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Radiation Test Report for National Semiconductors LMC6062 (Commercial devices)

Project STEREO

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

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Test Report Number	ESA_QCA0301T_I
Project	STEREO
SCC Component no.	
Component Designation	Precision CMOS Dual Micropower Operational Amplifier (LMC6062)
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	National Semiconductors
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 Radiation Test Report for LMC6062 Precision CMOS dual micropower 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) LMC6062, Flight Lot, National Semiconductors 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 employed 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 adapter 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 irradiation test operating conditions were provided by the STEREO project. The device operating conditions, temperature conditions and applied dose rates are listed in table1.

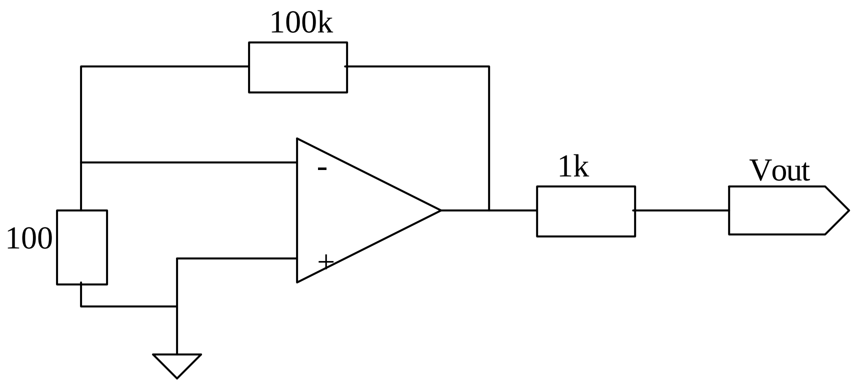

Figure 1 Schematic diagram of TLC6062 irradiation biasing scheme.

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 ^oC	20 ± 3 ^oC	20 ± 3 ^oC	20 ± 3 ^oC	20 ± 3 ^oC

Table 1 Irradiation Test Conditions

3.1 Measurement set-up

Two sets of measurements were performed one set of continuous measurements during the irradiation runs and one set of parametric measurement at regular intervals between irradiation steps. Continuous measurements (performed during irradiation at 10 min intervals) 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 0.9V
IOs	Upper 1nA
Ib	Upper 1nA
CMRR	Lower 72dB
+PSRR	Lower 72dB
-PSRR	Lower 81dB
Voh @ 25	Lower 4.99V
Vol @ 25	Upper 0.01V
Voh @ 25	Lower 4.975V
Vol @ 25	Upper 0.02V

Voh @ 25	Lower 14.974V
Vol @ 25	Upper 0.025V
Voh @ 25	Lower 14.9V
Vol @ 25	Upper 0.05V
Is @Vs	Lower 0V, Upper 0.038mA
Is @ Vs	Lower 0V, Upper 0.047mA
SR+ - S	Lower 0.02 V/us

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.

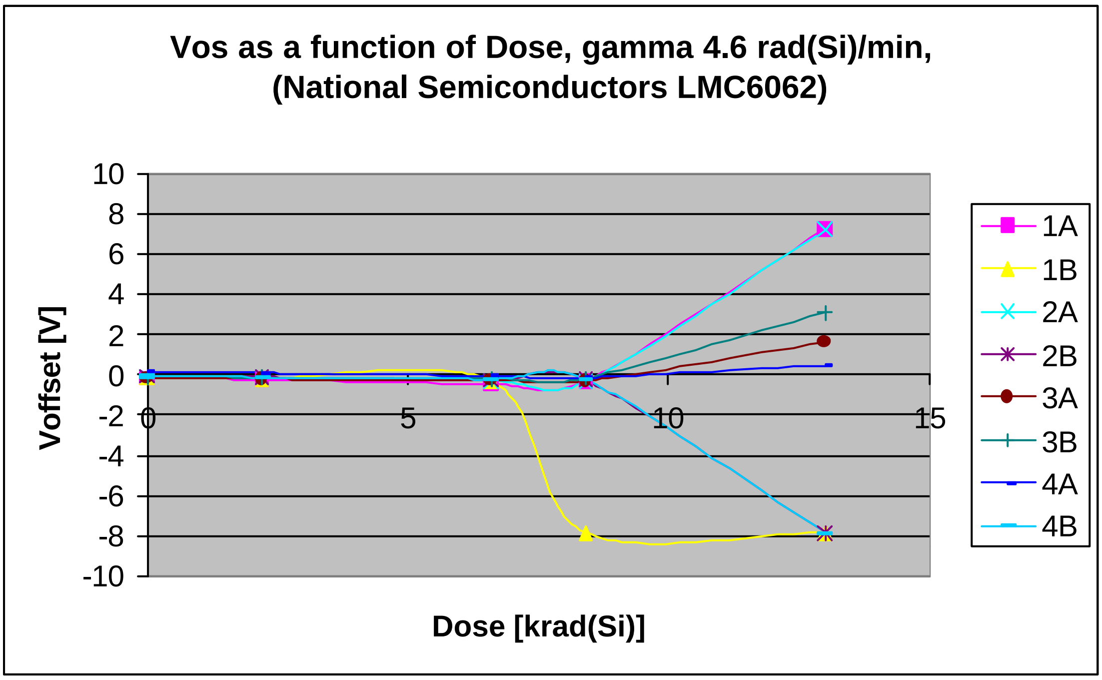

Figure 2 Voffs as a function of Dose, gamma 4.6 rad(Si)/min.

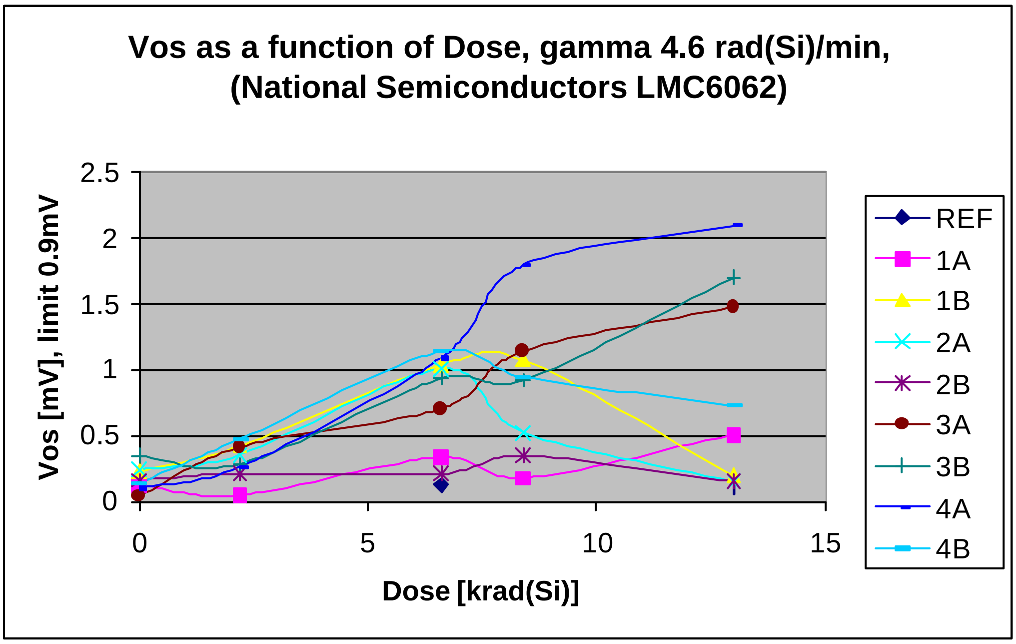

Figure 3 Vos as a function of Dose, gamma 4.6 rad(Si)/min.

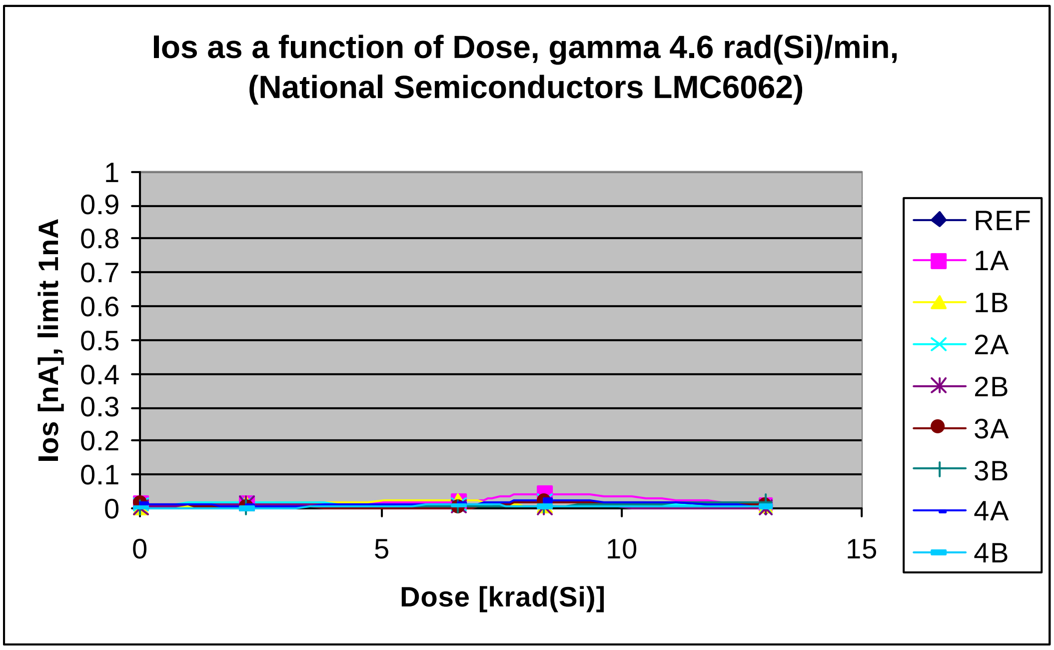

Figure 4 Ios as a function of Dose, gamma 4.6 rad(Si)/min.

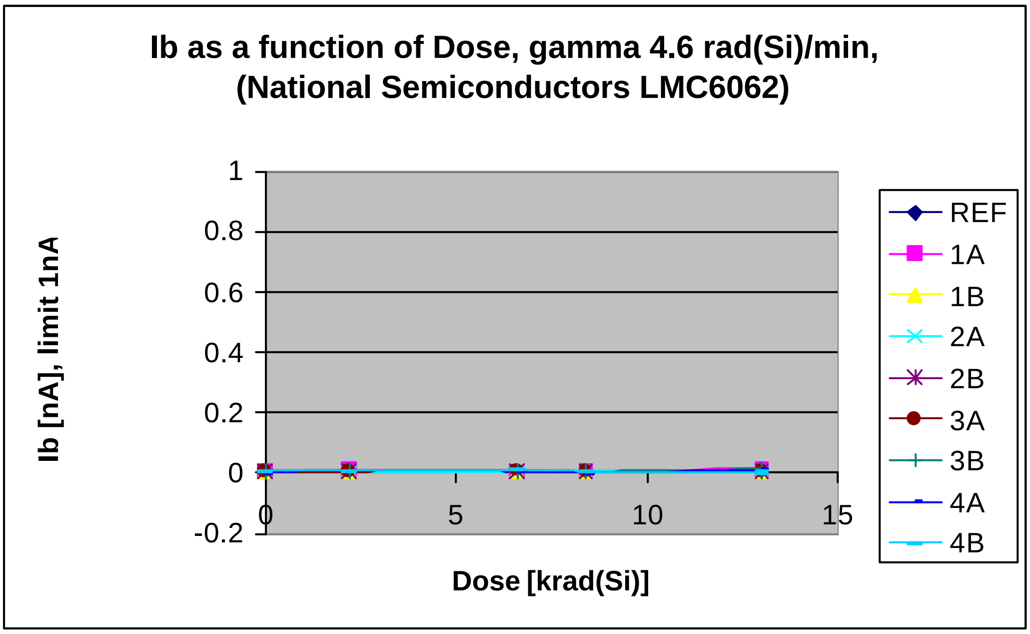

Figure 5 Ib as a function of Dose, gamma 4.6 rad(Si)/min.

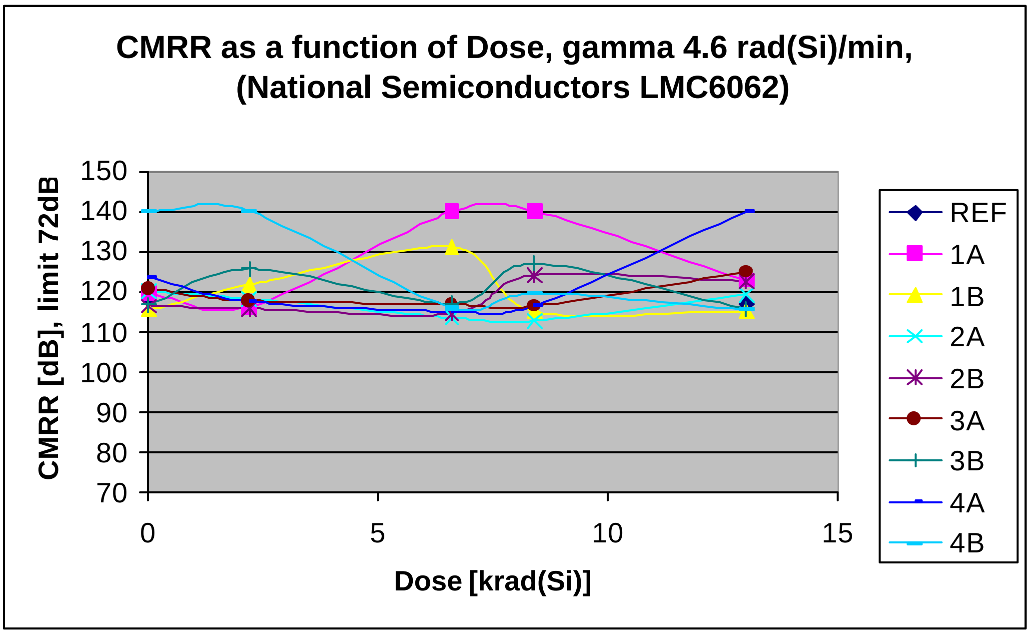

Figure 6 CMRR as a function of Dose, gamma 4.6 rad(Si)/min.

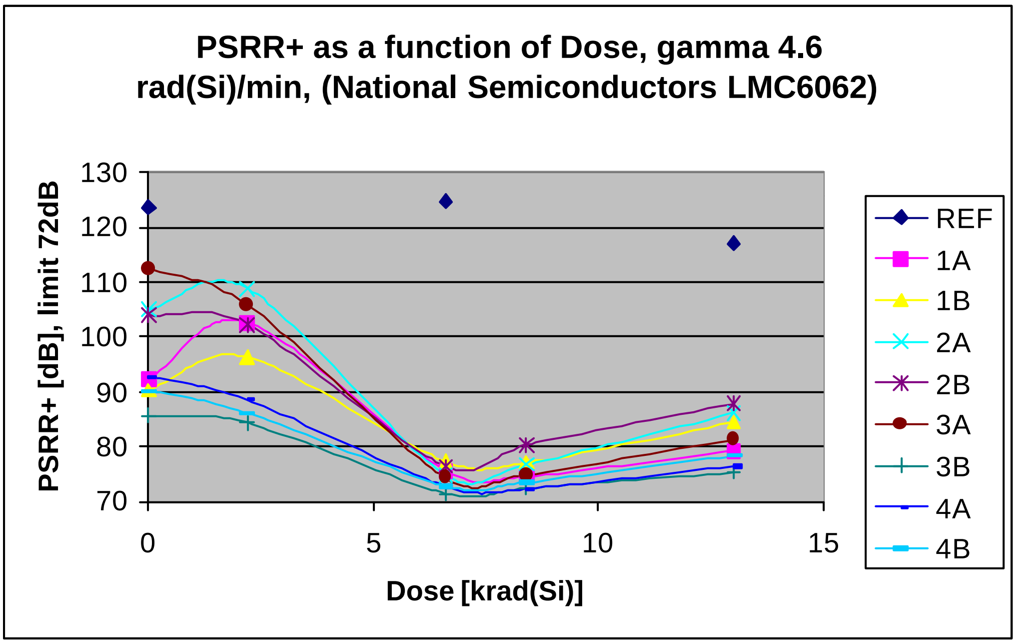

Figure 7 PSRR+ as a function of Dose, gamma 4.6 rad(Si)/min.

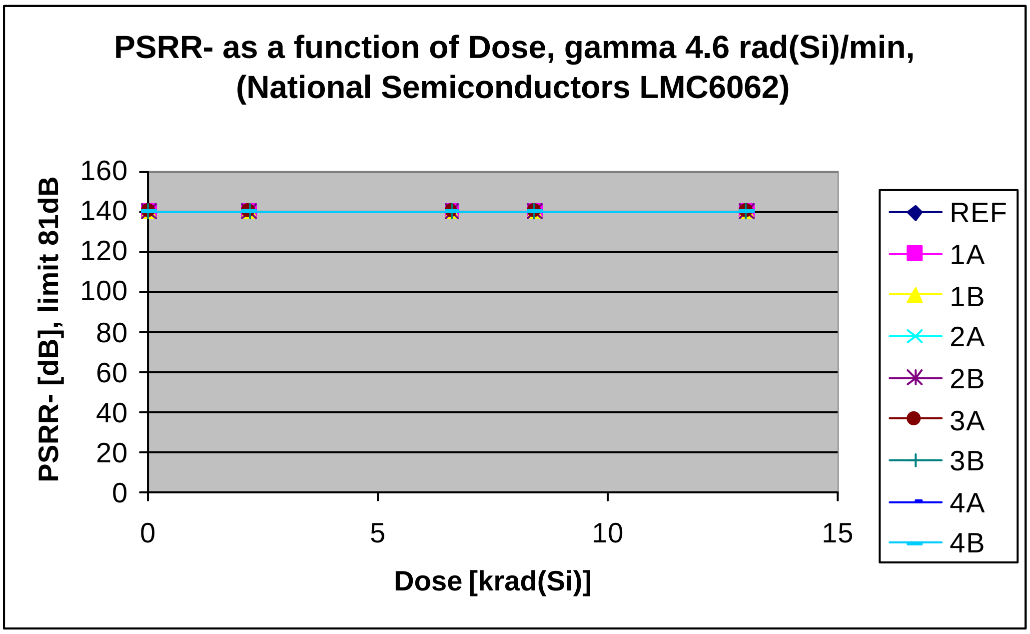

Figure 8 PSRR- as a function of Dose, gamma 4.6 rad(Si)/min.

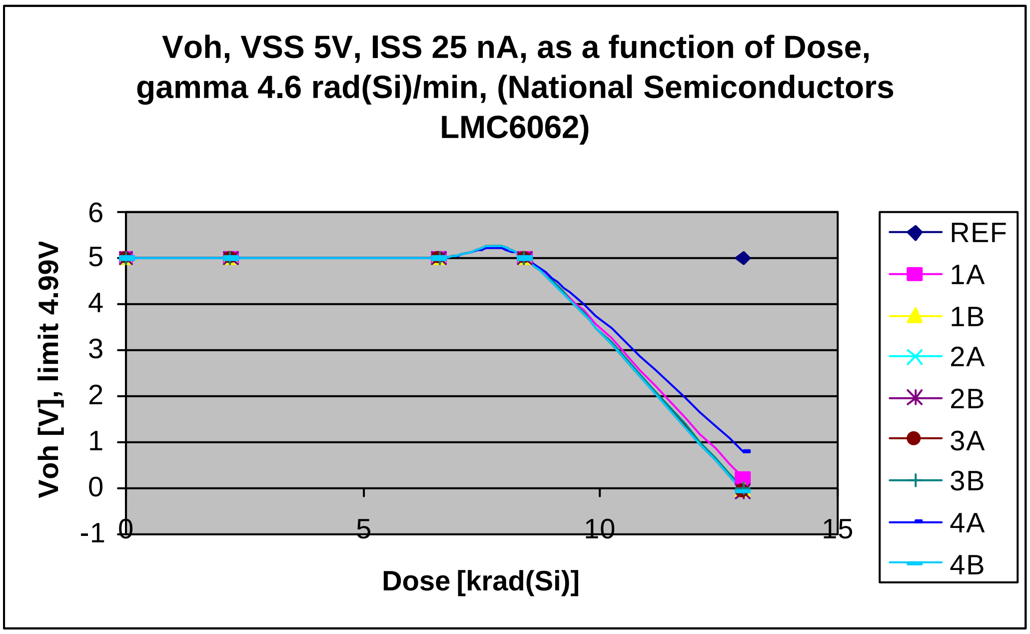

Figure 9 Voh (Vss 5V, Iss 25nA) as a function of Dose, gamma 4.6 rad(Si)/min.

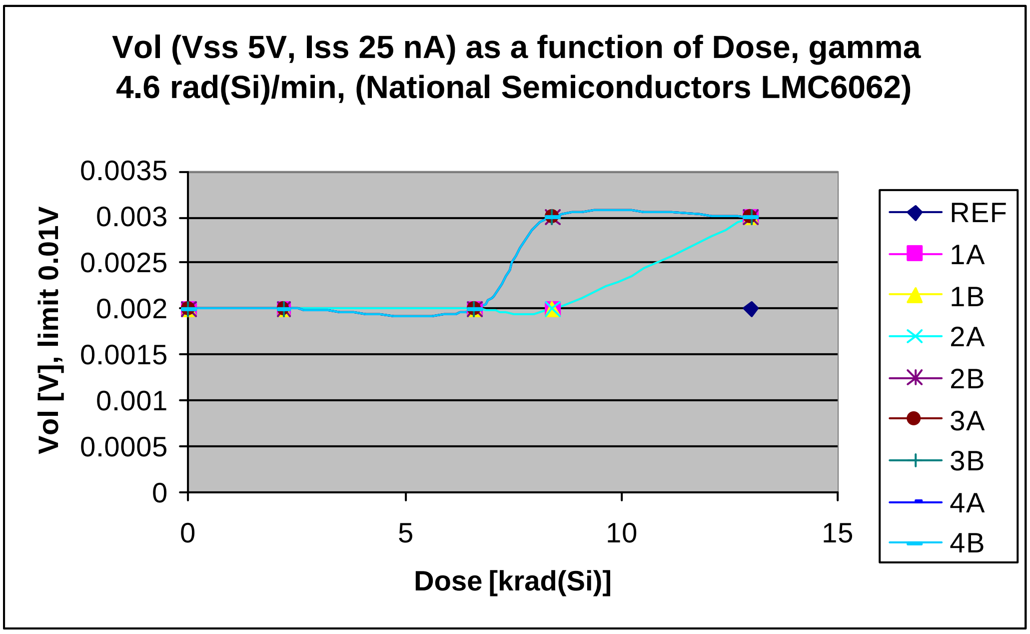

Figure 10 Vol (Vss 5V, Iss 25nA) as a function of Dose, gamma 4.6 rad(Si)/min.

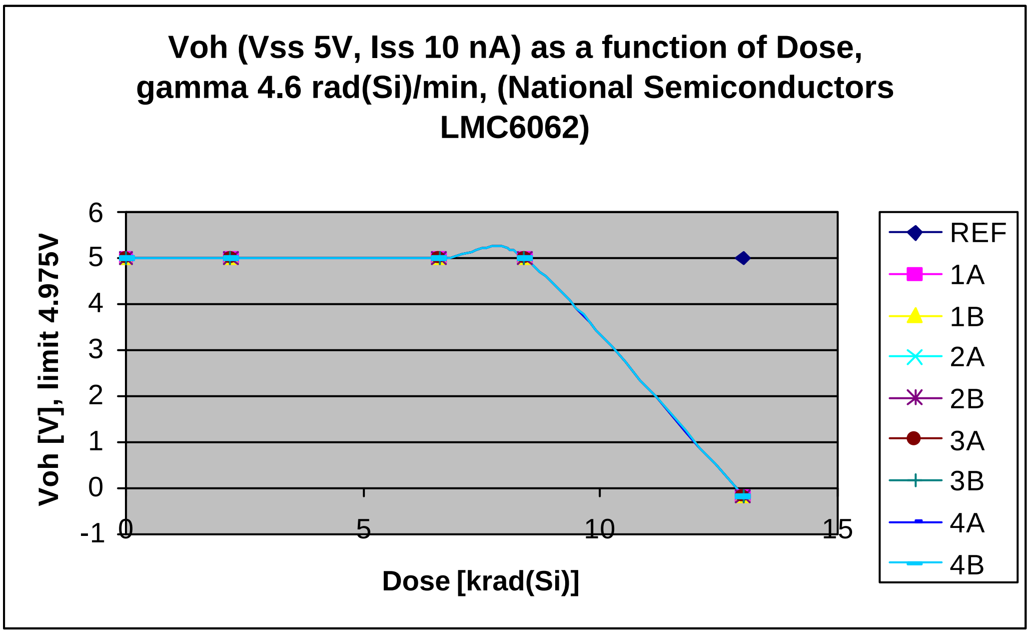

Figure 11 Voh (Vss 5V, Iss 10nA) as a function of Dose, gamma 4.6 rad(Si)/min.

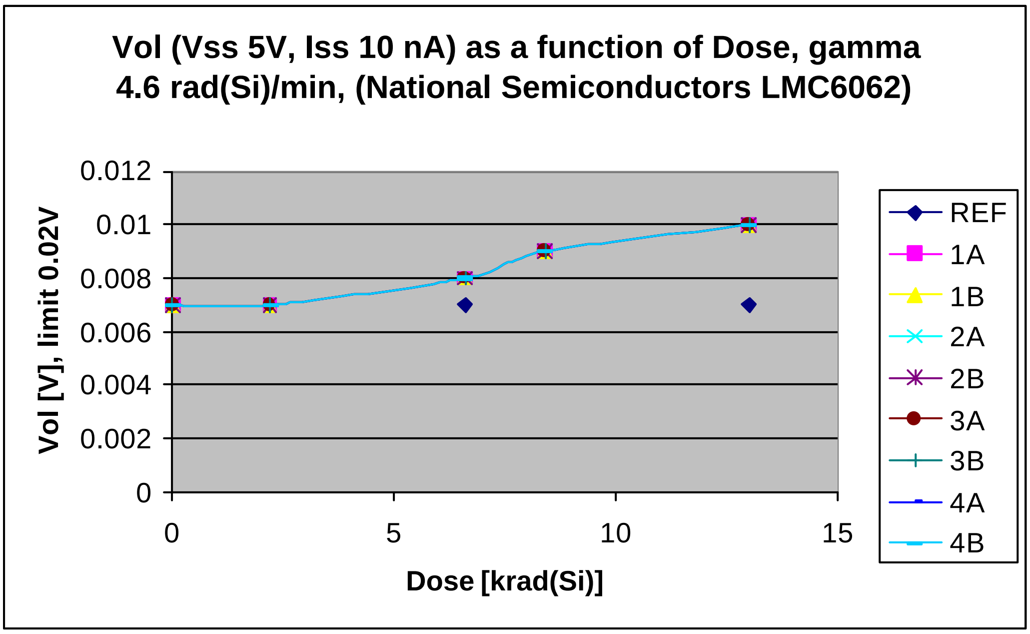

Figure 12 Vol (Vss 5V, Iss 10nA) as a function of Dose, gamma 4.6 rad(Si)/min.

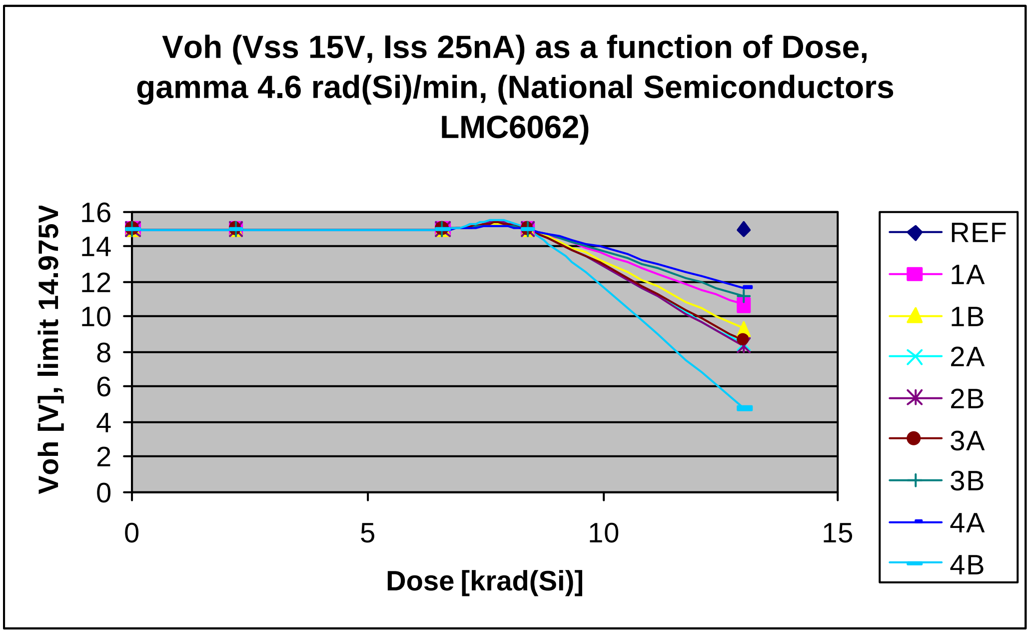

Figure 13 Voh (Vss 15V, Iss 25nA) as a function of Dose, gamma 4.6 rad(Si)/min.

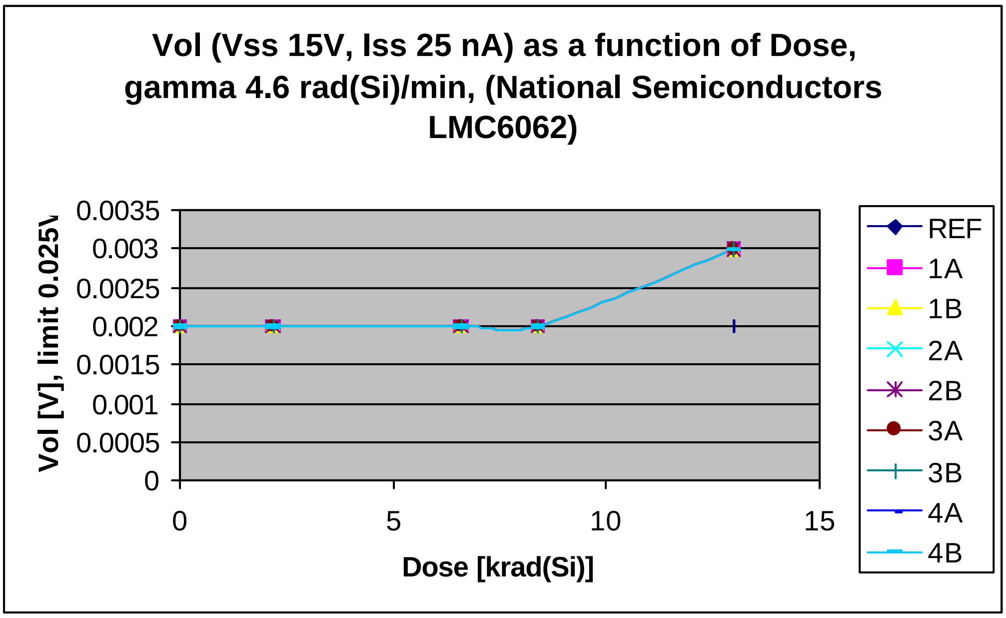

Figure 144 Vol (Vss 15V, Iss 25nA) as a function of Dose, gamma 4.6 rad(Si)/min.

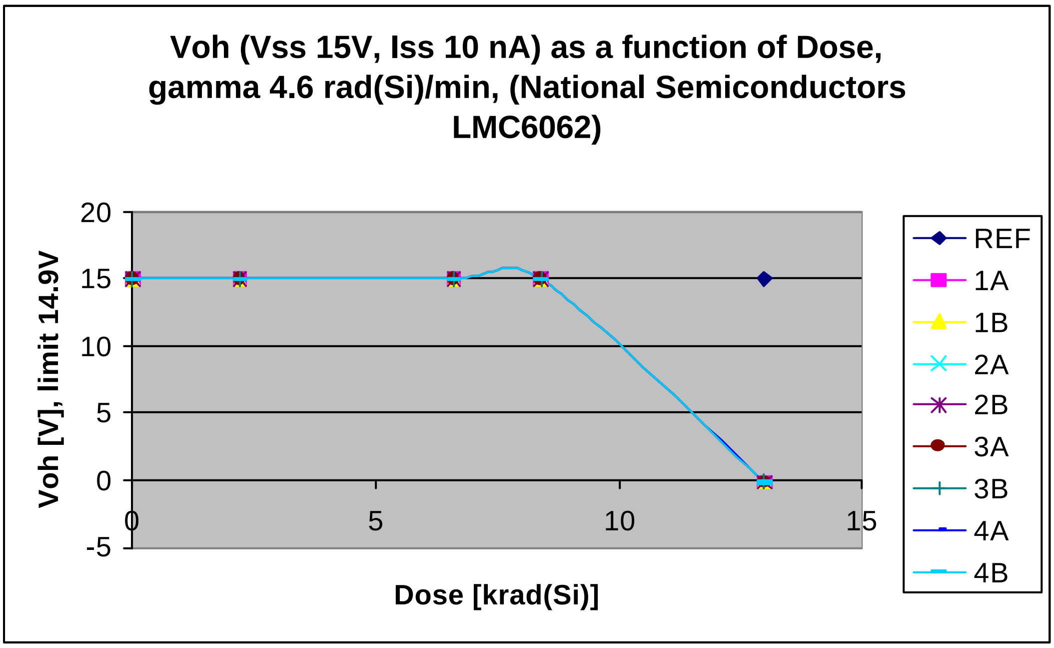

Figure 15 Voh (Vss 15V, Iss 10nA) as a function of Dose, gamma 4.6 rad(Si)/min.

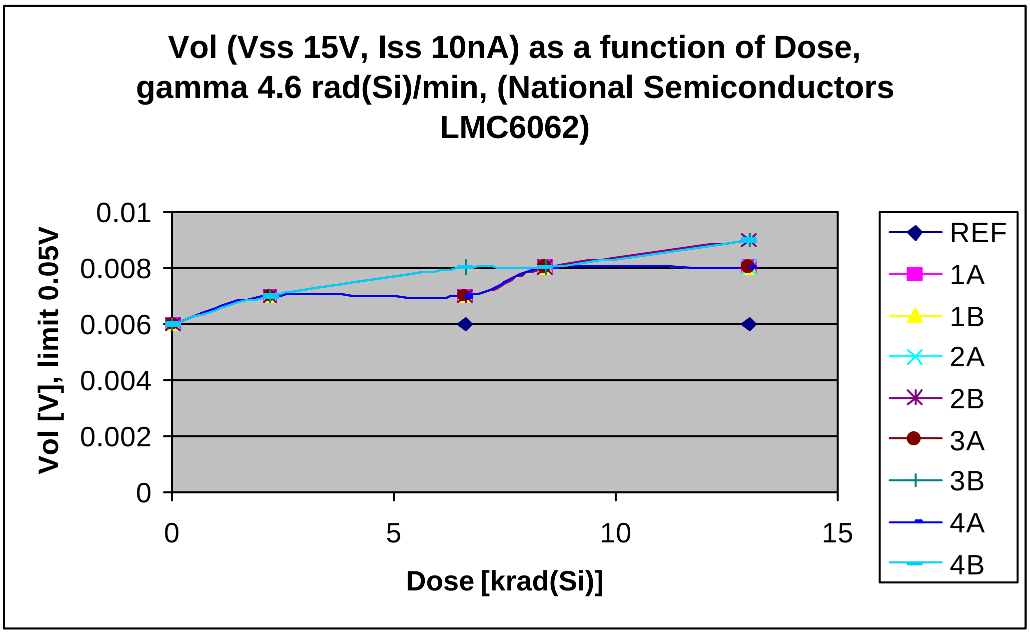

Figure 16 Vol (Vss 15V, Iss 10nA) as a function of Dose, gamma 4.6 rad(Si)/min.

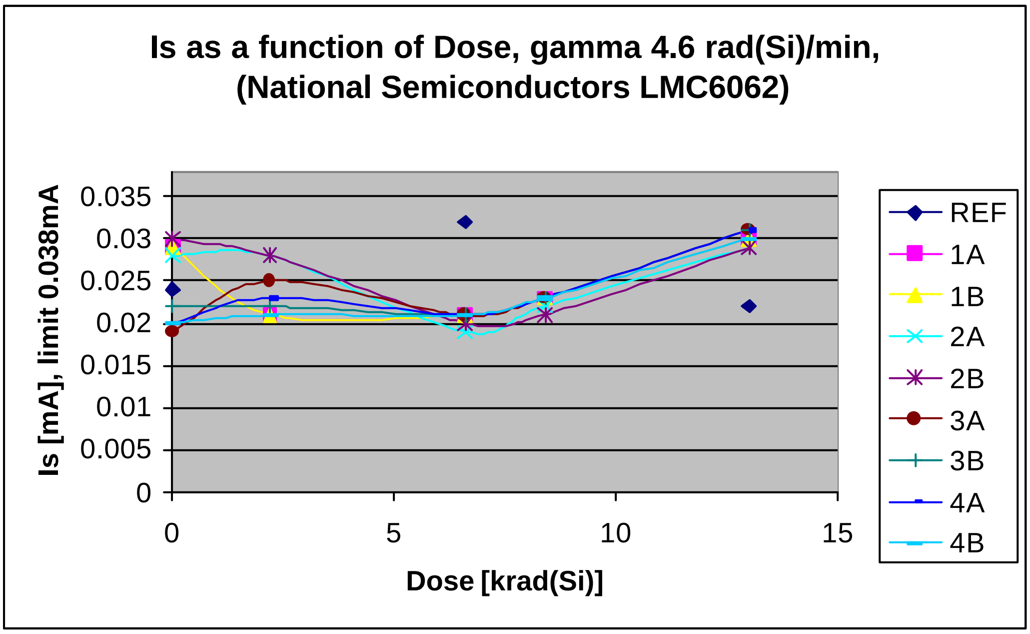

Figure 17 Is as a function of Dose, gamma 4.6 rad(Si)/min.

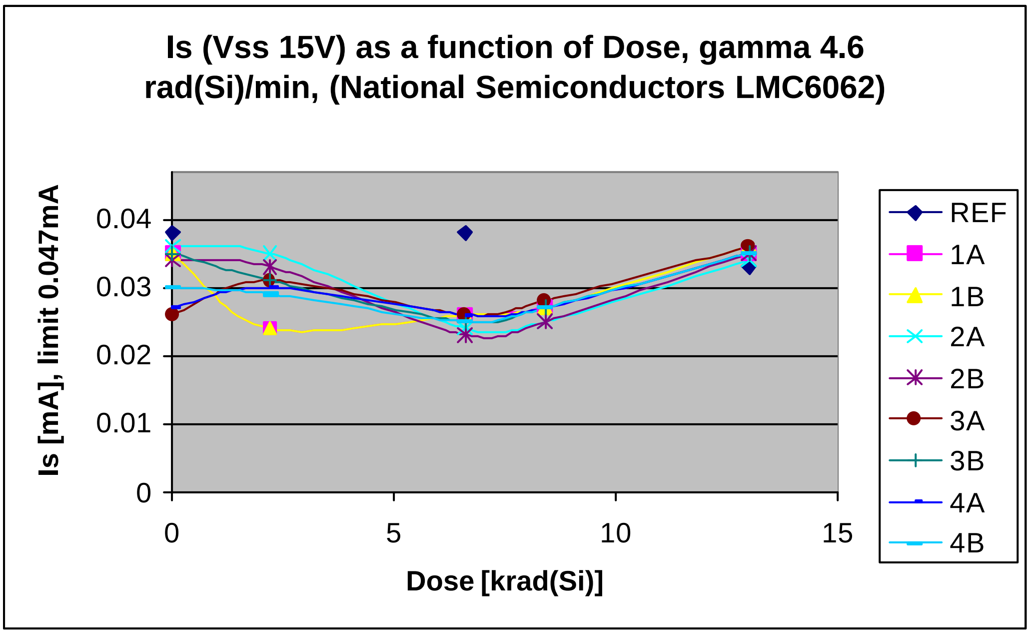

Figure 18 Is (Vss 15V) as a function of Dose, gamma 4.6 rad(Si)/min.

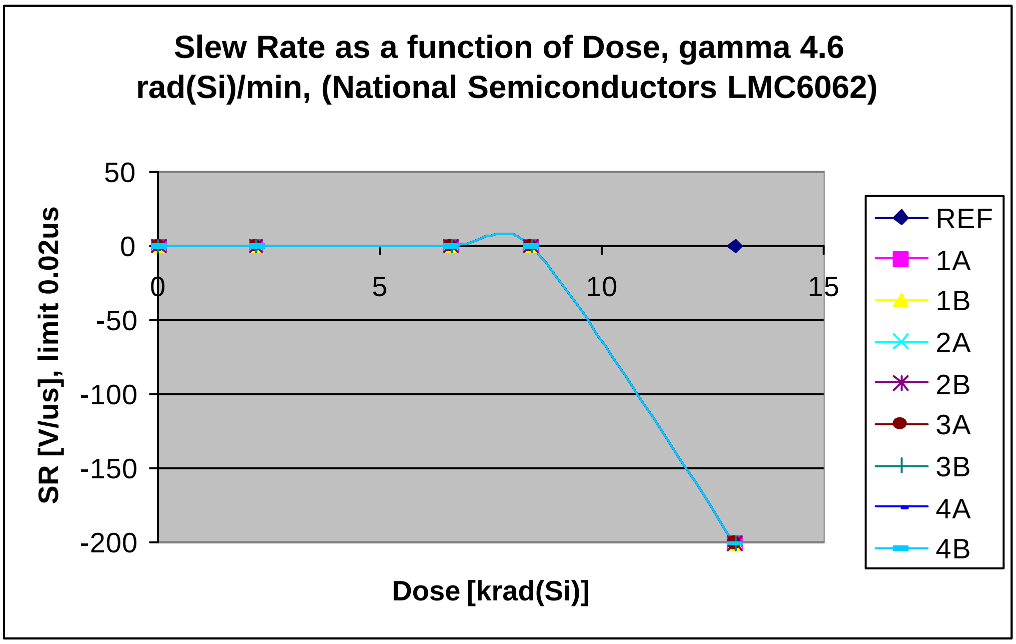

Figure 19 Slew Rate as a function of Dose, gamma 4.6 rad(Si)/min.

Figure 1 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 LMC6062 devices. The specified upper limit of 0.9mV is exceeded for some devices for total dose levels above 2.2 krad(Si).

The results in figure 7 illustrate that PSRR+ for device 3B fell below the lower limit of 72 dB at 6.6 krad(Si). The other devices also show a significant reduction of PSRR+ at this total dose level before slightly recovering for higher total dose levels.

The results in figures 9, 11, 13 and 15 illustrate that Voh for all devices dropped below the specified limit at total dose levels above 8.4krad(Si).

The results in figure 19 illustrates that the Slew Rate of all devices are out of specified limits above 8.4krad(Si). The failure of the output voltage rendered the Slew Rate value undefined.

All other parameters were within specified values.

3.5 Annealing Test Results

All devices were subjected 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 anneal tests were performed at +80°C instead of the required +100°C (AD1). Only anneal results for post-irradiation failed parameters are discussed below.

The 24h room temperature anneal results show improvement in some parameters while other parameters show an additional degradation. Anneal results for Vos (Figure 20) illustrate improvement for some devices and degradation for others. The spread in device-to-device behaviour is clearly illustrated in figure 20. The PSRR+ results (figure 21) show an additional degradation for all devices. The Voh results (figure 22) show an improvement of the results for all devices.

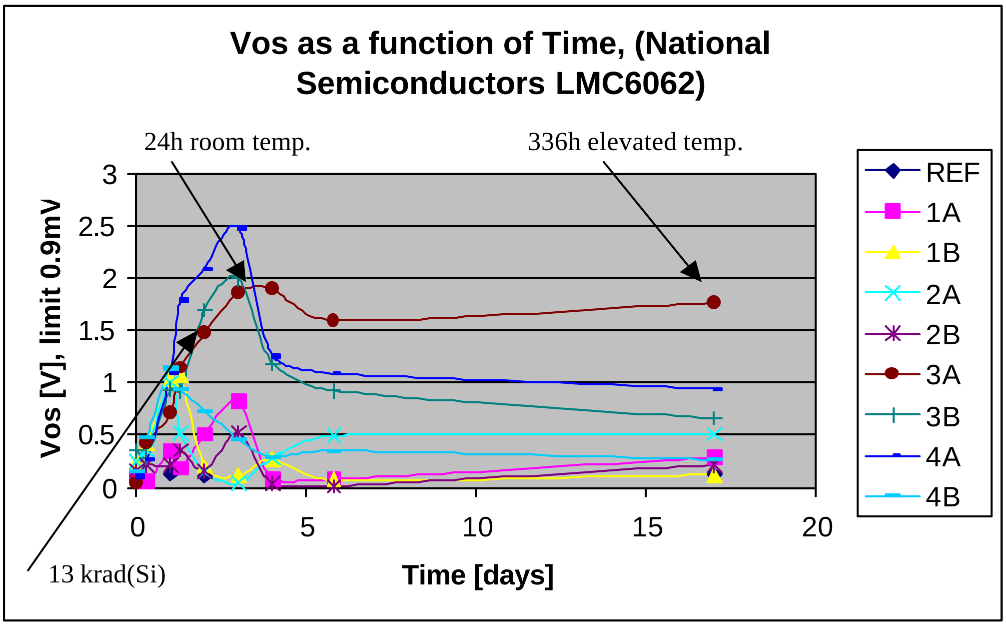

Figure 20 Vos as a function of time, gamma 4.6 rad(Si)/min.

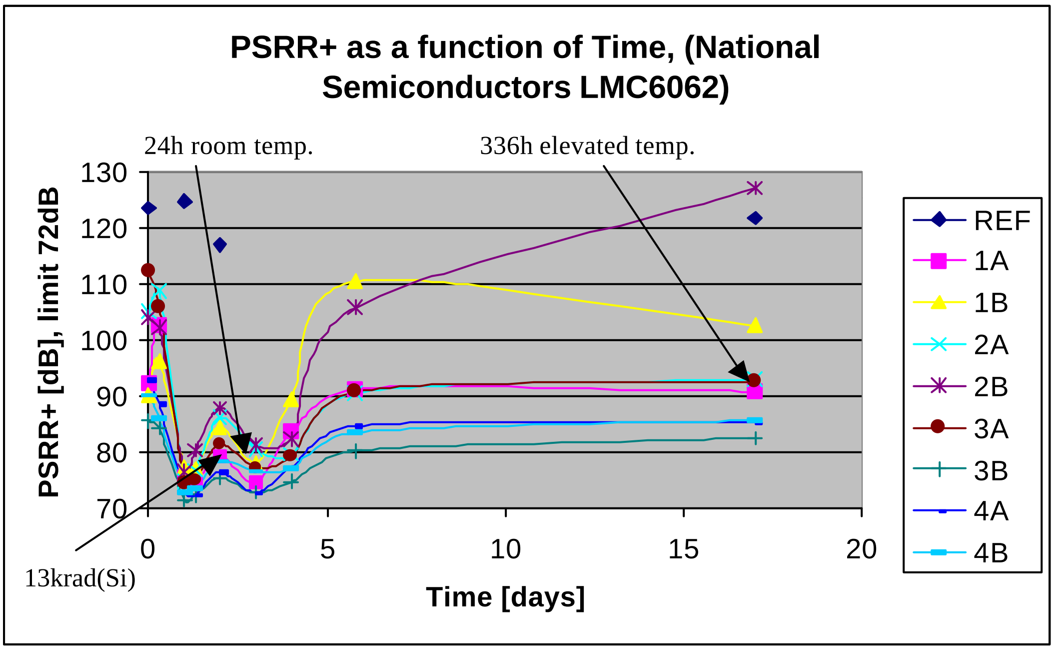

Figure 21 PSRR+ as a function of time, gamma 4.6 rad(Si)/min.

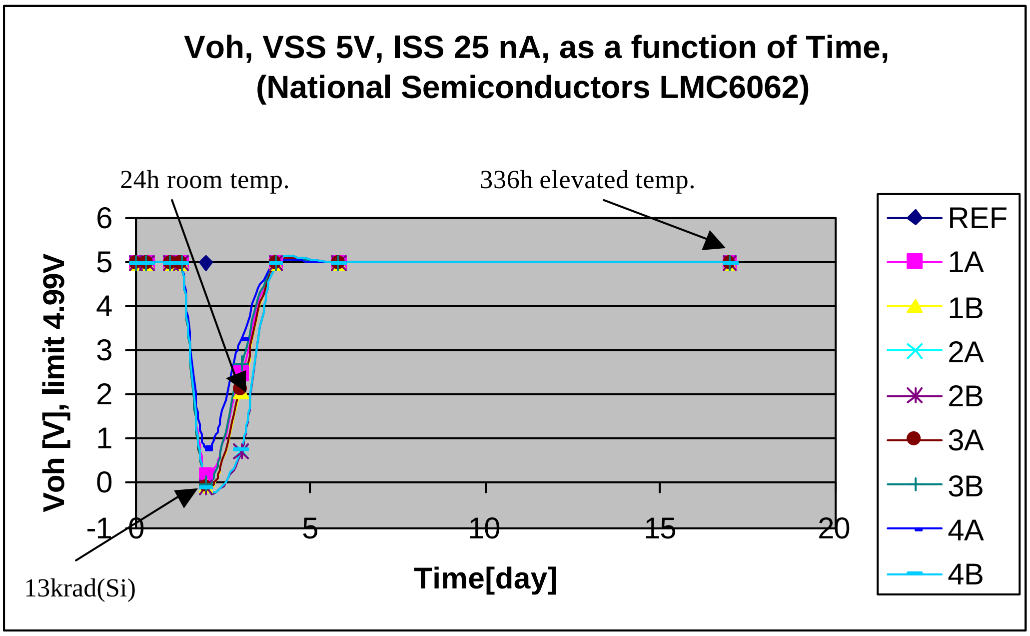

Figure 22 Voh as a function of time, gamma 4.6 rad(Si)/min.

The high temperature anneal results show that all failed parameters recovered to acceptable levels with the exception of Vos for two devices.

3.6 Conclusion

The commercial LMC6062 operational amplifier irradiation test show that several parameters failed after 6.6 and > 8.4krad(Si) total ionising dose. 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 for two devices. This may indicate a dose-rate dependency for which devices are less degraded in a low dose rate environment.

Considering the above (including the annealing results) the LMC6062 is not recommended for use on the STEREO project.