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Cf-252 SINGLE EVENT EFFECT TEST REPORT OF 20-BIT CS5508 A/D CONVERTER

for

RPC MAG / ROSETTA
ESA PROJECT

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TABLE OF CONTENTS

Figures

1 Abstract

The objective of this work was to determine the CS 5508 A/D converter susceptibility to radiation caused by heavy ions. Both Single Event Upsets (SEU's) and Single Event Latch-ups (SEL's) were recorded during these preliminary Cf-252 radiation tests that will be described here. Test set-up details including the test facility, test equipment and test philosophy will also be presented.

2 Introduction

Testing was performed at the European Space and Technology Centre (ESTEC) in Noordwijk. The irradiation was performed in August 1999. Three devices of the same lot were tested. The Device Under Test (DUT) was tested during irradiation runs lasting from 1 to 40 minutes. The used irradiation source was Californium-252.
The monitoring and evaluation equipment as well as the test software used were designed in the course of the preparation time of this work and will be presented here.
This test is a preliminary one and it is used as a preparatory test for the testing with an accelerator. It has been used to identify the types of effects that can occur and to establish a reasonable estimate of the saturation event cross section prior to the testing with an accelerator as well as to confirm the quality of the test set-up.

3 The test techniques and set-up

3.1 Facility Usage

The test facility used was situated at the European Space and Technology Centre (ESTEC), Noordwijk i.e. the Single Event Effect Test Facility. The test set-up utilises a Californium-252-test facility suitable to provide ions with Linear Energy Transfer (LET) in the range 42-45 MeV·cm2/mg at the surface of the DUT. The particle flux was $3{,}4 \cdot 10^3$ particles/cm^2/min at the working distance of 1 cm from the source. For each run the cumulated fluence received by the DUT sample was computed. The total received fluences per sample can be obtained from the result tables (see *Appendix* 2). Tests were performed under the ambient temperature. Each of the three samples tested was clearly marked and de-lidded as required for ion testing. The de-lidded devices were mounted on a device under test board inside a vacuum chamber.

3.2 Test Hardware, Software and Control

The test set-up consisted of the radiation source (Cf-252) within a vacuum chamber, an electrical measurement and monitoring system, a test circuit board and a power supply with latch up protection. The test circuit board was designed to provide a means of testing a CS 5508 A/D converter. It was configured for operation from ±5V dual voltage supply, with ADC operating from a 32.768 kHz crystal clock in a bipolar mode. The A/D converter was driven by the PIC microcontroller 16F84 mounted on the board.

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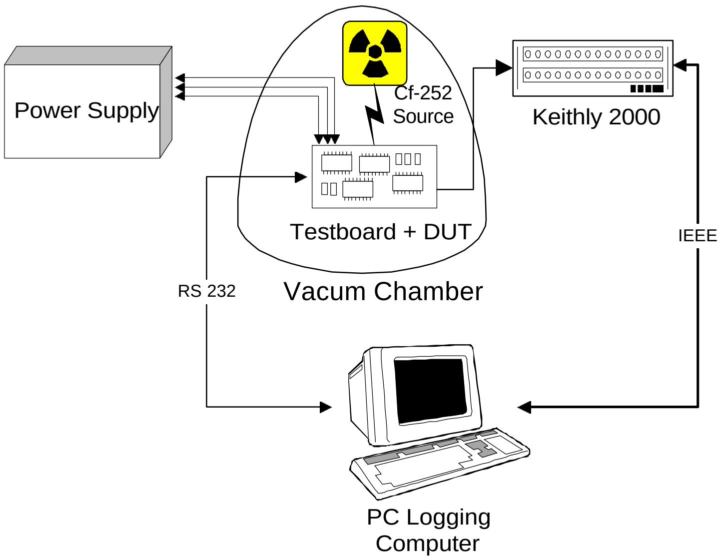


Figure 1: Test set-up / equipment

When operating, the digital data is collected from the ADC and then transferred to PC. The data was displayed to show the ADC performances and then saved in a file for further analysis and evaluation. Beside the collection of data, the PC also monitored the power supply via the IEEE bus and a Kheitly 2000 multimeter. This set-up use the "LabView" software. Two input signals were used for the testing procedure, a DC signal delivered by the battery source, 1.24 V, and a ground signal. Figure 1 illustrates the test set-up equipment.

3.2.1 The Radioactive Source Californium-252

Californium–252 is a radioactive source capable of undergoing fission. It emits alpha particles, fission fragments and fast neutrons. The fission fragments are used for SEE testing. 95% of the particles have LET between 42 and 45 MeV·cm^2/mg (Si). The mean range of the fission particles in silicon is 14,2 µm. The source has a nominal activity of 1.78µCi and is used in a vacuum chamber.
The Cf-252 source at ESTEC/ESA is used for preliminary SEE testing and for validation of testing equipment. It is calibrated once a year.
The flux measured at the different distances from the source, resulted in the following fluences:

- 1 cm 3824 particles/cm^2/min
- 2 cm 1236 particles/cm^2/min
- 3 cm 575 particles/cm^2/min
- 4 cm 341 particles/cm^2/min

3.2.2 ADC Board for Evaluation of CS 5508

The PCB board has the dimension of 160 mm x 100 mm. It provides a mean of testing a CS 5508 analogue-to-digital converter It is divided into an analogue and digital part, with the following main components:

- ADC (CS 5508) and its main circuitry
- microcontroller (PIC 16F84) and its circuitry
- the connectors for
  - the signal input (50 Ω coax cable, IC8)
  - the signal output (RS 232 9 pin connector, F09H)
  - the power supply (JP6)

The drawing of the PCB with marked components is presented in *Appendix 1*.
The board is configured for operation from +5V and –5V supply (V_A+ & V_A-) but can operate from a single supply if V_A- connected to the ground. The ADC is configured to operate from 32.765 kHz, the output sample rate was 20 Hz.
The board is designed to operate with external and internal voltage reference. It can convert the bipolar and unipolar signals and work in:

- synchronous self clocking mode
- synchronous external clocking mode
- sleep mode

The ADC is driven by an 8-Bit Microchip microcontroller PIC 16C84. The PIC 16F84 was used because of its special features to reduce external components, resulting in system reliability and reducing power consumption. The device was operated by a 4 MHz clock input with the 100 ns of instruction cycle.
The source code was created in the C-language. The testing and debugging of the source code was performed with the assistance of an Integrated Development Environment IDE-MPLAB, which consisting of a compiler, an assembler and linker for generating the executable file.
The executable file was downloaded to the PIC 16F84 by using PICSTART Plus, a programmable tool for the device. The PIC 16F84 has 1 KWords Flash program memory, allowing the code to be updated without the device being removed from the application. The flash program memory can be erased / rewritten up to 10000 times, thus offering flexibility of code writing and testing the device.

3.3 The Current Measurement Method

During the irradiation of the ADC, supply currents were monitored. Its values were saved in a file for each run for later analysis. A high precision Keithly 2000 programmable multimeter (6 decimal digit precision) was used for the purpose of measuring.
The 1 resistors were connected in a serial connection with the power supply cables (analogue positive and negative and digital supply). The multimeter measured the resistor's voltage drops over three coax cables. These measurements were at the same time the current measurements ($U=RI$, $R=1\Omega \Rightarrow 1V \cong 1A$). The current values were saved in the internal multimeter's buffer and every 10 seconds transferred to the PC over the IEEE bus.
The device (Keithly 2000) control and data acquisition was performed by "LabVIEW" software package, from National Instruments.

4 Test Method

In the test set-up presented above one basic test was used to measure and quantify the performance of analogue-to-digital converter. A ground signal (0V) was used as an A/D converter input signal. Due to the cable length (about 3 m), additional noise was created, resulting in an offset in the digital output signal.
The ADC was driven with a 32.768 kHz input clock. It converted and updated its output port at 20 samples/sec that were recorded in a file. In addition, the time and the date at which the samples occurred were recorded and saved in a file as well.
The ADC samples were plotted in real time for each individual run. Parallel to the ADC measurements, the power supply currents were measured and its values were stored in a file. The power supply voltages were limited in order to avoid high currents if a latch-up effect should occur and to prevent the device from being damaged.
Analysis of the data was made after irradiation. For each run one file was created. Differential Nonlinearity and Histogram analyses were performed. The Standard Deviation was calculated. The number of transient effects (single event effects) and latch-up was calculated. The current measurements were plotted for each run. The data analysis was made by means of "MS EXCEL" as well as "LabVIEW".

5 Results

The Crystal CS 5508 device was proven to be very difficult to analyse because of its high precision (20 Bits) and random errors induced by heavy ion radiation.
It is not known that the device CS 5508 has been previously tested for SEE under heavy ion irradiation. Three parts were tested all de-lidded when being irradiated. Each part was clearly marked to facilitate the traceability of the test data. As it was described earlier, the test software was capable of saving the data and the time of their occurrence in a file. The result tables (see *Appendix* 2) provide the test results for all three devices: typical time for the test, particle fluence, number of single effect events as well as the occurrence of latch-up effects.
For each test-run the cross section is computed. The cross section is the SEE sensitivity of the device under test and is expressed as the ratio of the number of upsets to the particle fluence for each run.
Analysis of the received data was performed and two different types of heavy ion induced single event effects were detected.
The first effect was the transient upset, a data conversion error that has temporary character. This error lasted for only one conversion and was followed by a normal output value. The number of transient upsets for each run is given in the result tables.
The second effect is the lingering error, where the ADC converts the input value, but repeatedly outputting the incorrect value. The cross section as well as the number of the lingering errors obtained during the heavy ion radiation for each run is presented in the result tables. Both the transient and lingering errors can be resolved by initiating a re-calibration of the ADC or by resetting the device (power off /on).
Special types of errors were the combination of transient and lingering errors. The occurrence of the transient errors has also been noticed at the lingering output levels. This work does not distinguish between the transient errors that occurred while ADC outputs normal value and the transients during the lingering errors. Therefore, the transient failures during the lingering errors have been counted together with other transient errors.

Another interesting effect observed during the heavy ion experimentation were Single Event Latch up (SELs) effects and the Single Event Functional Interrupt (SEFI) i.e. sudden stop of the conversion of the ADC.
The latch-up effect was detected during different runs performed on the devices. The latch-up effect was recognised by a high analogue current, more than 100 times its nominal value. An ADC performed no conversion after the latch-up effect occurred, until it was restarted (power off /on). The cross section for the latch-up as well as the frequency of latch-up occurrence is presented in the result tables.
Beside the latch-up effect, the ADC showed a tendency to stop the conversion process of the input signal when being irradiated. When this effect occurred, the output signal was not on the display and the digital current was lower then nominal. This kind of error could be resolved by resetting the ADC.

5.1 Test Under Control Conditions

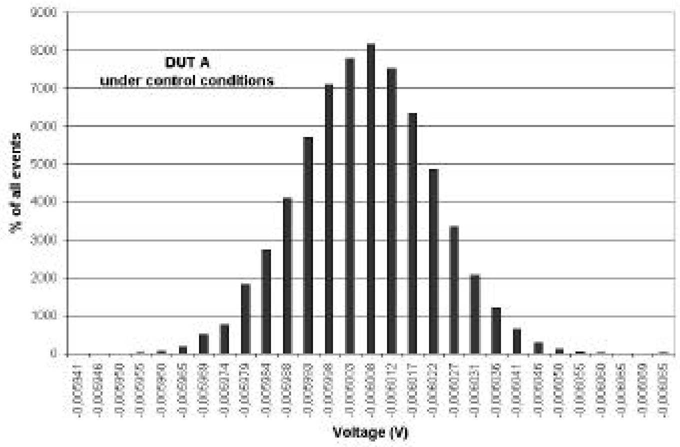


Figure 2 presents the ground input test histogram recorded under control conditions for the 20 Bit CS 5508 ADC, part A. 65656 conversions were recorded in total. The mean value is 0.0060109 V, what responds to 523947 LSB. The Standard Deviation is 3 LSB (1.52504E-05V). The output on the static input can be one of the values presented in the histogram. The output values vary between –0.00607416V and –0.00593612V, what results in 31 LSB.

Figure 2: DUT A, run under control conditions

Figure 3 presents the ground input test histogram recorded under control conditions for the 20 Bit CS 5508 ADC, part B. 65656 conversions were recorded in total. The mean value is -0.00600983V, what corresponds to 523947 LSB. The Standard Deviation is 3 LSB (1.52449E-05V). The output on the static input can be one of the values presented in histogram. The output values vary between –0.00607892V and –0.00594564V (32 LSB).

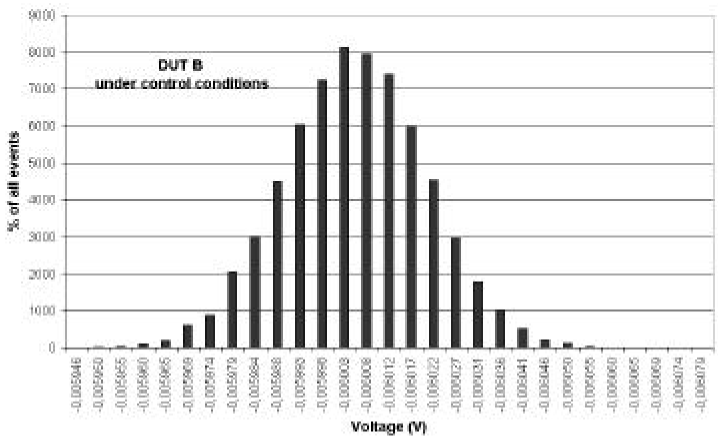


Figure 3: DUT B, run under control conditions

5.2 Device Under Test A

Figure 4 presents the ADC converted and expected value over the full scale against the number of the conversions for the heavy ion irradiation sample A, run # 12. Seven lingering errors were observed during the course of the test, which are clearly seen in the Figure 4a. Twenty-two transient upset events were observed. After 24 min of radiation, the ADC jammed, repeatedly outputting the same value FFFFF.

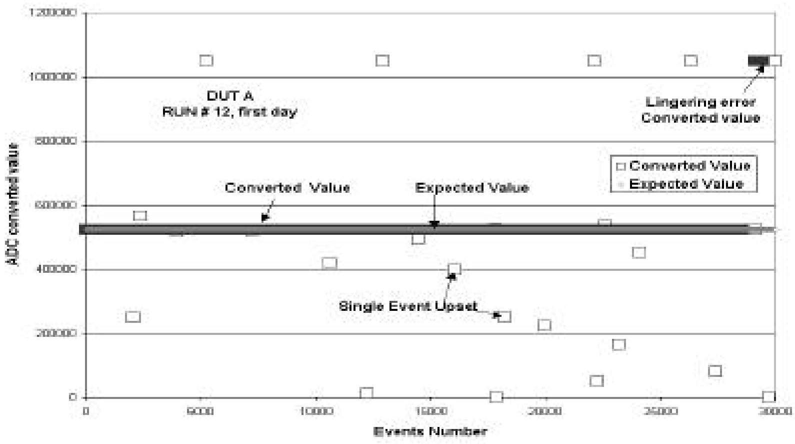


Figure 4: DUT A, run # 12

Figure 4a illustrates the same as the previous figure, but not over the full scale. The y-axis magnitudes are from 523600 to 524200, i.e. from –0.007664 V to –0.004808 V.

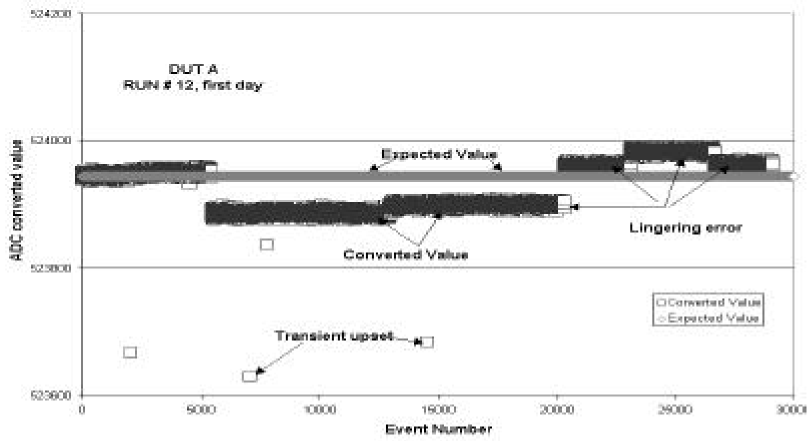


Figure 4a.

Figure 5 presents the ADC converted and expected value (full scale) against the upset event number for the heavy ion irradiation sample A, run # 11. 12 lingering errors were observed during the course of the test, some of them are clearly seen in the following Figure 5a. 17 transient upset events were observed. After approx. 36 min of radiation, the Single Event Latch-up has occurred.

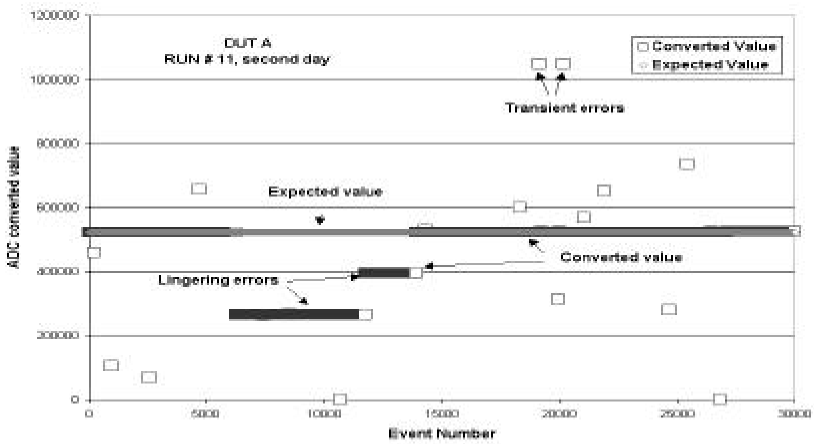


Figure 5: DUT A, run #11

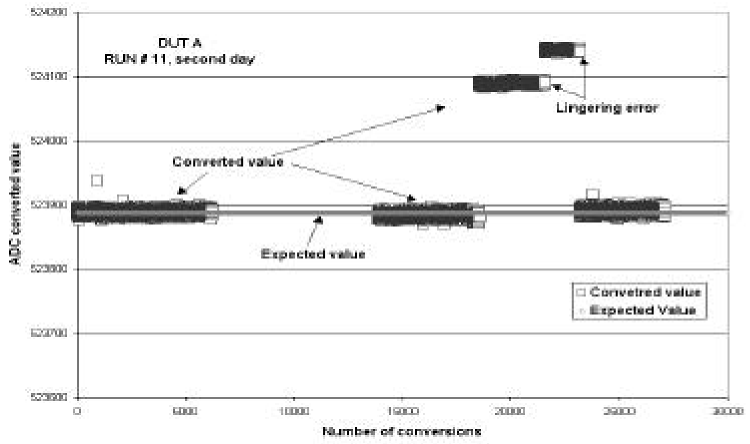


Figure 5a

Comparing the Figures 5 and 5a it can clearly be seen that the ADC CS 5508 is more susceptible to small lingering errors (small offset drift; up to ± 2-300 LSB) rather than high lingering errors. The same was observed for the DUT B.

Figures 6, 6a and 6b present the histogram plot for run number 4, device A.

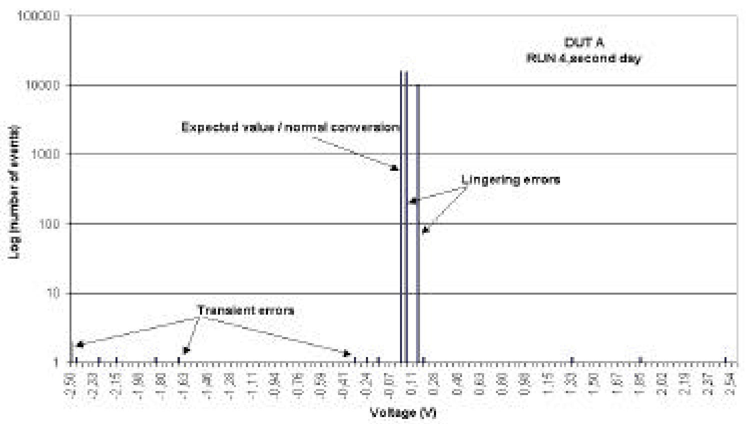


Figure 6: DUT A, run #4

The ADC was irradiated with approx. 128869 heavy ions particles per cm2. After approx. 33 min and 42 sec. of irradiation under the heavy ion, the ADC stopped to convert the input signal. 9 changes in offset (lingering "jam" error) and 13 transient upset errors were observed. Figure 6a presents the histogram plot output over the full scale (from –2.5 to 2.5 V).

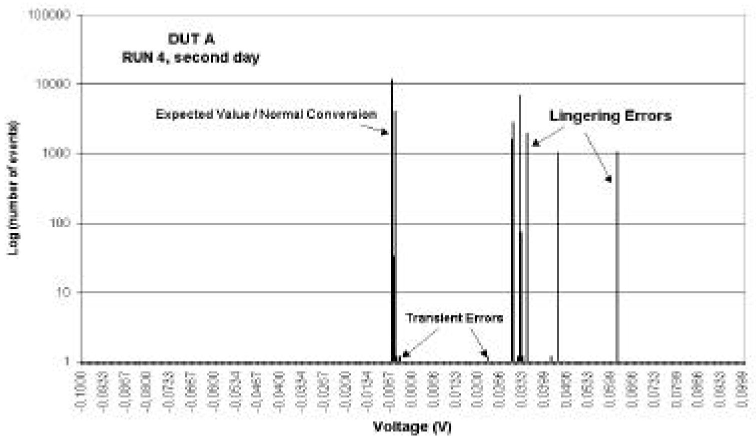


Figure 6a

Figure 6a and 6b illustrate the same as Figure 6, although not over the full scale. The frequency of occurrence of lingering and transient errors was computed over a narrower voltage scale, ranging from –0.1 to 0.1 V (Figure 6a) and –0.01 to 0.01V (Figure 6b). Obviously if higher resolution for the x-axis is used, more lingering errors are distinct.

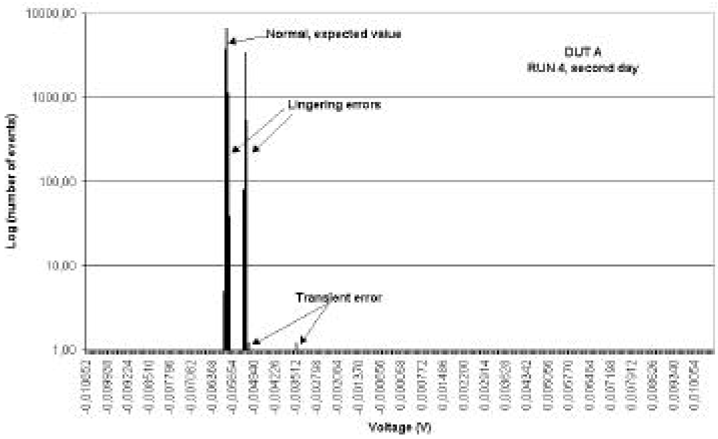


Figure 6b

It is clear that most of the lingering events lie close to the ADC output value. The large lingering errors are rather rare (except when the ADC became jammed at +2.5 V). The transient events can be observed everywhere over the full scale.

5.3 Device Under Test B

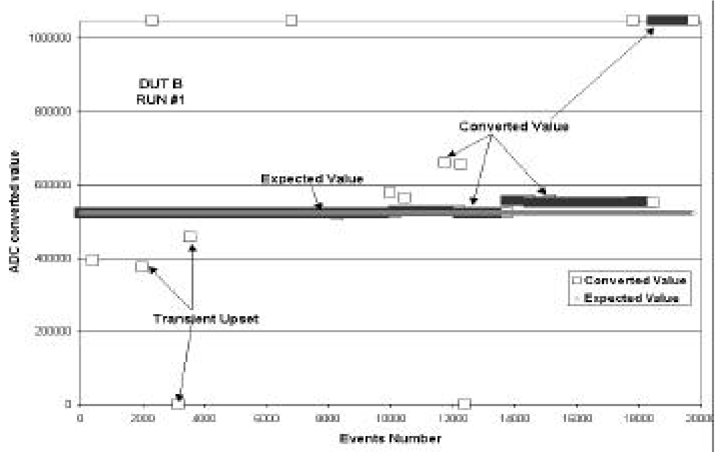


Figure 7: DUT B, run # 1

Figure 7 presents the ADC converted and expected value against the number of conversion of the DUT B for heavy ion irradiation. Nearly 20000 conversions are recorded. Fluence was 62267 par/cm^2. 14 transient events and 6 lingering errors were observed. At the end of irradiation the ADC jammed, constantly outputting the same value, (FFFFF).

Figure 7a presents the same as Figure 7, except that high resolution is used for the y-axis. Note that 520000 corresponds to –0.0248 V and 560000 to 0.1656 V. Lingering errors occurring near the ADC expected value can clearly be observed here.

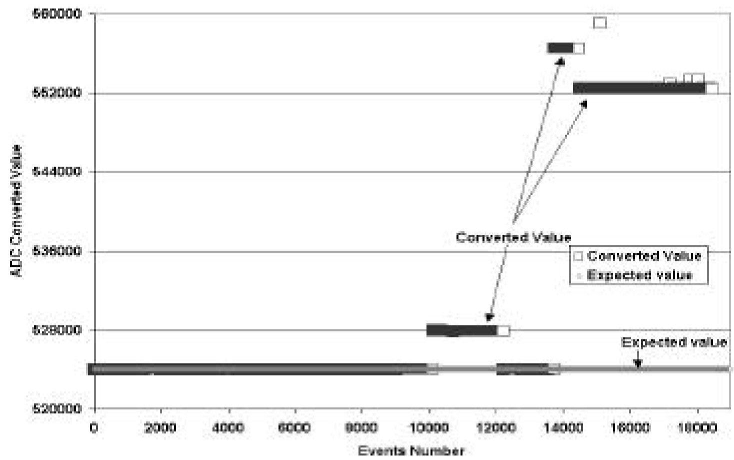


Figure 7a

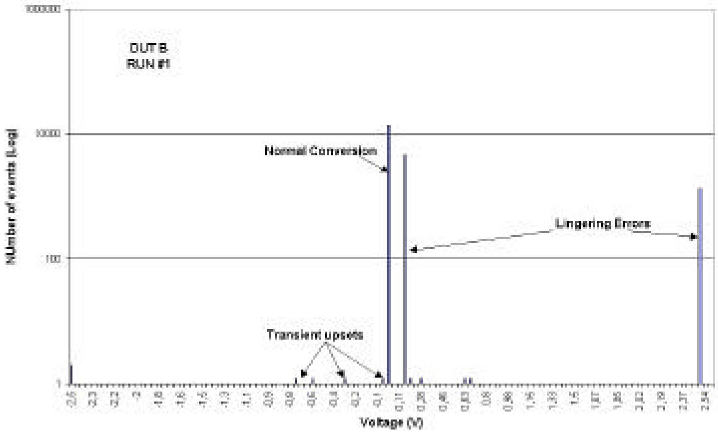


Figure 7b

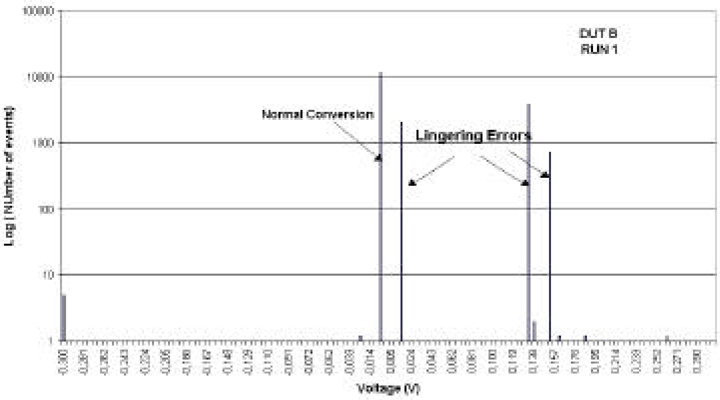


Figure 7c

Figure 7b and 7c illustrate the histogram plot for the same run, 8b over the full scale, 8c over the part of the scale (from –0.3 V to 0.3V).

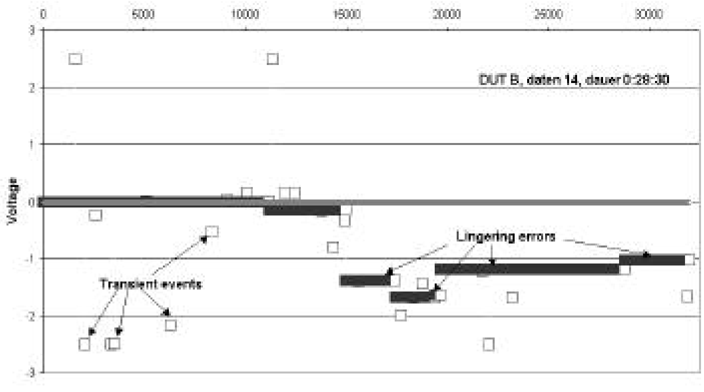


Figure 8: DUT B, run # 14

Figure 8 presents the ground-input data for sample B, run # 14. The fluence was 108984 par/cm^2. The ADC stopped converting the input signal after approximately 28.5 min. The device was rested; it started to function normally, outputting again the expected signal. A totally of 20 transient events and 16 lingering errors were observed.

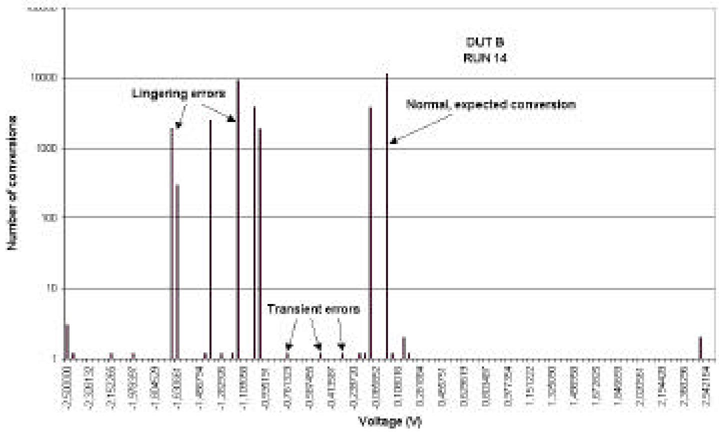


Figure 8a

Figures 8a and 8b illustrate the histogram plot over the full scale and over parts of the scale (-1.8 V to 0.3 V). This is the one of the rare examples presenting the occurrence of higher lingering errors. Standard Deviation for this run was 0.604 V.

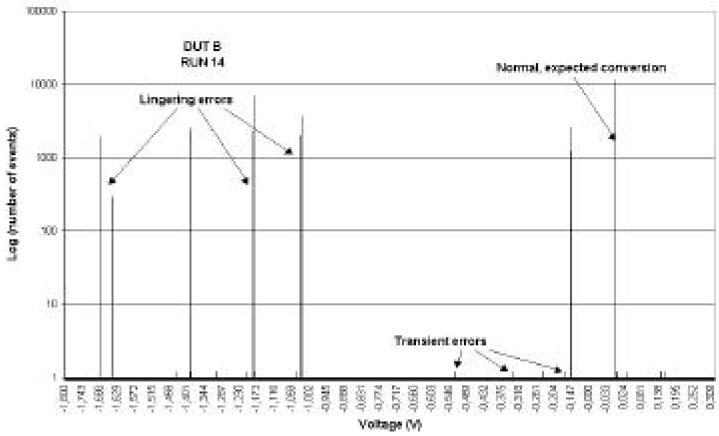


Figure 8b

5.4 Current Measurement Results

Typical values for the positive and negative power supply currents are ±300 µA. Maximum current allowed according to the specification is 450 µA. The digital power supply current has the typical value of 40-60 µA. The following diagrams illustrate some typical examples for the current progression versus time, recorded under irradiation. The currents were recorded approximately every second.

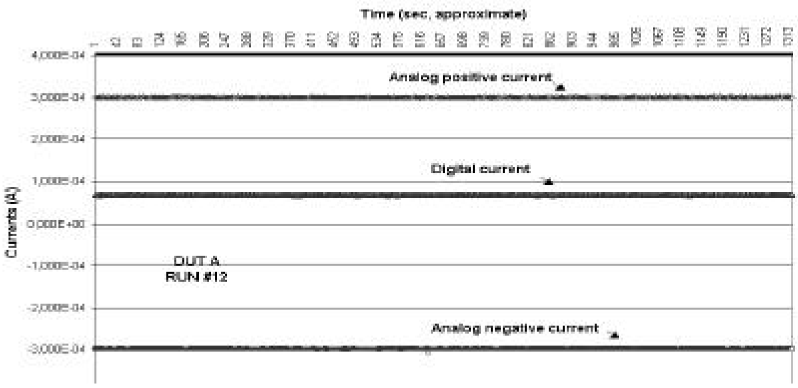


Figure 9: Current Measurement, DUT A, run # 12

Figure 9 illustrates the current progression versus time for run # 12. The device was irradiated approximately 25 min. Power supply currents were not affected by the irradiation, their values remained stable during the irradiation.

Figure 10 presents the power supply currents versus time for run # 6, device A, recorded during irradiation. The ADC was irradiated approximately 26 min. 21 transient events and 5 lingering errors were observed. Two times the ADC stopped converting the input signal. Analogue positive and negative power supply currents remained stable during the whole time of irradiation. Whenever the ADC stopped converting the input signal, digital current consumption decreased. This effect was not noticed during the preparation of the test method in laboratory in Graz and it is caused by the irradiation. It is a random effect, with time and duration incalculable. The ADC rarely recovers from this effect by itself. Usually it jams and error can only be resolved by resetting the device.

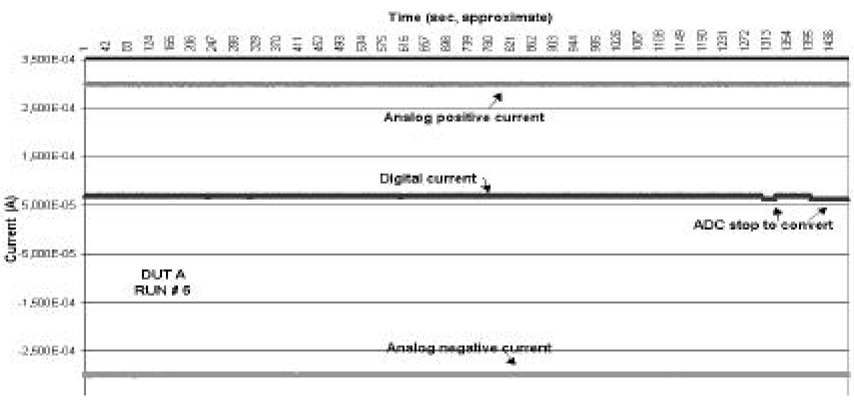


Figure 10: Current Measurement, DUT A, run # 6

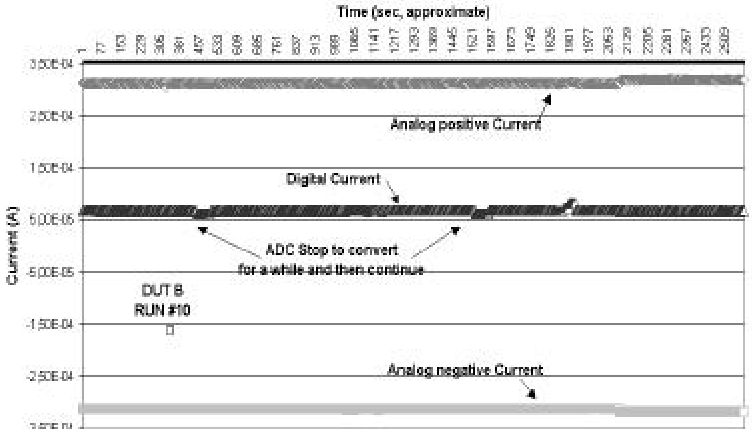


Figure 11: Current Measurement, DUT B, run # 10

Figure 11 illustrates power supply currents progression for run # 10, device B. Two stops to convert errors were observed. The first error lasted for 54 sec, the digital current decreased from 70µA to 61µa. The second error lasted for approximately 50 sec and the digital current was 61µA. In both cases, the ADC recovered from this effect by itself.

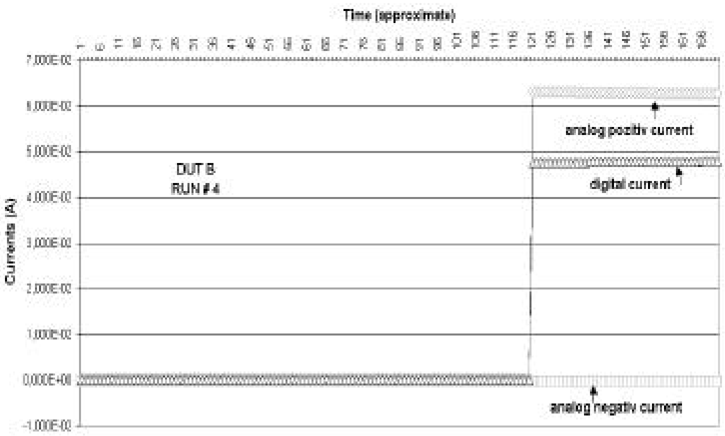


Figure 12: Latch–up, DUT B, run # 4

Figure 12 illustrates the power supply currents recorded under the irradiation for run #4, device B. The device was irradiated for only 3 minutes. The Single Event Latch-up Effect occurred already in the second minute of the radiation. The analogue positive current increased from 300µA to 62 mA, the digital current increased from 70 µA to 61mA. No major changes in analogue negative supplies current were noticed.

6 Conclusion

Single Event Effect tests were performed on three parts, ADC CS 5508 20-Bit A/D converter by Crystal, Ltd. using the heavy ions facilities (Cf-252) available at the European Space and Technology Centre in Noordwijk. During testing, the Device Under Test (DUT) was sent a DC signal level of 0V. Changes in the output were detected and counted. A computer controlled-power supply was monitored for SEL (single event latch–up).
Measurements of digital values of the A/D converters were sometimes unexpected, resulting in two main types of errors: transient and lingering errors. Several Single Event Latch-up effects were detected during the different runs performed on the three samples. A further interesting effect was the Single Event Functional Failure, resulting in malfunctioning of the device.
Device #4 was earlier Co^{60} tested, biased, with a dose rate of 20.43 rad(Si)/min to a level of 27 krad. After only two weeks of annealing at the room temperature the power consumption of the device #4 decreased from 1 mA to 0,3 mA and the device regained functionality. This device was used during the preliminary set-up phase.

Devices A and B are from the same lot and have not been tested and used before. Therefore, the measurements performed on these devices were similar and are relevant for the final conclusion.

Both lingering and transient errors were observed during the device irradiation. Transient noise events of different magnitudes were observed. Most of the lingering errors lie close to the expected value. The large output level shifts under the static input operation were rarely observed. The Single Event Latch-up effect and Single Event Functional Interrupt occurred while irradiating devices A and B.

The computed cross-sections for lingering errors for device A is 7.07E-5 cm^2/dev at the first day of radiation and 6.76E-5 cm^2/dev at the second day of radiation. Device B has 9.84E-5 cm^2/dev at an LET of 43 MEVcm^2/mg.

The latch-up cross-section for device A is 9.66E-06 cm^2/dev (second day of radiation) and 1.4E-06 cm^2/dev for device B. Device A was irradiated 3.5 hours longer then device B, and 7 latch-up effects were observed under the irradiation. Device B was irradiated only for 3 hours and only 1 latch-up effect occurred during this time.

The transient cross section values for device A are 1.51E-04 cm^2/dev (first day of radiation) and 1.42E-04 cm^2/dev (second day of radiation) and for device B 2.12E-04 cm^2/dev.

The devices showed high susceptibility to lingering and transient errors as well as high danger of the potential occurring of the latch-up effects.

These Cf-252 tests are of a preliminary nature in order to

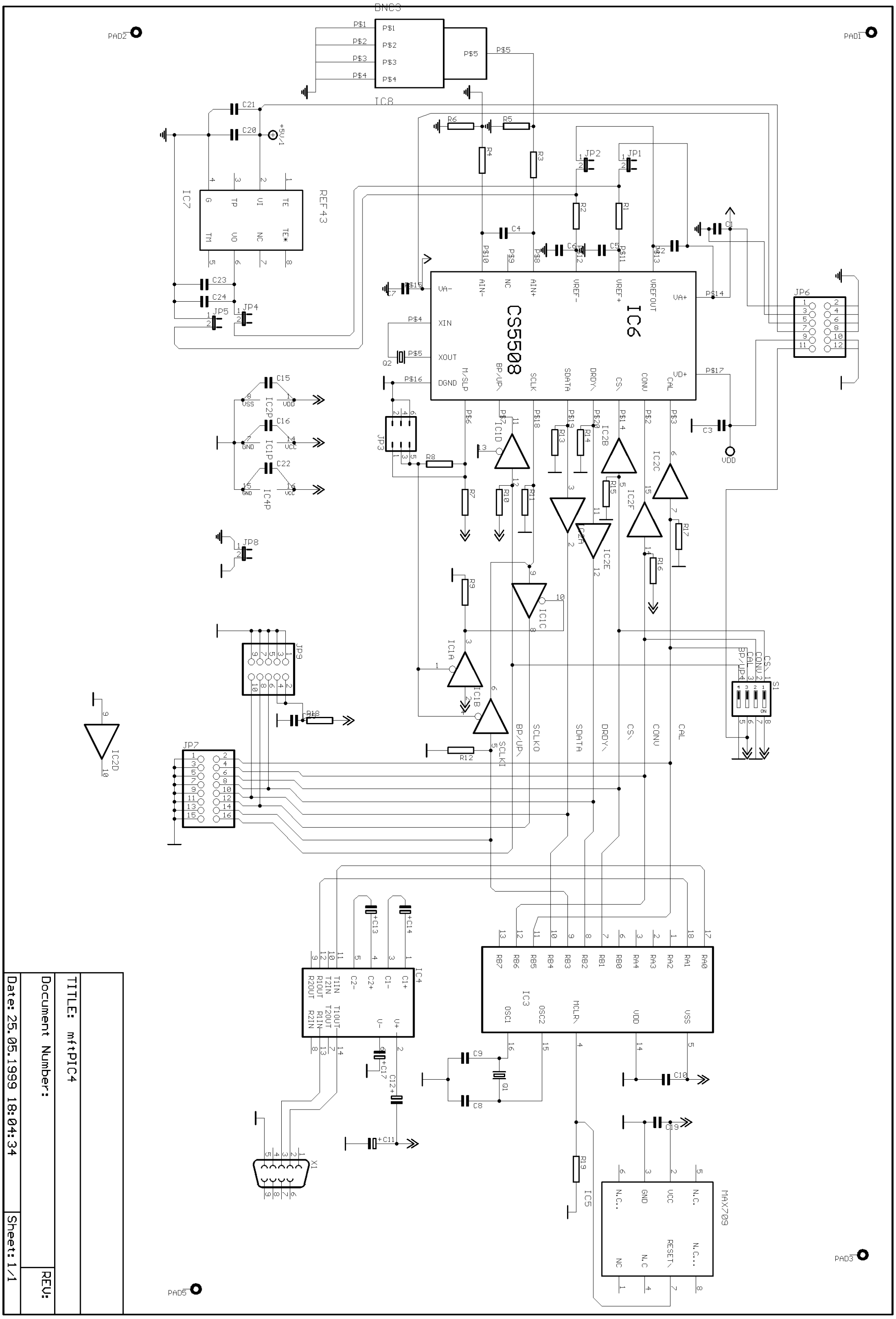
a) validate and optimise the test strategy and

b) to get preliminary indication of the CS 5508's SEE behaviour.

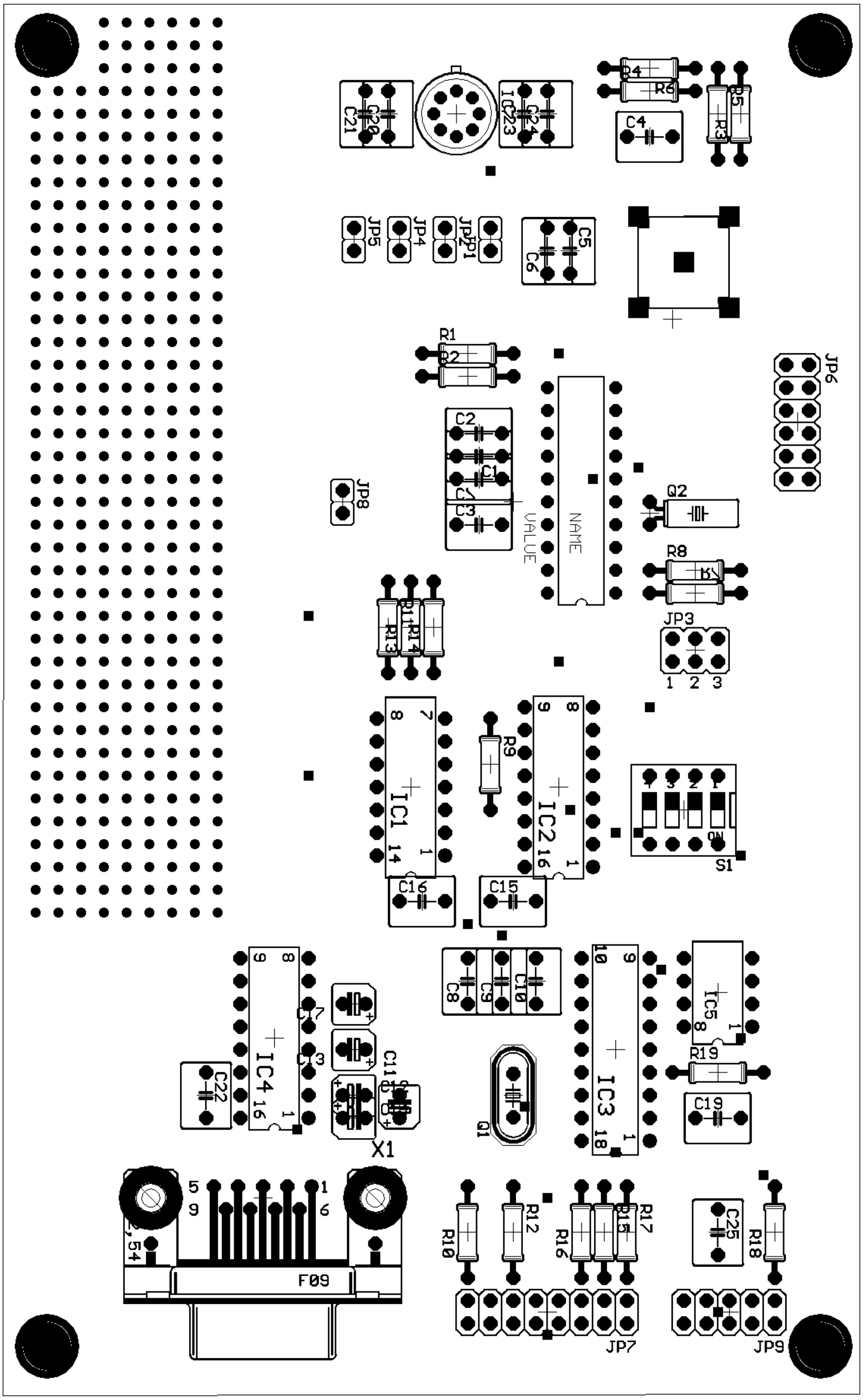
Further accelerator testing over the full LET range will be needed for a full device SEE characterisation. However, such tests should take advantages of these lessons learned here by updating both test software and hardware.

Appendix 1

Printed Circuit Board for the SEE Test



Schematic



Components' Placement

Appendix 2

Result Tables

Device under test A

Heavy Ion Radiation Source Californium-252

Device Under Test A, first day											
Run. No.	Datum Day/Mon/Year	Time H/M/S	Fluence p/cm2	Transient Errors	X-section cm2/dev	Lingering Errors	X-section cm2/dev	Latch Up	X-section cm2/dev	Stop-Func.	X Section cm2/dev
2	04.08.99	00:03:18	12619,20	1	7,92E-05	1	7,92E-05	0	0	1	7,92E-05
3	04.08.99	00:09:56	37985,07	7	1,84E-04	3	7,90E-05	0	0	1	2,63E-05
4	04.08.99	00:13:57	53344,80	6	1,12E-04	6	1,12E-04	0	0	0	0,00E+00
5	04.08.99	00:00:41	2613,07	1	3,83E-04	1	3,83E-04	0	0	0	0,00E+00
6	04.08.99	00:26:06	99806,40	21	2,10E-04	5	5,01E-05	0	0	2	2,00E-05
7	04.08.99	00:33:40	128741,33	26	2,02E-04	4	3,11E-05	0	0	1	7,77E-06
8	04.08.99	00:12:37	48246,13	6	1,24E-04	7	1,45E-04	0	0	1	2,07E-05
9	04.08.99	00:01:53	7201,87	1	1,39E-04	2	2,78E-04	0	0	0	0,00E+00
10	04.08.99	00:40:00	152960,00	1	6,54E-06	2	1,31E-05	0	0	0	0,00E+00
11	04.08.99	00:07:27	28488,80	6	2,11E-04	4	1,40E-04	0	0	0	0,00E+00
12	04.08.99	00:24:45	94644,00	22	2,32E-04	7	7,40E-05	0	0	0	0,00E+00
13	04.08.99	00:10:22	39642,13	9	2,27E-04	7	1,77E-04	0	0	1	2,52E-05
14	04.08.99	00:07:32	28807,47	4	1,39E-04	3	1,04E-04	0	0	0	0,00E+00
subtotal first day		***3:12:14***	**735100,27**	**111**	**1,51E-04**	**52**	**7,07E-05**	**0**	**0**	**7**	**9,52E-06**

Table 1: DUT A, First day of radiation

Device Under Test A, second day											
Test No.	Datum Day/Mon/Year	Time H/M/S	Fluence p/cm2	Transient Errors	X-section cm2/dev	Lingering Errors	X-section cm2/dev	Latch Up	X-section cm2/dev	Stop-Func.	X-section cm2/dev
1	05.08.99	00:18:45	71700,00	11	1,53E-04	5	6,97E-05	0	0	0	0
2	05.08.99	00:01:51	7074,40	0	0,00E+00	0	0,00E+00	0	0	0	0
3	05.08.99	00:01:36	6118,40	0	0,00E+00	1	1,63E-04	0	0	0	0
4	05.08.99	00:33:42	128868,80	13	1,01E-04	9	6,98E-05	0	0	1	7,7598E-06
5	05.08.99	00:18:41	71445,07	16	2,24E-04	3	4,20E-05	0	0	1	1,3997E-05
6	05.08.99	00:17:51	68258,40	12	1,76E-04	5	7,33E-05	1	1,47E-05	0	0
7	05.08.99	00:12:14	46780,27	12	2,57E-04	2	4,28E-05	1	2,14E-05	0	0
8	05.08.99	00:03:55	14977,33	1	6,68E-05	0	0,00E+00	0	0	0	0
9	05.08.99	00:01:41	6437,07	0	0,00E+00	0	0,00E+00	1	0,000155	0	0
10	05.08.99	00:01:16	4843,73	0	0,00E+00	0	0,00E+00	0	0	0	0
11	05.08.99	00:36:56	141233,07	17	1,20E-04	12	8,50E-05	1	7,08E-06	0	0
12	05.08.99	00:03:19	12682,93	2	1,58E-04	2	1,58E-04	1	7,88E-05	0	0
13	05.08.99	00:08:13	31420,53	2	6,37E-05	2	6,37E-05	0	0	0	0
14	05.08.99	00:07:24	28297,60	4	1,41E-04	2	7,07E-05	1	3,53E-05	0	0
15	05.08.99	00:22:09	84701,60	13	1,53E-04	6	7,08E-05	1	1,18E-05	0	0
subtotal second day		***3:09:33***	**724839,20**	**103**	**1,42E-04**	**49**	**6,76E-05**	**7**	**9,66E-06**	**2**	**2,7592E-06**

Table 2: DUT A, Second day of radiation

Device under test B and # 4

Heavy Ions Radiation source, Californium-252

Device Under Test B													
Run No.	Datum Day/Mon/Year	Time H/M/S	Fluence p/cm2	Transient Errors	X-section (cm2/dev)	Lingering Errors	X-section cm2/dev	Latch Up	X-section cm2/dev	Stop-Func.	X-section cm2/dev	Power on /off
1	06.08.99	00:16:17	62267,47	14	2,25E-04	6	9,64E-05	0	0	0	0	1
2	06.08.99	00:02:25	9241,33	1	1,08E-04	1	1,08E-04	0	0	1	0,000108	0
3	06.08.99	00:13:24	51241,60	8	1,56E-04	5	9,76E-05	0	0	1	1,95E-05	0
4	06.08.99	00:02:48	10707,20	2	1,87E-04	1	9,34E-05	1	9,3E-05	0	0	0
5	06.08.99	00:03:22	12874,13	4	3,11E-04	0	0,00E+00	0	0	1	7,77E-05	0
6	06.08.99	00:09:04	34670,93	10	2,88E-04	4	1,15E-04	0	0	0	0	1
7	06.08.99	00:15:18	58507,20	11	1,88E-04	5	8,55E-05	0	0	0	0	1
8	06.08.99	00:27:00	103248,00	27	2,62E-04	8	7,75E-05	0	0	1	9,69E-06	1
9	06.08.99	00:00:56	3569,07	1	2,80E-04	1	2,80E-04	0	0	0	0	1
10	06.08.99	00:48:24	185081,60	46	2,49E-04	15	8,10E-05	0	0	2	1,08E-05	1
11	06.08.99	00:11:06	42446,40	6	1,41E-04	2	4,71E-05	0	0	1	2,36E-05	0
12	06.08.99	00:12:48	48947,20	5	1,02E-04	8	1,63E-04	0	0	1	2,04E-05	0
14	06.08.99	00:28:30	108984,00	20	1,84E-04	16	1,47E-04	0	0	1	9,18E-06	0
	subtotal first day	***3:11:22***	**731786,13**	**155**	**2,12E-04**	**72**	**9,84E-05**	1	**1,4E-06**	9	**1,23E-05**	

Table 3: Device under test B

Device Under Test #4											
Run No.	Datum Day/Mon/Year	Time H/M/S	Fluence p/cm2	Transient Errors	X-section (cm2/dev)	Lingering Errors	X-section cm2/dev	SEL	X-section cm2/dev	Stop-Func.	X-section cm2/dev
4	04.08.99	00:05:05	19438,67	3	1,54E-04	4	2,06E-04	0	0	0	0
5	04.08.99	00:24:22	93178,13	13	1,40E-04	6	6,44E-05	0	0	1	1,07E-05
6	04.08.99	00:11:48	45123,20	7	1,55E-04	4	8,86E-05	0	0	1	2,22E-05
7	04.08.99	00:12:13	46716,53	6	1,28E-04	3	6,42E-05	0	0	1	2,14E-05
8	04.08.99	00:03:20	12746,67	6	4,71E-04	1	7,85E-05	0	0	0	0
9	04.08.99	00:08:24	32121,60	8	2,49E-04	3	9,34E-05	0	0	0	0
10	04.08.99	00:04:20	16570,67	1	6,03E-05	4	2,41E-04	0	0	0	0
11	04.08.99	00:26:55	102929,33	16	1,55E-04	6	5,83E-05	0	0	1	9,72E-06
12	04.08.99	00:03:21	12810,40	1	7,81E-05	0	0,00E+00	1	7,8E-05	0	0
subtotal first day		**01:39:48**	**381635,20**	**61**	**1,60E-04**	**31**	**8,12E-05**	**1**	**2,6E-06**	**4**	**1,05E-05**

Table 4: Device under test #4

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