Heavy ion Single Event Effects test of 8 bits ADC AD1175 from National Semiconductor

Test Report

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Table of Contents

1 INTRODUCTION 3

2 TESTED DEVICES 3

3 TEST DESCRIPTION 3

3.1 IRRADIATION FACILITY 3
3.2 TEST SET-UP 4

4 TEST RESULTS 4

5 CONCLUSIONS 8

1 Introduction

This report gives heavy ion SEE test data on the 8 bits ADC AD1175 from National Semiconductor. This work has been performed in the frame of the ST5 project.

2 Tested Devices

The tested devices are described in Table 1.

Type	**ADC1175CIJM**
Manufacturer	National Semiconductors
Function	8 bit, 20 MHz, 60 mW ADC
Package	SOIC 24
Technology	
Lot date code	1317
Package marking	EJ03AB ADC1175CIJM
Previous SEE testing	No data available

Table 1: description of the tested devices.

3 Test description

3.1 Irradiation facility

The tests have been performed at the Brookhaven National Laboratories, and on TEXAS A&M University cyclotron in March 2002. The ion beams used at BNL are described in Table 2. The ion beams used at TEXAS A&M are described in Table 3.

Ion	**Energy (MeV)**	**Average flux (#/cm^2-s)**	**Range (μm)**	**LET (MeVcm^2/mg)**
Cl-35	210	~2E+04	63	11.4
I-127	288	~5E+04	29	59.4
Br-79	280	~1E+04	36	37.2
Ni-58	266	~5E+04	42	26.6

Table 2: Ions used at BNL.

Ion	**Energy (MeV)**	**Average flux (#/cm^2-s)**	**Range (μm)**	**LET (MeVcm^2/mg)**
Ne	244	~2E+05	228	2.96
Ne	106	~8E+04	67	5
Ar	729	~3E+05	90	9.42
Ar	154	~2E+05	40	15
Kr	729	~1E+05	90	31.6

Table 3: Ions used at TEXAS A&M.

3.2 Test set-up

The National semiconductor ADC1175 evaluation board has been used for the SEE testing. This board operates the AD1175 from a single +5V supply at a 20 MHz clock. Before each irradiation, the device digital output is stored in a 8 bit register. Then, during the irradiation, the DUT output is compared to the register content. In case of difference, an error is counted. Input voltage during the experiment is 4.5V.

The evaluation board supply current is also monitored about every 10 ms during the irradiation. As soon as this current reaches a limit of 50 mA, the power supply is shutdown. The nominal power supply current of the board is about 16 mA at the 20 MHz clock frequency and the 5V power supply voltage.

4 Test results

Due to test set-up problems during the experiments, we have only performed a SEL characterization at BNL. SEL test results are presented in Table 4. The SEU tests have been performed at TEXAS A&M, test results are shown in Table 5.

run#	SN#	tilt	eff. LET ($MeVcm^2/mg$)	eff. Fluence ($ions/cm^2$)	SEL	Cross section SEL (cm^2)
283	1	0	11.44	5.00E+06	0	0.00E+00
284	1	60	22.88	5.00E+06	0	0.00E+00
285	1	60	118.78	5.00E+05	1	2.00E-06
286	1	60	118.78	6.20E+04	1	1.61E-05
287	1	60	118.78	8.20E+04	1	1.22E-05
288	1	60	118.78	1.01E+05	1	9.90E-06
289	1	60	118.78	3.36E+05	1	2.98E-06
290	1	60	118.78	2.45E+05	1	4.08E-06
291	1	60	118.78	2.00E+05	1	5.00E-06
292	1	0	59.39	1.17E+06	1	8.55E-07
293	1	0	59.39	1.13E+05	1	8.85E-06
294	1	0	59.39	6.20E+05	1	1.61E-06
295	1	0	59.39	3.60E+05	1	2.78E-06
296	1	0	59.39	2.75E+05	1	3.64E-06
297	1	0	59.39	6.30E+05	1	1.59E-06
298	1	0	59.39	3.00E+05	1	3.33E-06
299	1	0	37.29	3.50E+06	1	2.86E-07
300	1	0	37.29	5.00E+06	1	2.00E-07
301	1	0	37.29	1.23E+06	1	8.13E-07
302	1	0	26.55	1.00E+06	1	1.00E-06
303	1	0	26.55	1.30E+06	1	7.69E-07
304	1	0	26.55	1.00E+07	0	0.00E+00
305	1	0	26.55	1.00E+07	0	0.00E+00

Table 4: SEL test results

run#	dut#	tilt	LETeff ($MeVcm^2/mg$)	fluence_eff ($\#/cm^2$)	SEL	SEU	sigma SEL (cm^2/dev)	sigma SEU (cm^2/dev)
1	2	0	2.96	1.01E+07	0	247	0.00E+00	2.45E-05
2	2	0	2.96	1.01E+07	0	212	0.00E+00	2.10E-05
3	2	0	2.96	9.86E+06	0	214	0.00E+00	2.17E-05
4	2	0	2.96	1.01E+07	0	220	0.00E+00	2.18E-05
5	2	0	2.96	9.96E+06	0	236	0.00E+00	2.37E-05
6	2	30	3.42	1.00E+07	0	274	0.00E+00	2.73E-05
7	2	30	3.42	1.00E+07	0	274	0.00E+00	2.73E-05
8	2	30	3.42	9.96E+06	0	221	0.00E+00	2.22E-05
9	2	30	3.42	1.00E+07	0	236	0.00E+00	2.35E-05
10	2	30	3.42	1.01E+07	0	232	0.00E+00	2.29E-05
11	2	40	3.86	9.96E+06	0	285	0.00E+00	2.86E-05
12	2	40	3.86	9.88E+06	0	288	0.00E+00	2.91E-05
13	2	40	3.86	9.96E+06	0	299	0.00E+00	3.00E-05
14	2	40	3.86	9.96E+06	0	299	0.00E+00	3.00E-05
15	2	40	3.86	9.96E+06	0	286	0.00E+00	2.87E-05
16	2	50	4.60	1.00E+07	0	369	0.00E+00	3.68E-05
17	2	50	4.60	1.01E+07	0	368	0.00E+00	3.65E-05
18	2	50	4.60	9.96E+06	0	342	0.00E+00	3.43E-05
19	2	50	4.60	9.96E+06	0	372	0.00E+00	3.73E-05
20	2	50	4.60	9.96E+06	0	402	0.00E+00	4.03E-05
21	2	0	5.00	9.98E+06	0	449	0.00E+00	4.50E-05
22	2	0	5.00	9.98E+06	0	482	0.00E+00	4.83E-05
23	2	0	5.00	1.00E+07	0	422	0.00E+00	4.22E-05
24	2	40	6.53	1.00E+07	0	544	0.00E+00	5.42E-05
25	2	40	6.53	9.96E+06	0	603	0.00E+00	6.06E-05
26	2	40	6.53	1.00E+07	0	601	0.00E+00	5.99E-05
27	2	0	9.42	1.01E+07	0	752	0.00E+00	7.45E-05
28	2	0	9.42	1.01E+07	0	782	0.00E+00	7.74E-05
29	2	0	9.42	9.89E+06	0	738	0.00E+00	7.46E-05
30	2	30	10.88	9.96E+06	0	834	0.00E+00	8.37E-05
31	2	30	10.88	9.96E+06	0	838	0.00E+00	8.41E-05
32	2	30	10.88	9.96E+06	0	848	0.00E+00	8.51E-05
33	2	40	12.30	9.96E+06	0	972	0.00E+00	9.76E-05
34	2	40	12.30	1.00E+07	0	967	0.00E+00	9.64E-05
35	2	40	12.30	9.96E+06	0	955	0.00E+00	9.59E-05
36	2	50	14.65	1.00E+07	0	1174	0.00E+00	1.17E-04
37	2	50	14.65	9.96E+06	0	1178	0.00E+00	1.18E-04
38	2	50	14.65	1.00E+07	0	1138	0.00E+00	1.13E-04
39	2	0	15.00	9.92E+06	0	1207	0.00E+00	1.22E-04
40	2	0	15.00	9.90E+06	0	1209	0.00E+00	1.22E-04

Table 5: TEXAS A&M test results (1/2)

run#	dut#	tilt	LETeff ($MeVcm^2/mg$)	fluence_eff ($\#/cm^2$)	SEL	SEU	sigma SEL (cm^2/dev)	sigma SEU (cm^2/dev)
41	2	30	17.32	1.00E+07	0	1343	0.00E+00	1.34E-04
42	2	30	17.32	9.96E+06	0	1351	0.00E+00	1.36E-04
43	2	40	19.58	9.96E+06	0	1515	0.00E+00	1.52E-04
44	2	40	19.58	9.96E+06	0	1507	0.00E+00	1.51E-04
45	2	50	23.34	1.00E+07	0	1833	0.00E+00	1.83E-04
46	2	50	23.34	9.96E+06	0	1838	0.00E+00	1.84E-04
47	2	0	31.60	5.68E+06	1	981	1.76E-07	1.73E-04
48	2	0	31.60	8.28E+06	1	1640	1.21E-07	1.98E-04
49	2	0	31.60	1.08E+06	1	236	9.26E-07	2.19E-04
50	2	0	31.60	9.97E+06	0	2071	0.00E+00	2.08E-04
51	2	30	36.49	8.44E+06	1	2483	1.18E-07	2.94E-04
52	2	30	36.49	2.82E+06	1	860	3.54E-07	3.05E-04
53	2	30	36.49	8.26E+05	1	220	1.21E-06	2.66E-04
54	2	30	36.49	1.23E+06	1	365	8.13E-07	2.97E-04
55	2	40	41.25	1.00E+07	0	3717	0.00E+00	3.70E-04
56	2	40	41.25	2.87E+06	1	1071	3.48E-07	3.73E-04
57	2	40	41.25	6.60E+05	1	281	1.51E-06	4.26E-04
58	2	50	49.16	1.11E+05	1	34	9.04E-06	3.08E-04
59	2	50	49.16	1.91E+04	1	7	5.24E-05	3.67E-04
60	2	50	49.16	4.99E+06	1	2279	2.00E-07	4.56E-04
61	2	50	49.16	8.55E+05	1	398	1.17E-06	4.66E-04
62	2	50	49.16	9.96E+06	0	4489	0.00E+00	4.51E-04

Table 5: TEXAS A&M test results (2/2)

The device is not sensitive to SEL up to a LET of about 23 $MeVcm^2/mg$. The SEL cross section is about 4.6E-04 cm^2/device at the LET of 118 $MeVcm^2/mg$. The SEL cross section curve is shown in Figure 1. The latchup current is 86 mA.

A worst-case estimation of the SEL rate in the ST5 environment has been performed for conservative estimates of the part geometry (thickness of the sensitive volume = 2µm). The results are shown in Table 6.

	SEL rate/device day
GCR solar minimum	2.7E-7
Solar Particle Event worst day	2.8E-4

Table 6: SEL rates on ST5

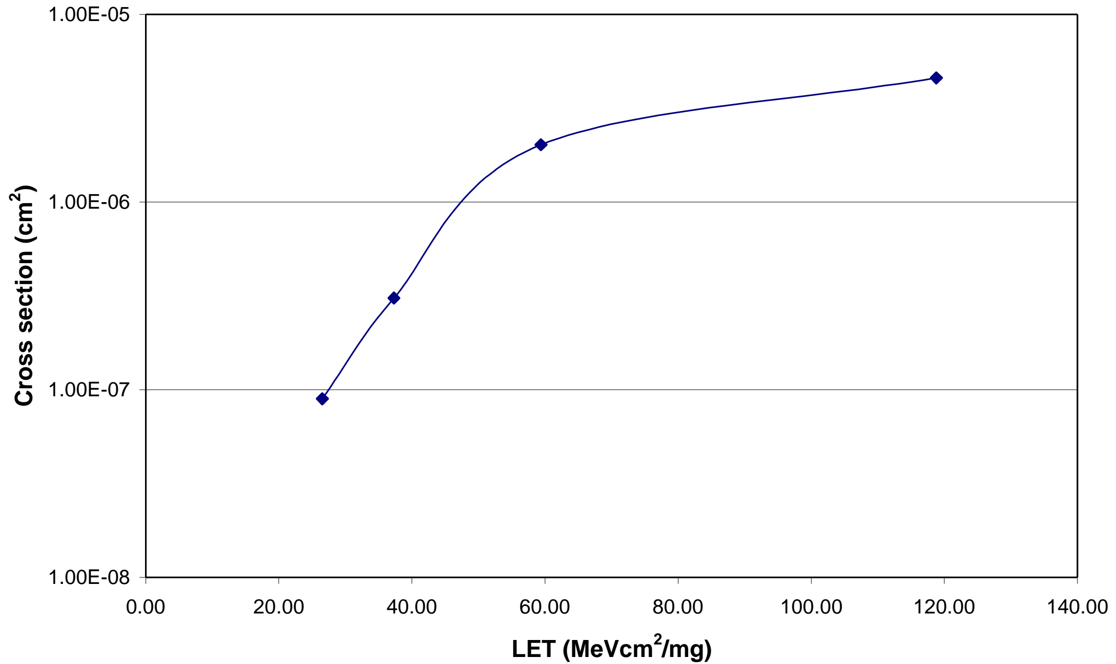

Figure 1: SEL cross section.

The device has a significant SEU/SET sensitivity with a LET threshold lower than 2 $MeVcm^2/mg$ and a device SEU/SET cross section of 4.5E-4 cm^2/device at a LET of 49 $MeVcm^2/mg$. The SEU/SET cross section curve is shown in Figure 2. With such a low LET threshold, a proton induced SEU/SET sensitivity is expected.

No SEFI has been observed during all the experiments.

A worst-case estimation of the SEU/SET rate in the ST5 environment has been performed for conservative estimates of the part geometry (1 sensitive volume of thickness = 2µm). The results are shown in Table 7.

	SEL rate/device day
GCR solar minimum	0.8
Solar Particle Event worst day	14

Table 7: SEU/SET rates on ST5

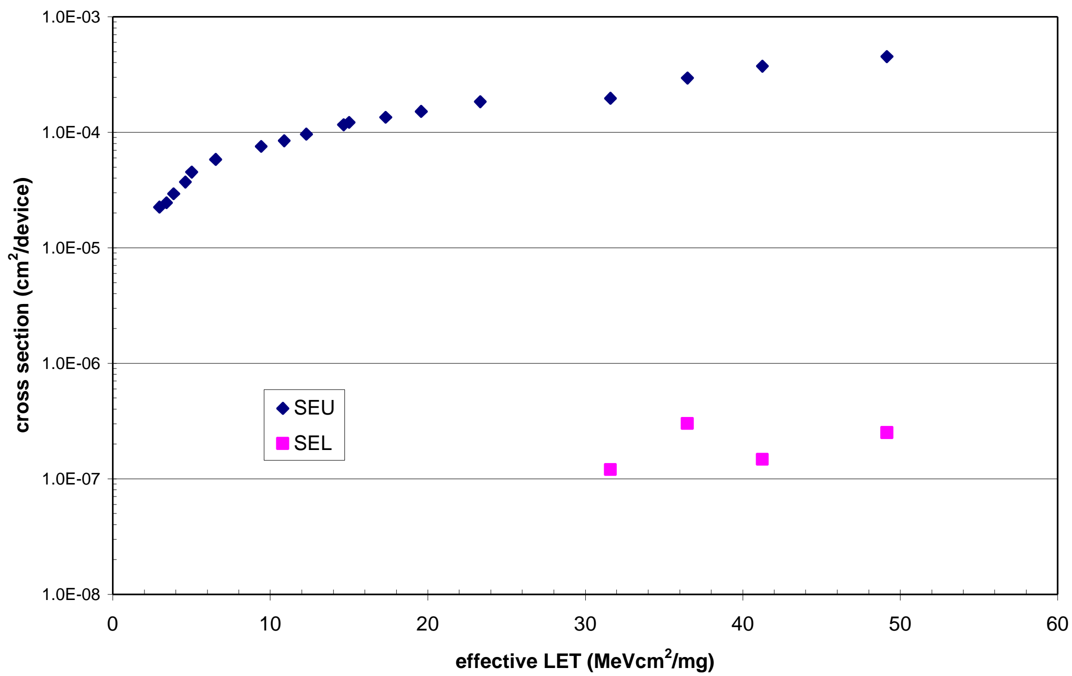

Figure 2: TEXAS A&M experiments, cross section curves

5 Conclusions

The test results show that the 8bits ADC ADC1175 is sensitive to SEL. This sensitivity is low, the SEL rate in the ST5 GCR environment is 2.9E-7 SEL/device-day. This event rate is quasi negligible for the three months ST5 mission. During a solar event the SEL is 2.8E-4 SEL/device-day. The risk is not negligible during a solar event and a SEL circumvention circuitry is recommended.

The results show a significant SEU/SET sensitivity. Because of the low SEU LET threshold, proton induced SEU sensitivity is also expected. About 1 SEU or SET/day is expected during the 3 months ST5 mission. Around 10 SEUs or SETs are also expected during a Solar Event. This should not be a concern if the application is able to filter out these erroneous data words.