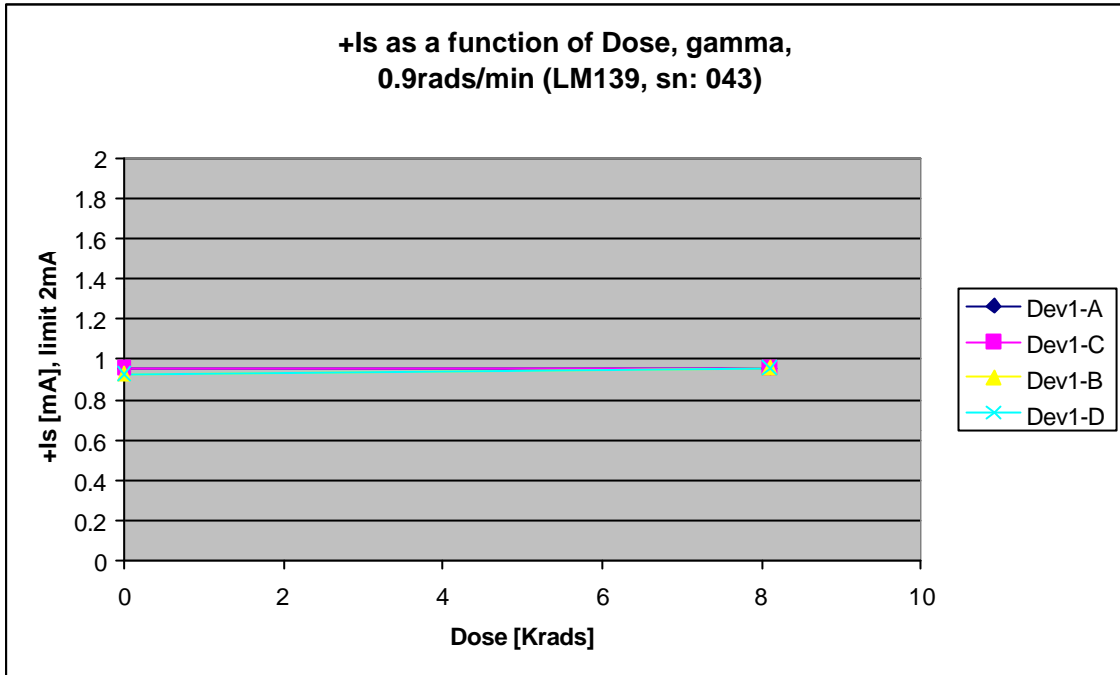


Figure 15 +Is as a function of dose. During irradiation device1 was biased at 20V.

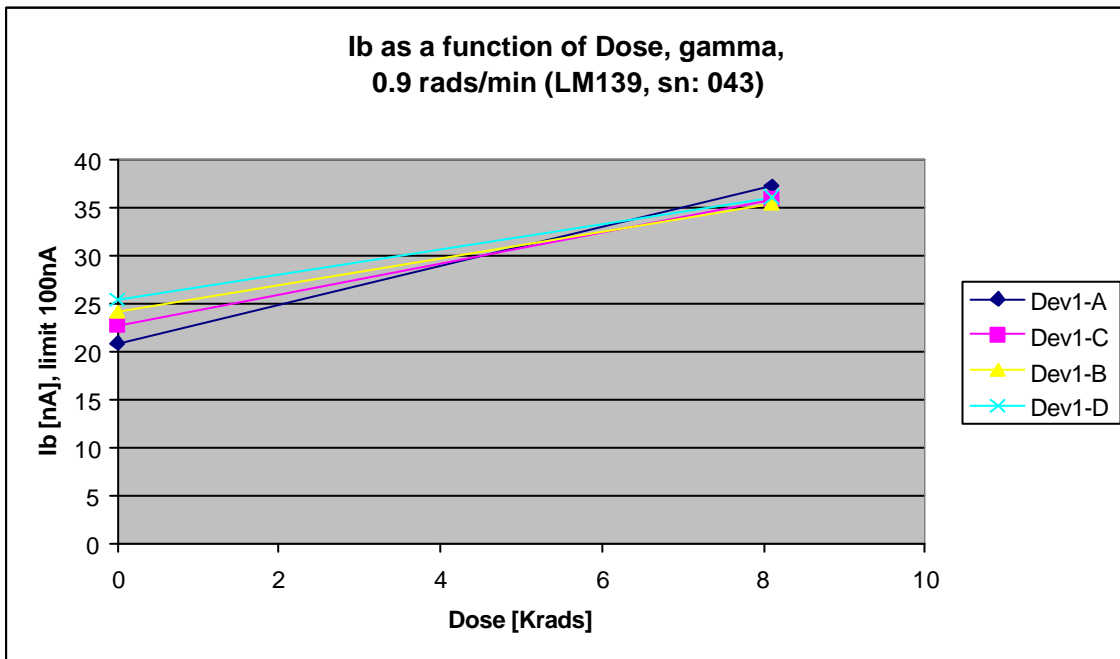


Figure 16 Ib as a function of dose. During irradiation device1 was biased at 20V.

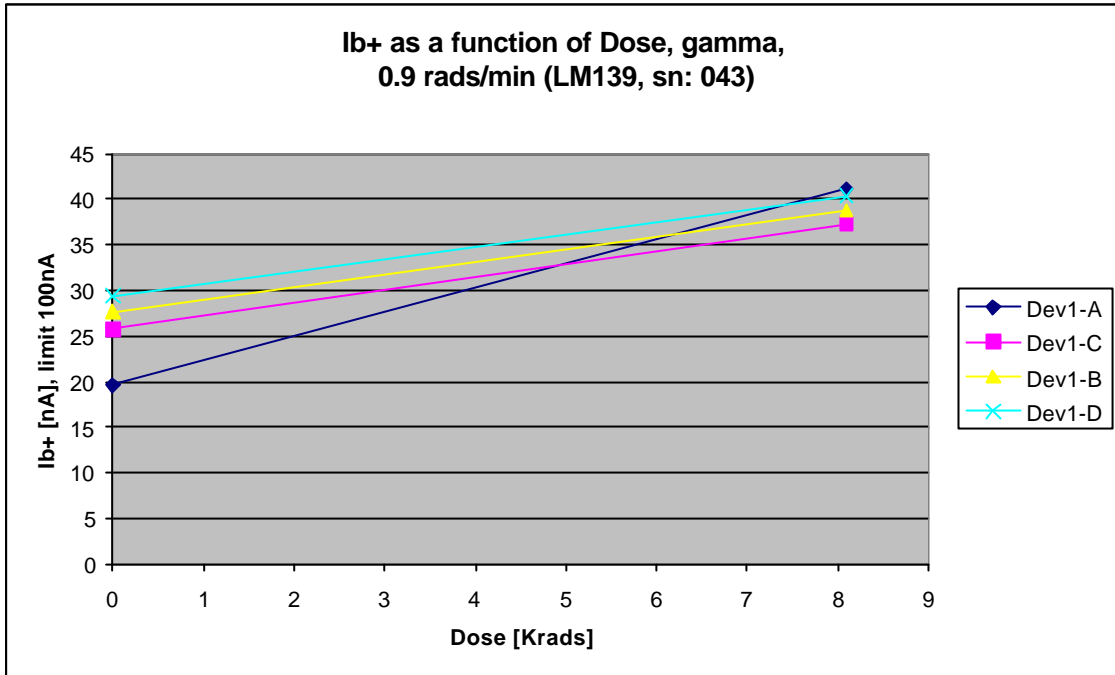


Figure 17 Ib+ as a function of dose. During irradiation device1 was biased at 20V.

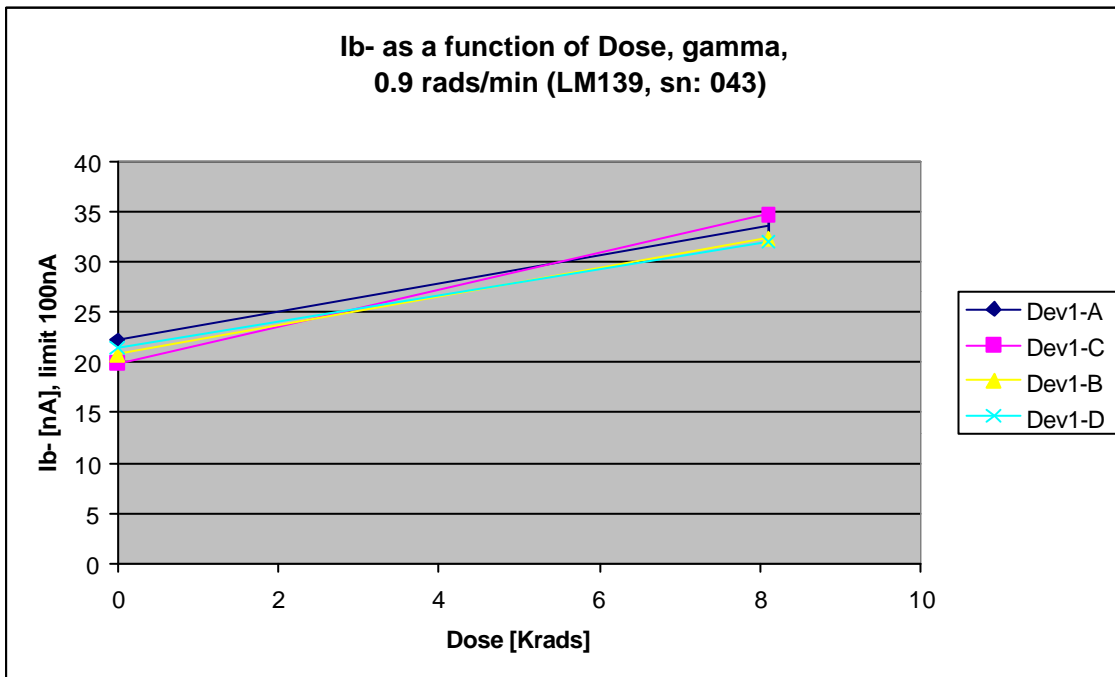


Figure 18 Ib- as a function of dose. During irradiation device1 was biased at 20V.

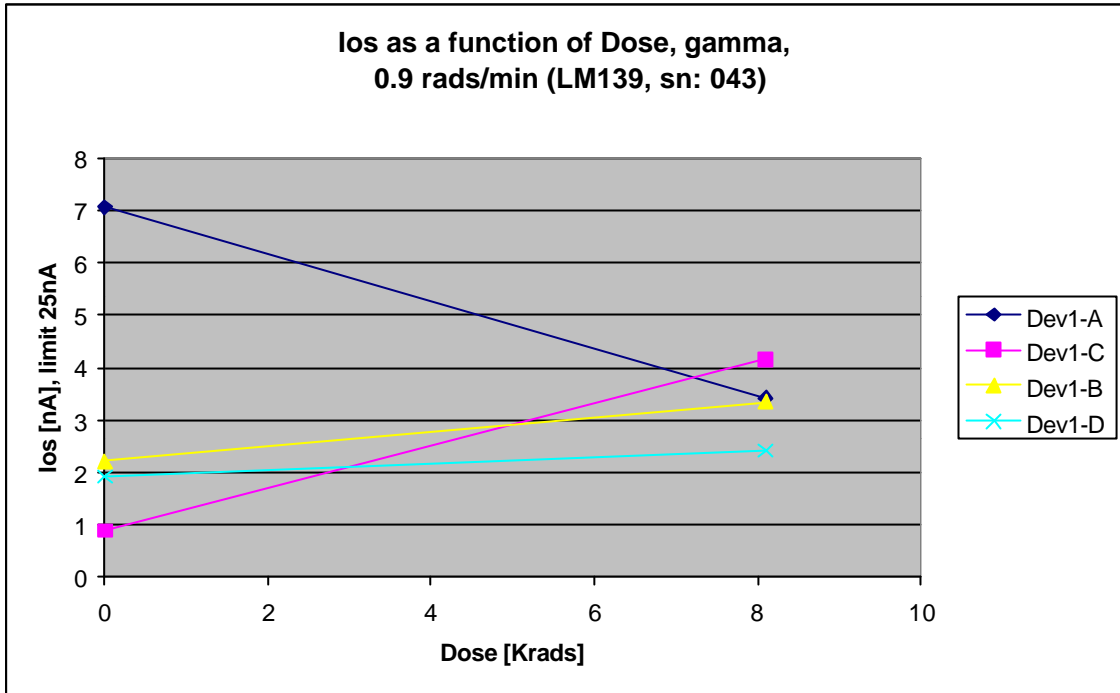


Figure 19 Ios as a function of dose. During irradiation device1 was biased at 20V.

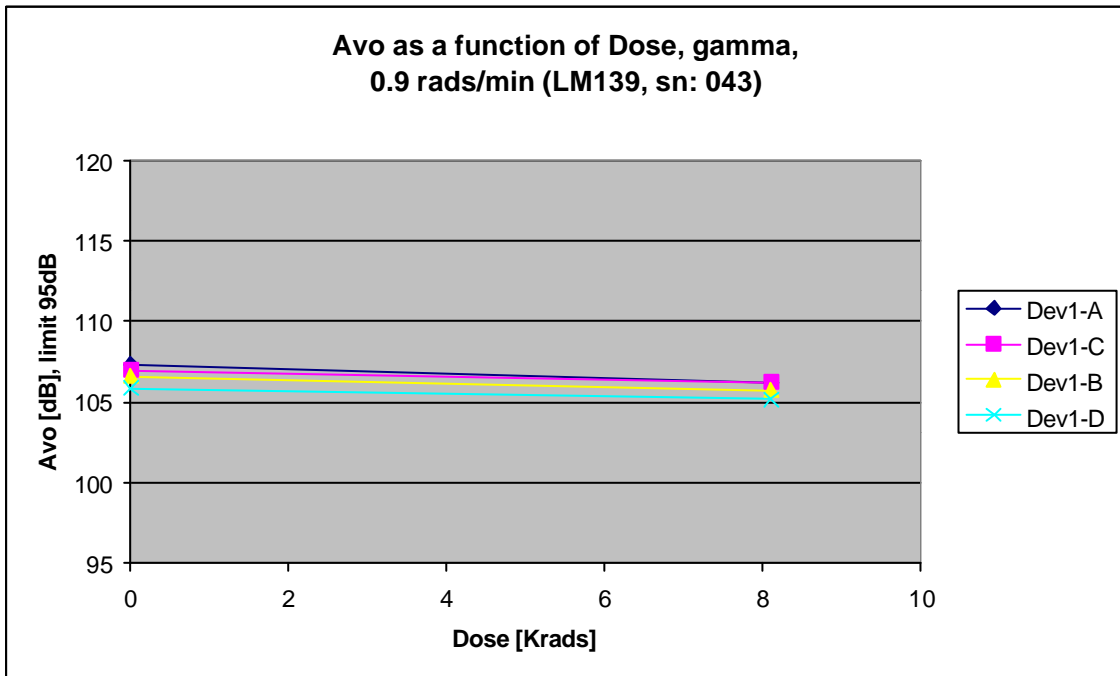


Figure 20 Avo as a function of dose. During irradiation device1 was biased at 20V.

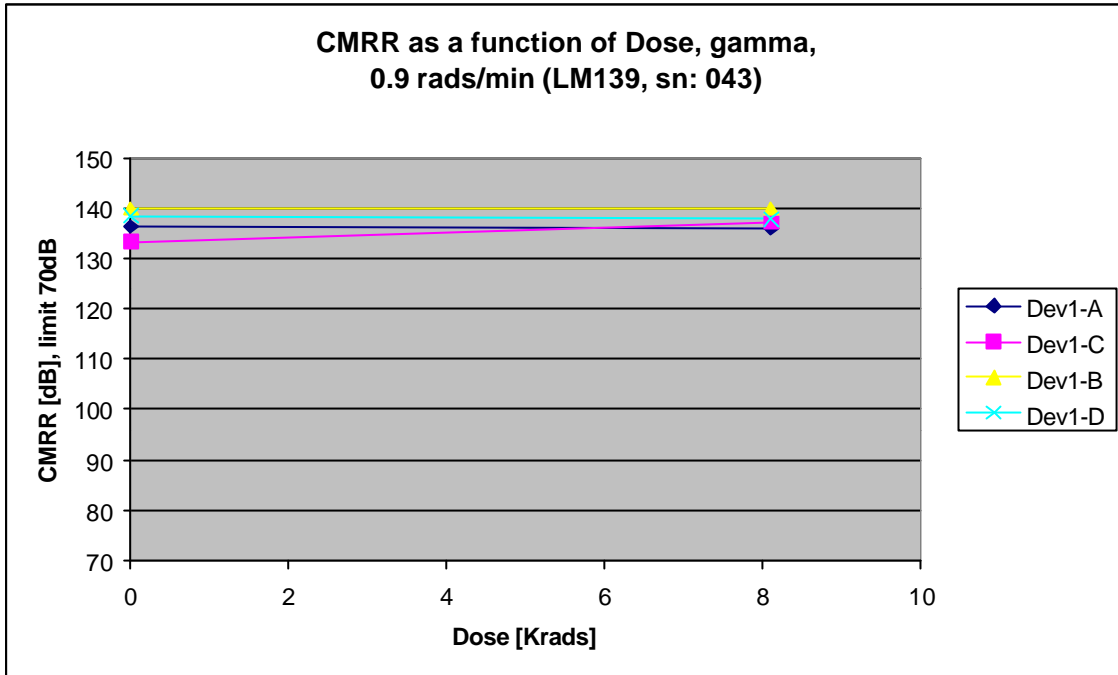


Figure 21 CMRR as a function of dose. During irradiation device1 was biased at 20V.

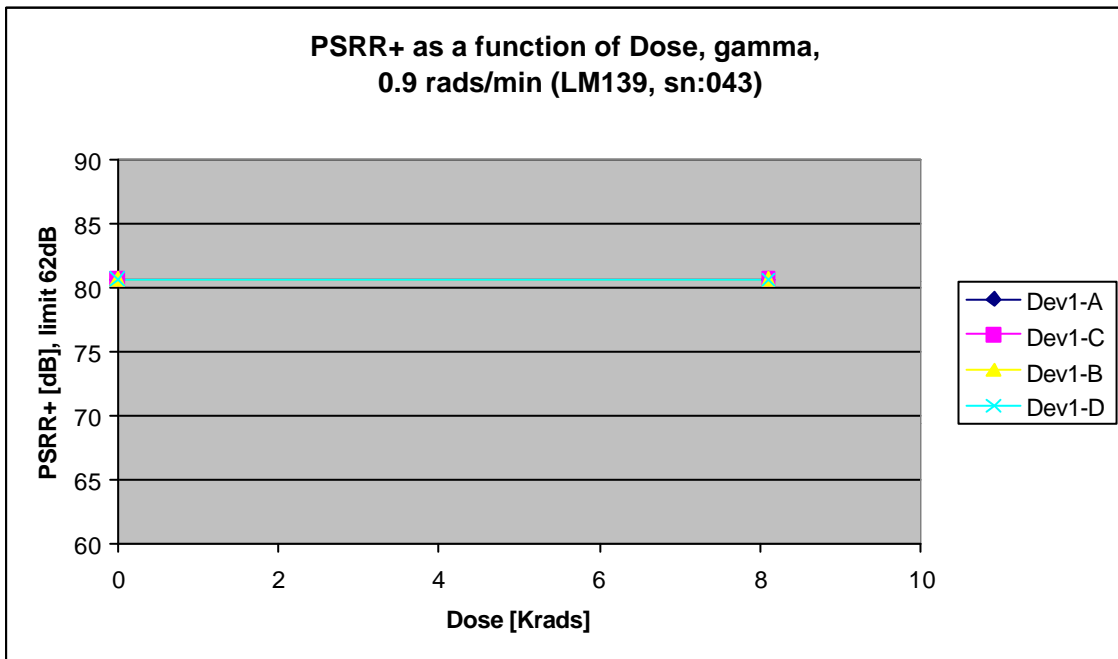


Figure 22 PSRR+ as a function of dose. During irradiation device1 was biased at 20V.

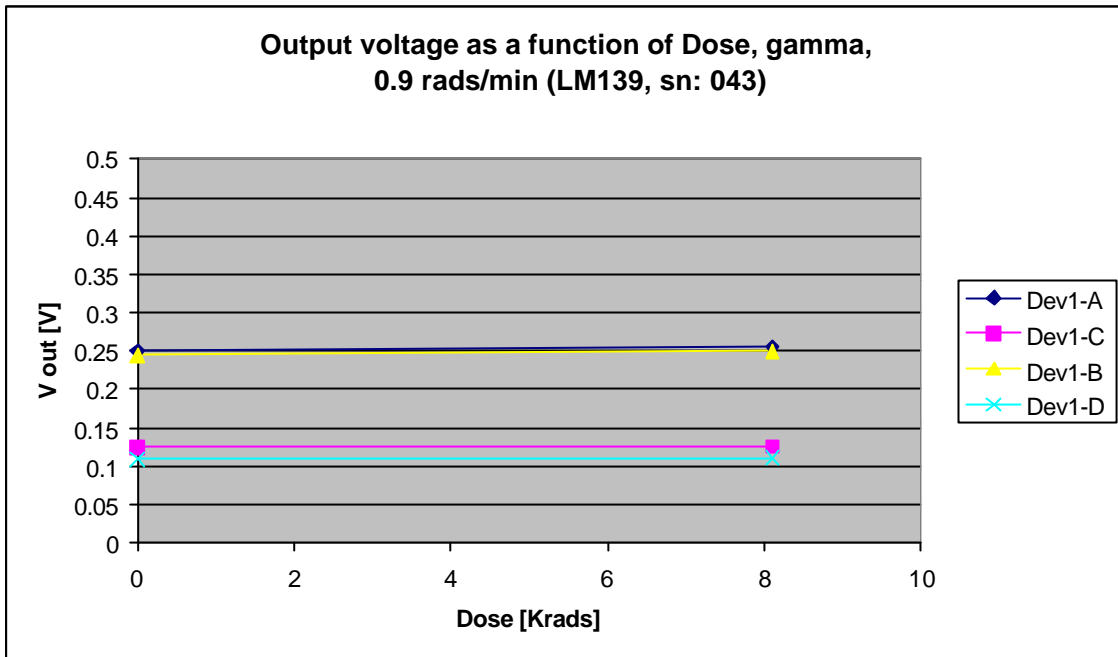


Figure 23 Real time measurement of output voltage during irradiation, device1 biased to 20V.

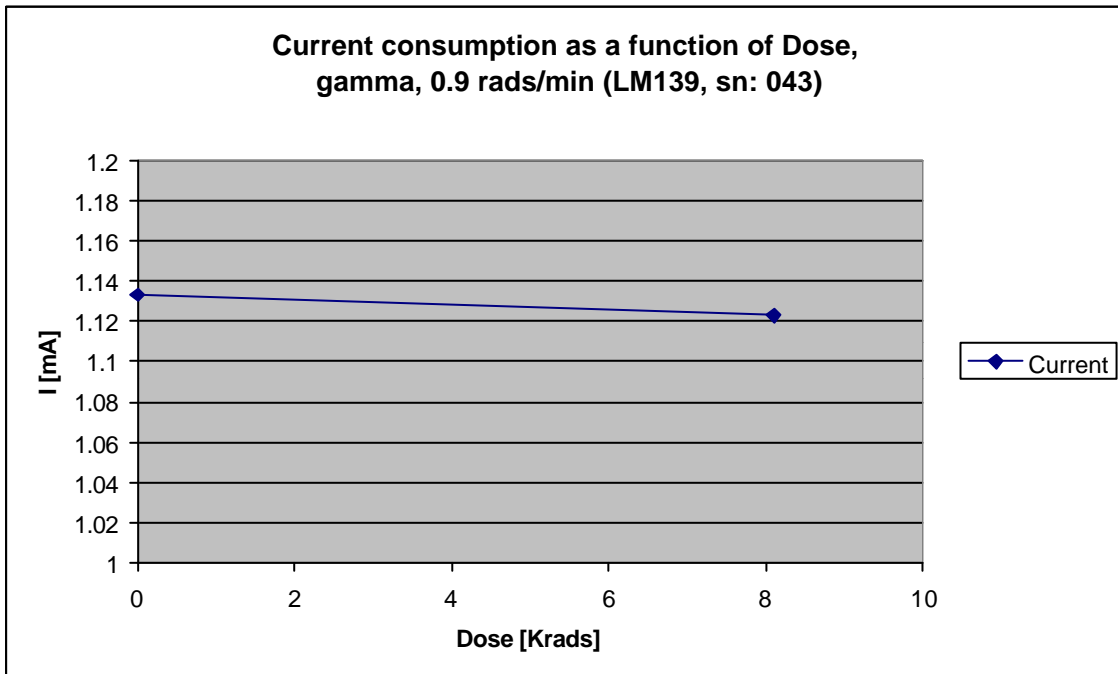


Figure 24 Real time measurement of current consumption during irradiation, device1 biased to 20V.

Figures 14 to 24 illustrate that the Motorola LM139a (date code 9447) parameters do not significantly change for low dose rate tests up to 8krad (H<sub>2</sub>O). The following parameters changed slightly with increasing total dose, however, they were all within the specified values up to 8krad: Ios, Ib, Ib+ and Ib-.

### 3.5.1 CONCLUSION LOW DOSE RATE TESTS

Up to 8krad only small changes were observed both for parametric and functional measurements, all parameters still within specified values.

## 3.6 *Conclusion Total Dose Testing*

Both high and low dose rate tests illustrate only minor degradation of parameters up to 15 and 8 krad respectively. No evidence of enhanced low dose rate effects were detected (for dose rates employed here). The Motorola LM139a date code 9447 has passed the irradiation tests up to a total dose of 15 krad.