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Radiation Test Report for Maxim MAX478 (commercial devices)

Project STEREO

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Test Report Number	ESA_QCA0302T_I
Project	STEREO
SCC Component no.	
Component Designation	Dual, Single Supply, Precision Operational Amplifier (MAX478)
Irradiation Spec. no.	
Family	Integrated Circuits
Group	Silicon Monolithic
Package	Plastic DIP/SO
Component Specification	
Test House Name	ESA / ESTEC
Irradiation Test Plan Number	
Manufacturer name	MAXIM
Application type of Acceptance	
Serial Number of samples	Five (5) samples serialised as Ref, 1, 2, 3 and 4
Manufacturing Date Code	
Irradiation Measurement Interval: Biased Unbiased: Circuit Reference: Supply Voltage: Temp ^{o}C: Duration:	 Yes No +8V Rom temperature 20 ± 3
Electrical Measurement Parameters	
Facility Source: Energy: Dose Rate: Absorbed Material: Thickness: Temperature ^{o}C:	 60Co 4.6 rad/min N/A N/A 20 ± 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	 Yes No +8V 24 hours room temperature and 336 hours at +80 ^{o}C

1 INTRODUCTION

The following document contains the TID Radiation Test Report for MAX478 dual, single supply, precision operational amplifier for the STEREO project.

2 APPLICABLE DOCUMENTS

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

3 TEST DESCRIPTION

Five (5) MAX478, Flight Lot, MAXIM devices were selected for TID irradiation testing at the ESTEC ^{60}Co facility. Irradiations were performed at a dose rate of 4.6 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, four were serialised for radiation exposure. All devices were of the Small Outline (SO) type and for ease of measurements were soldered on special adapter boards. These boards were mounted on the irradiation test-boards during exposure. After each exposure-step the adapter boards were removed and mounted on the SZ-test system for parametric measurements. The irradiation test-board can accommodate and bias four adapter boards (four devices). Each op-amp was operated in a high gain configuration for real-time measurement of the output-offset voltage. The biasing scheme of the operational amplifiers is illustrated in figure 1. The operating conditions during irradiation were provided by the STEREO project. The device operating conditions, temperature conditions and applied dose rates are listed in table1.

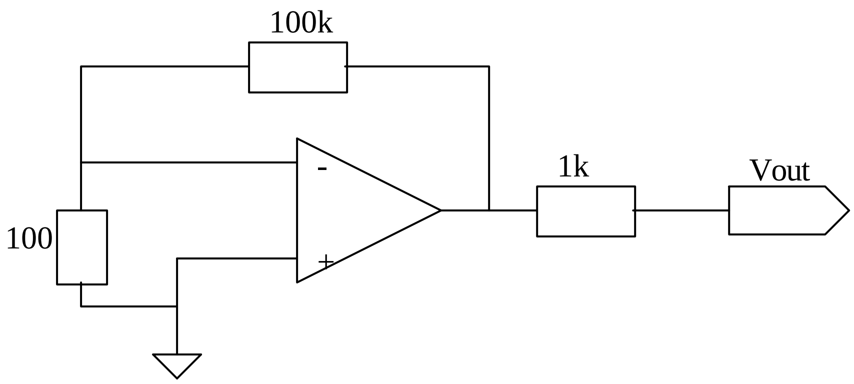

Figure 1 Schematic diagram of MAX478 irradiation biasing scheme.

Parameter	Ref. Dev.	Dev1	Dev2	Dev3	Dev4
Bias During Irradiation	NA	+8V	+8V	+8V	+8V
Dose Rate	NA	4.6rad(Si)/min	4.6rad(Si)/min	4.6rad(Si)/min	4.6rad(Si)/min
Irradiation Temperature	20 ± 3 ^{o}C	20 ± 3 ^{o}C	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 continuo us 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

Measurement number	Devices 1,2,3 and 4
1	Device Output Offset Voltage
2	Device power consumption

Table 2 Continuous measurements for each device during irradiation.

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

Table 3 list all parametric measurements performed and their limit values.

Test Parameter	Limit
Vos	Upper 0.18mV
IOs	Upper 1nA
Ib	Upper 6nA
CMRR	Lower 90dB
+PSRR	Lower 92dB
Vol (no load)	Upper 9mV
Vol (2kÙ load)	Upper 1mV
Vol (100ì A sink)	Upper 0.16V
Voh (no load)	Lower 4.2V

Voh (2kÙ load)	Lower 3.5V
Is	Lower 0V, Upper 0.05mA
Is @ Vs+	Lower 0V, Upper 0.02mA

Table 3 Parameters measured by the SZ parametric Test System

The time between irradiation stop, performing parametric measurements and starting irradiation for all irradiation steps were less than 60min. 4 irradiation steps were performed and parametric measurements performed after each step (parametric also performed for the reference device except after 2.2 and 8.4 krad(Si)). Pre-irradiation measurements were performed on all devices. Table 4 illustrates the irradiation and measurement history.

Irradiation steps	Ref. Dev.	Dev1	Dev2	Dev3	Dev4
Pre-rad. Par. measurements	Yes	Yes	Yes	Yes	Yes
2.2 krad(Si)	NA	Yes	Yes	Yes	Yes
par. measurements	NA	Yes	Yes	Yes	Yes
6.6 krad(Si)	NA	Yes	Yes	Yes	Yes
par. measurements	Yes	Yes	Yes	Yes	Yes
8.4 krad(Si)	NA	Yes	Yes	Yes	Yes
par. measurements	NA	Yes	Yes	Yes	Yes
13 krad(Si)	NA	Yes	Yes	Yes	Yes
Par. measurements	Yes	Yes	Yes	Yes	Yes

Table 4 Irradiation and measurement history

3.2 Thermal conditions

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

3.3 Dosimetry

A calibrated NE2571, 0.66cc air ionisation chamber read by a calibrated Farmer 2670 dosimeter was used to measure the Total Ionising Dose.

3.4 Test Results

Figure1 1 illustrates the real-time measurements of the output voltage during irradiation. Figures 2 to 18 illustrate the parametric results. The graphs illustrate results for the two devices on each chip. The limit for which a parameter is considered out of specification is provided in the vertical axis legend of all graphs except graph1.

Following figure18, a discussion of the results is presented.

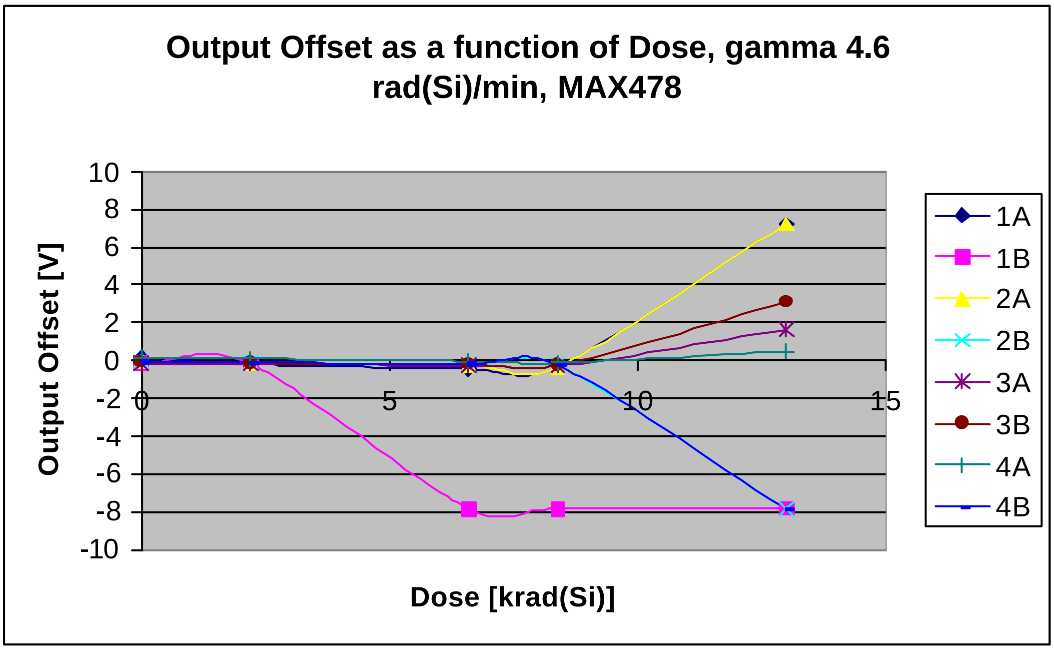

Figure 2 Output offset (real time measurements) as a function of Dose, gamma 4.6 rad(Si)/min.

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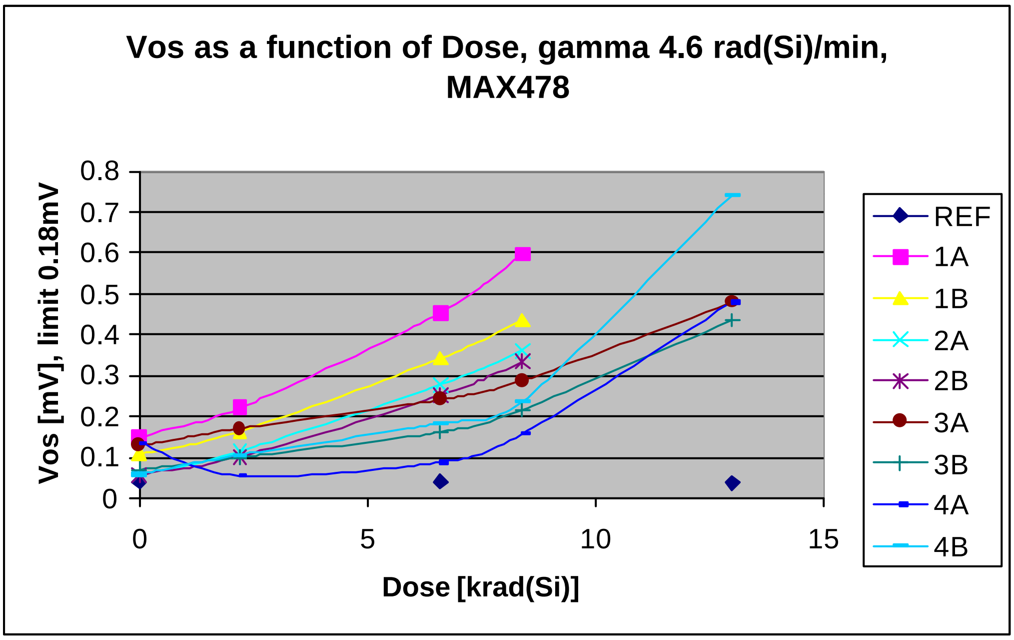

Figure 3 Vos as a function of Dose, gamma 4.6 rad(Si)/min.

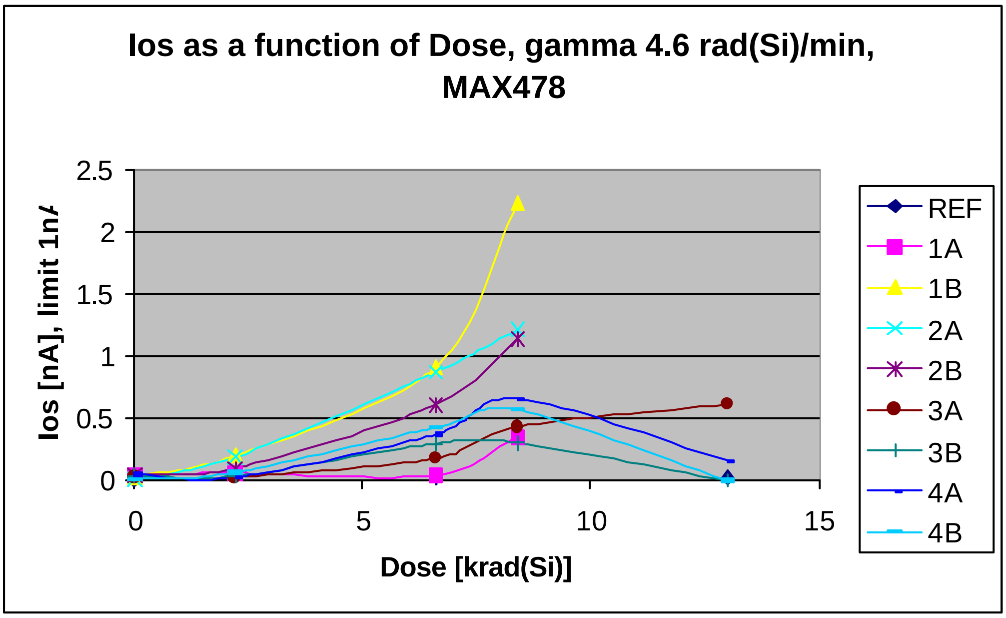

Figure 4 Ios as a function of Dose, gamma 4.6 rad(Si)/min.

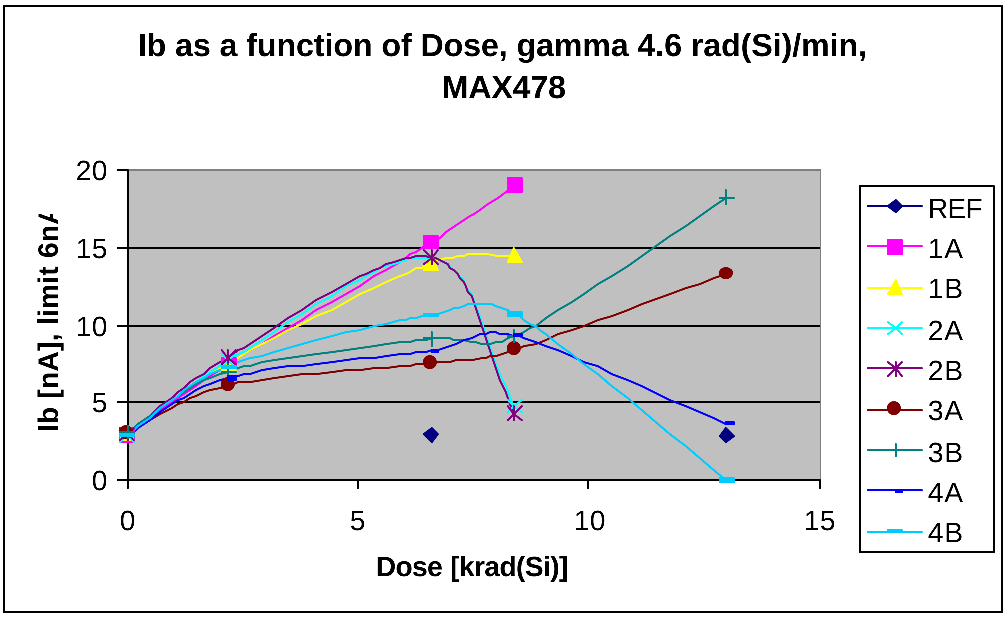

Figure 5 Ib as a function of Dose, gamma 4.6 rad(Si)/min.

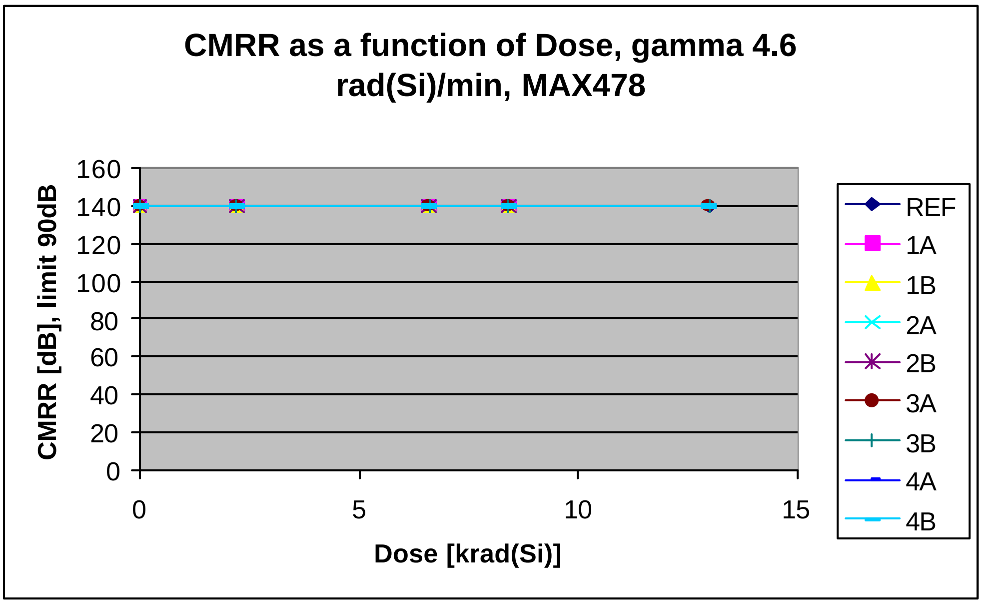

Figure 6 CMRR as a function of Dose, gamma 4.6 rad(Si)/min.

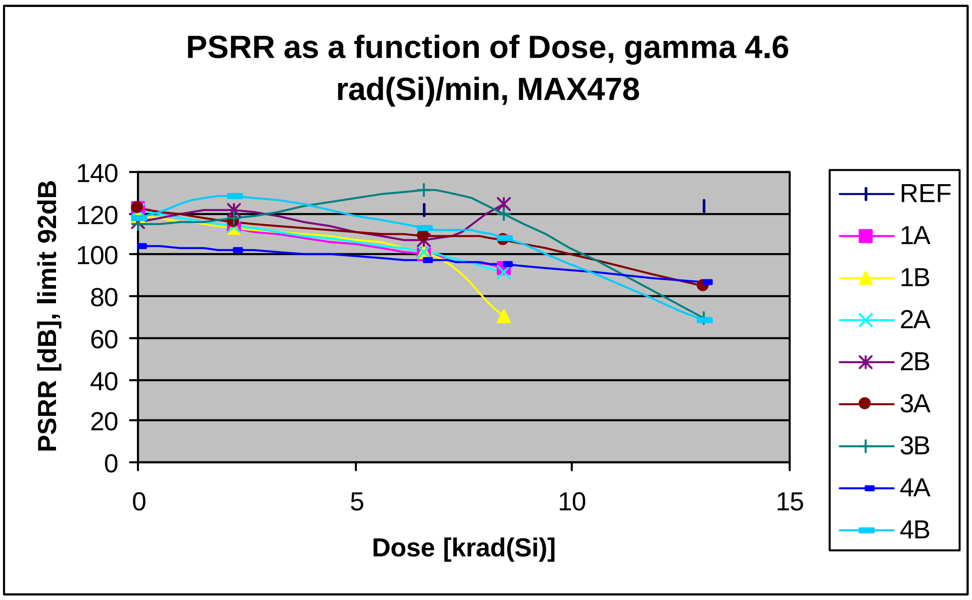

Figure 7 PSRR+ as a function of Dose, gamma 4.6 rad(Si)/min.

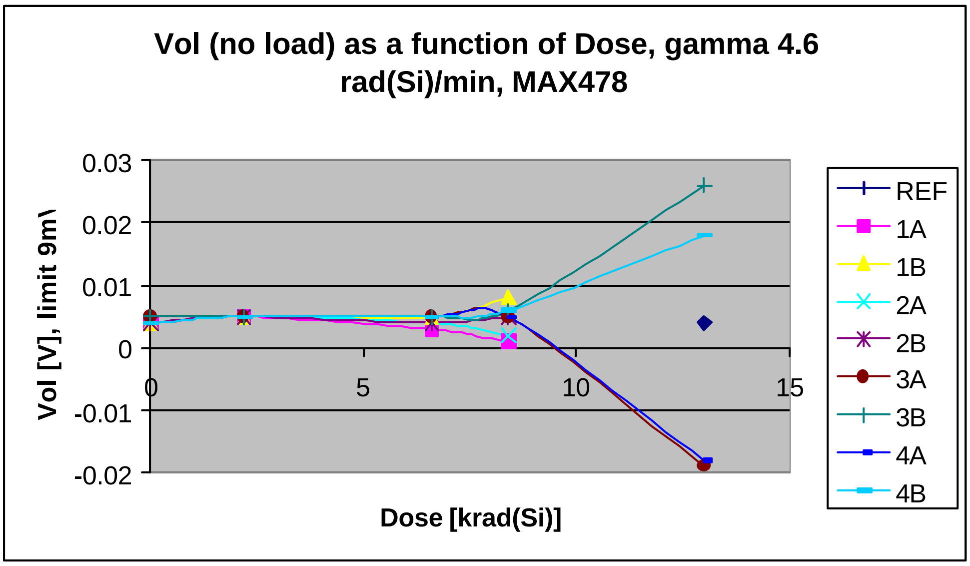

Figure 8 Vol (no load) as a function of Dose, gamma 4.6 rad(Si)/min.

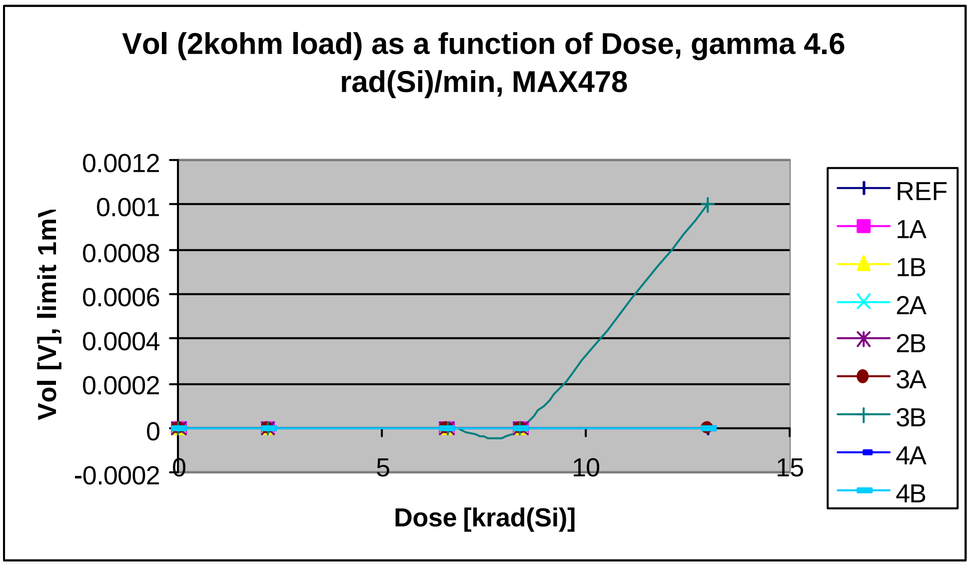

Figure 9 Vol (2kohm load) as a function of Dose, gamma 4.6 rad(Si)/min.

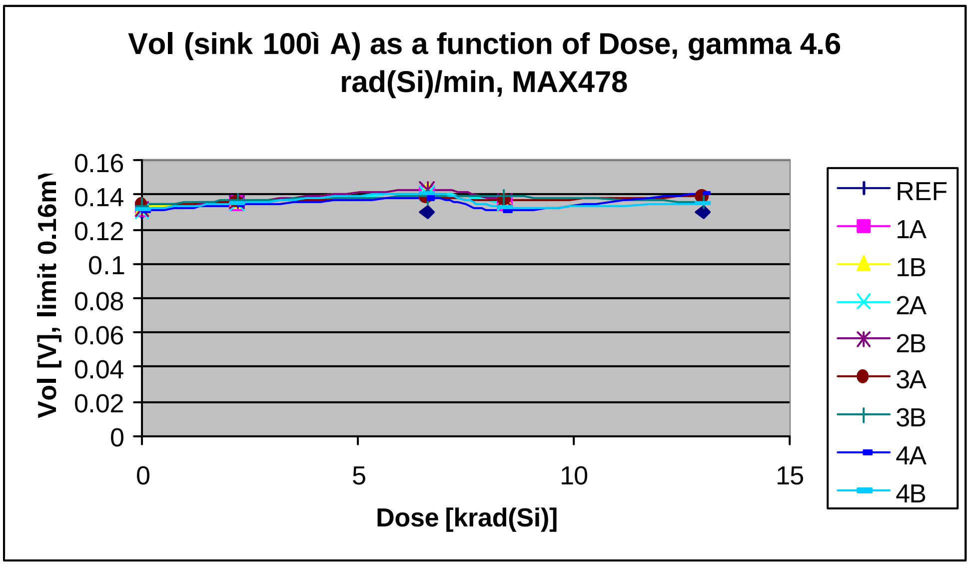

Figure 10 Vol as a function of Dose, gamma 4.6 rad(Si)/min.

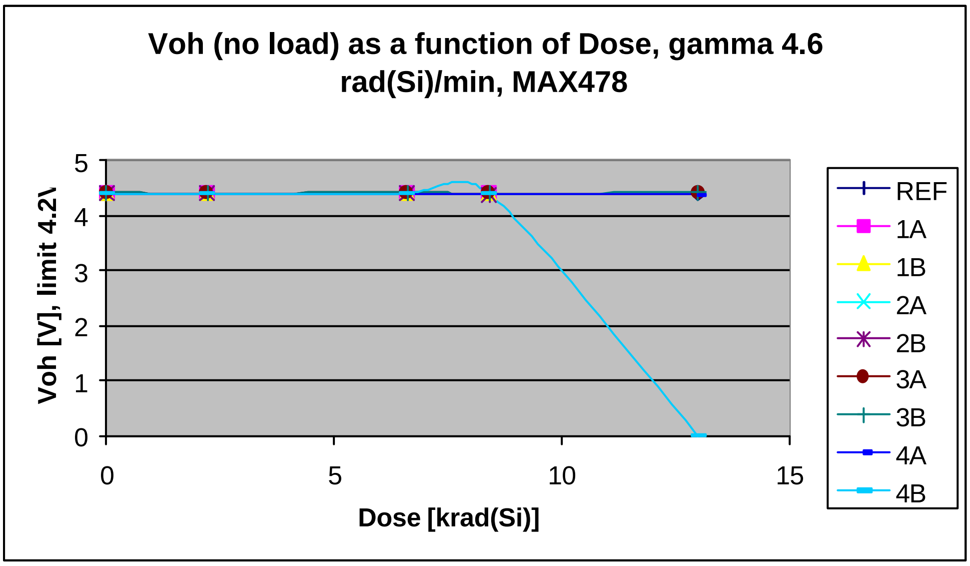

Figure 11 Voh as a function of Dose, gamma 4.6 rad(Si)/min.

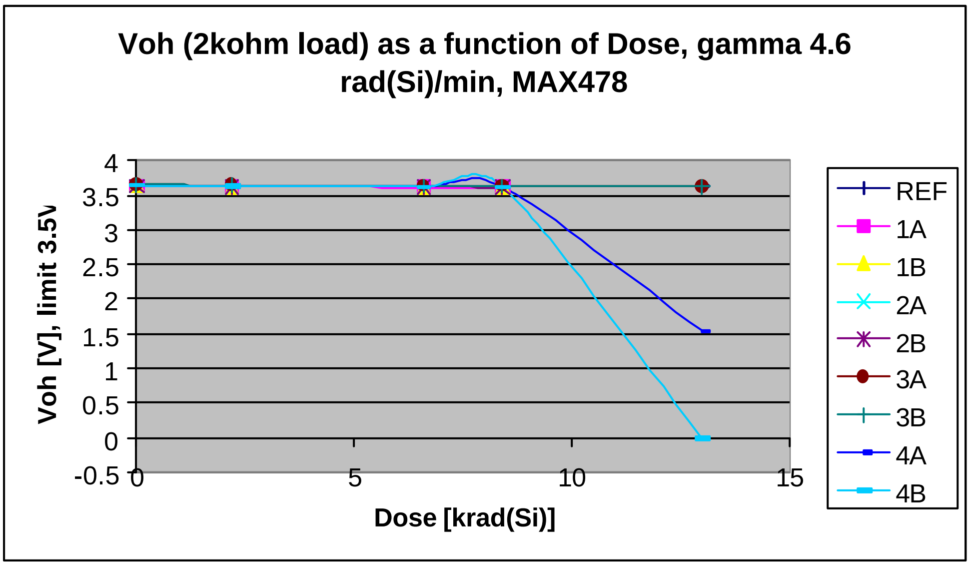

Figure 12 Voh as a function of Dose, gamma 4.6 rad(Si)/min.

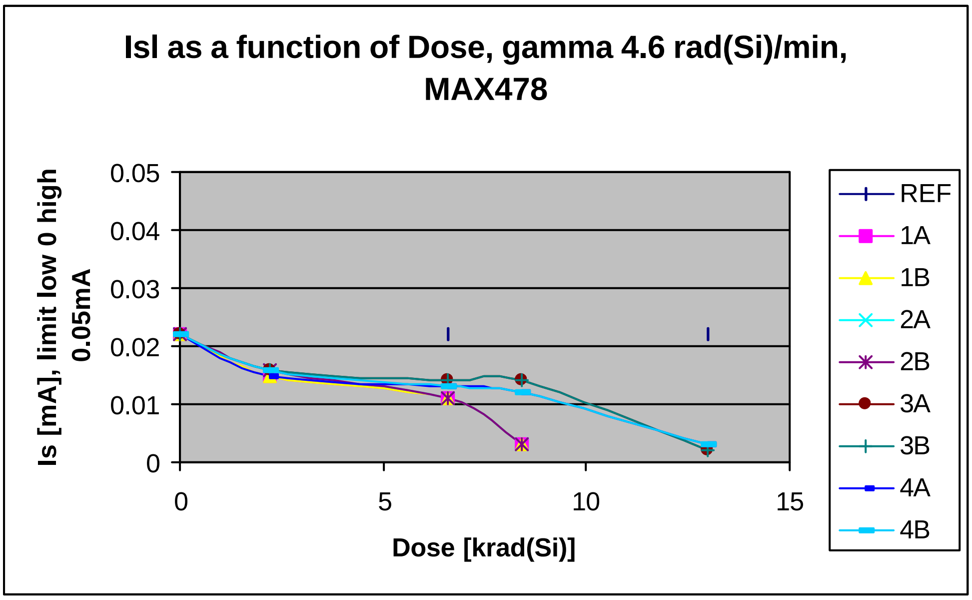

Figure 13 Is as a function of Dose, gamma 4.6 rad(Si)/min.

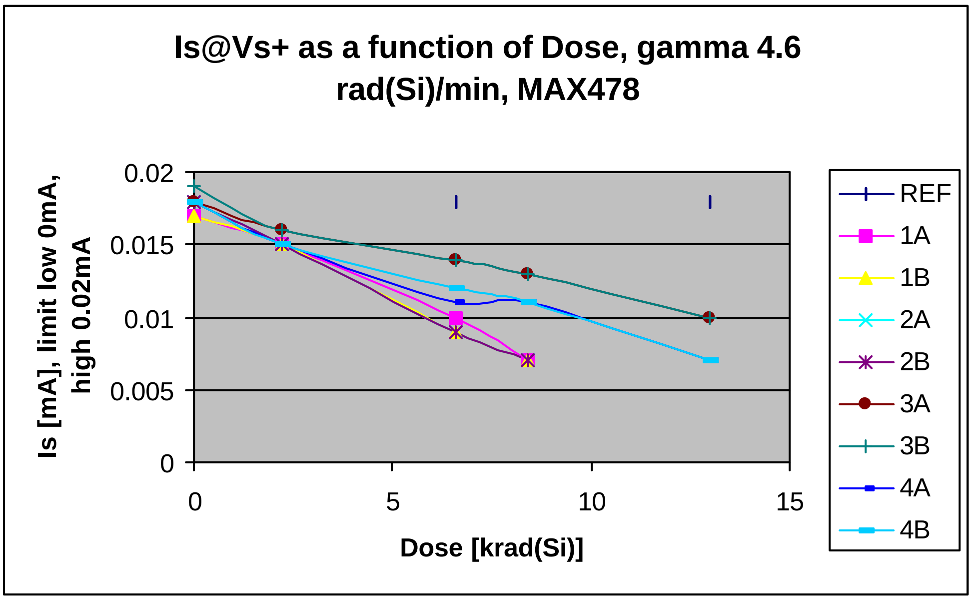

Figure 14 Is at Vs as a function of Dose, gamma 4.6 rad(Si)/min.

Note: Post 13krad(Si) parametric measurements were not obtained for samples 1 and 2, as these devices were not functioning any more.

Figure 2 illustrates the real-time measurement data during the irradiation run. The results show that the output of one of the amplifiers (1B) has dropped to the lower rail voltage at > 6.6krad(Si) total dose level. The figure also illustrates the large spread in the results, which is common for COTS devices.

The Vos results in figure 3, once more confirm the measurement spread for the MAX478 devices. The specified upper limit of 0.18mV is exceeded for device 1A above 2.2 krad(Si), devices 1B, 2B and 2A above 6.6krad(Si), devices 3A, 3B and 4B above 8.4krad(Si) and device 4A at 13krad(Si).

The Ios results in figure 4 illustrate a large spread in the data. Additionally, the Ios trend as a function of dose differs for devices (1,2) and (3,4). The specified upper limit of 1nA is exceeded for devices 1B, 2A and 2B above 8.4krad(Si).

The Ib results in figure 5 illustrate the specified upper limit of 6nA exceeded by all devices above 2.2krad(Si). However, some devices show a recovery at above 8.4krad(Si) and at 13krad(Si).

The PSRR+ results in figures 7, illustrate that some devices above 8.4krad(Si) and all devices at 13krad(Si) are below the specified lower limit of 92dB.

The Vol (no load) results in figure 8 illustrates that all devices have exceeded the specified upper limit of 9mV at 13krad(Si).

The Voh results in figures 11 and 12 illustrates that most devices were below their specified lower limits at 13krad(Si).

All other parameters were within specified values.

Annealing Test Results

All devices were subject to 24 hour room temperature biased annealing and 336h elevated temperature biased annealing. The maximum temperature rating for these plastic packaged devices was +80°C. Thus, the elevated temperature annealing tests were performed at +80°C instead of the required +100°C as stated in AD1. Annealing results for only three parameters are discussed below.

The 24h room-temperature annealing results show improvement in some parameters while other parameters show an additional degradation. Anneal results for Vos (Figure 15) illustrate a marked improvement for devices 1 and 2. The spread in device-to-device behaviour is clearly illustrated in figure 16 (Ib) where some devices recover while others illustrate reverse annealing effects. The Vol results (figure 17) show a general recovery for all devices.

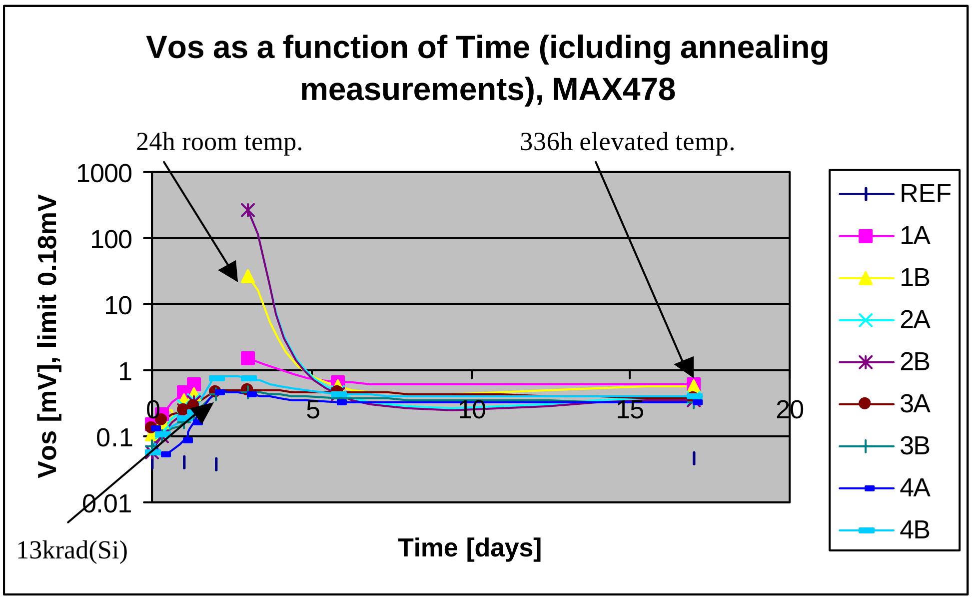

Figure 15 Vos as a function of time.

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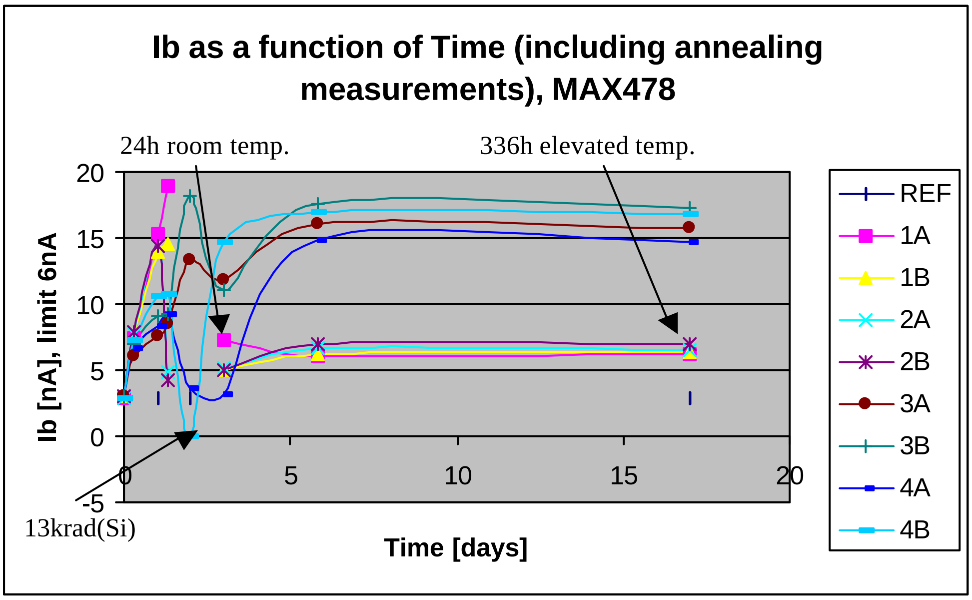

Figure 16 Ib as a function of time.

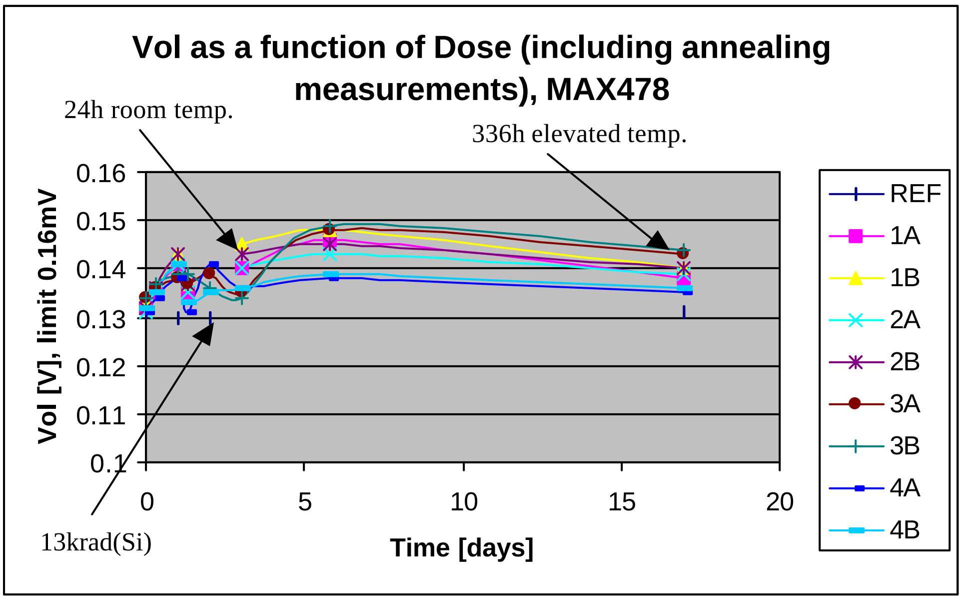

Figure 17 Vol as a function of time.

The high temperature anneal results show that all failed parameters recovered to acceptable levels with the exception of Vos and Ib (where some devices actually reverse anneal to the level of exceeding the upper specified limit of 6nA).

3.5 Conclusion

The commercial MAX478 op-amp irradiation tests show that Ib for all devices failed at 2.2krad(Si). Additional parameters failed at total dose levels of 8.4krad(Si) and 13krad(Si). The total ionising dose requirement set by the STEREO project is 15krad(Si) (including a margin of 2).

Room temperature annealing results are inconclusive as some parameters improve while others degrade. However, 336h annealing at elevated temperature (+80^{o}C) show a recovery of all parameters with the exception of Vos and Ib.

The spread in device-to-device behaviour with increasing total dose levels and subsequent annealing is large, as expected for commercial devices. A parameter for consideration when calculating required margins.

Considering the above (including the annealing results) the MAX478 is not recommended for use on the STEREO project.