Heavy ion Single Event Effects test of
8 bits ADC AD7821 from Analog Devices
12 bits ADC AD9223 from Analog Devices
12 bits ADC LTC1272 from Linear Technology

Test Report

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1 Introduction

This report gives heavy ion SEE test data on three Analog to Digital Converters (ADC). This work has been performed in the frame of the ST5 project.

2 Tested Devices

The tested devices are described in Table 1.

Type	**AD7821TQ**	**AD9223AR**	**LTC1272-3ACSW**
Manufacturer	Analog Devices	Analog Devices	Linear Technology
Function	1 MSPS 8 bits ADC w track&hold	3 MSPS 12 bits ADC	250 KHz 12 bits ADC
Package	20 lead DIL	28 lead SOIC	24 lead SOL
Technology	LC2MOS	High speed CMOS	LT BiCMOS
Date code	0034	0015	0018
Package marking	Top: AD7821TQ 0034 I47103 Bottom: C63050M Philippines	AD9223AR 0015 I10602	LT 0018 LTC1272-3ACSW N10883
Previous SEE testing	No data	No SEL at 11.4 MeVcm^2/mg, SEL at 14 MeVcm^2/mg (Cross section=1E-6 cm2/device) [Hopkinson, IEEE NSREC 2000 dataworkshop]. No SEU data.	No data

Table 1: description of the tested devices.

3 Test description

3.1 Irradiation facility

The tests have been performed at TEXAS A&M in August 2001. The ion beams used are described in Table 2. Irradiation has been performed in Air. The distance of Air between the beam output and the Device Under Test is 3 cm. The LET and range values given in Table 2 are the LET and range on the device after 3 cm of Air and the 25.4 µm Aramica window.

Ion	**Energy (MeV/u)**	**Range (mm)**	**LET (MeVcm^2/mg)**
Ne	24.8	762	1.8
Ar	25	464	5.6
Kr	25	300	20.2
Xe	24.8	250	39.8

Table 2: Ions used at TEXAS A&M.

3.2 Test set-up

The test method used is the golden chip. The same input signal is sent to the Device Under Test (DUT) and a reference device that is not irradiated. The outputs of the these two devices are compared. The errors are counted and recorded. The test set-up allows dissociating the errors that occur in the 4 Most Significant Bits (MSB), the 4 medium bits and the 4 Least Significant Bits (LSB).
The power supply is +5/0 V. The sampling rate used during the tests is 250 KHz.
Due to noise problems during the experiments on site, only static input signals have been applied and only the 7 MSB have been tested for each device.

4 Test results

4.1 AD7821

The test results are shown in Table 3.

run#	dut#	Vin (V)	Ion	Angle	Eff LET (MeVcm2/mg)	eff. Fluence (#/cm2)	time (s)	SEL	SEU high DB7 to DB4	SEU low DB3,DB2,DB1	SEU total	Cross Section SEU (cm2)
1	1	1	Ne	0	1.8	1.00E+06	187	0	0	1	**1**	1.00E-06
2	1	1	Ne	60	3.6	1.00E+06	309	0	0	1	**1**	1.00E-06
3	1	1	Ne	60	3.6	1.18E5	46	0	0	0	**0**	0.00E+00
4	1	4.5	Ne	60	3.6	1.00E+06	373	0	1	3	**4**	4.00E-06
5	1	0.5	Ne	60	3.6	1.00E+06	447	0	0	0	**0**	0.00E+00
6	1	4.5	Ne	60	3.6	1.00E+06	475	0	0	2	**2**	2.00E-06
7	2	4.5	Ne	60	3.6	1.00E+06	523	0	0	0	**0**	0.00E+00
73	1	0.5	Ar	0	5.6	1.00E+06	39	0	13	5	**18**	1.80E-05
74	1	0.5	Ar	0	5.6	1.00E+06	38	0	4	4	**8**	8.00E-06
75	1	2.5	Ar	0	5.6	1.00E+06	36	0	2	5	**7**	7.00E-06
76	1	2.5	Ar	0	5.6	1.00E+06	36	0	9	1	**10**	1.00E-05
77	1	2.5	Ar	60	11.2	1.00E+06	66	0	34	10	**44**	4.40E-05
78	1	0.5	Ar	60	11.2	1.00E+06	62	0	31	20	**51**	5.10E-05
79	1	4.5	Ar	60	11.2	1.00E+06	69	0	41	4	**45**	4.50E-05
80	2	4.5	Ar	0	5.6	1.00E+06	34	0	9	2	**11**	1.10E-05
81	2	2.5	Ar	0	5.6	1.00E+06	31	0	4	0	**4**	4.00E-06
82	2	0.5	Ar	0	5.6	1.00E+06	32	0	4	2	**6**	6.00E-06
83	2	0.5	Ar	60	11.2	1.00E+06	62	0	45	18	**63**	6.30E-05
84	2	0.5	Ar	60	11.2	1.00E+06	68	0	47	18	**65**	6.50E-05
85	2	2.5	Ar	60	11.2	1.00E+06	63	0	42	0	**42**	4.20E-05
86	2	4.5	Ar	60	11.2	1.00E+06	58	0	43	5	**48**	4.80E-05
87	2	4.5	Ar	45	7.9	1.00E+06	45	0	25	2	**27**	2.70E-05
88	2	2.5	Ar	45	7.9	1.00E+06	45	0	34	1	**35**	3.50E-05
89	2	0.5	Ar	45	7.9	1.00E+06	43	0	29	12	**41**	4.10E-05

Table 3: AD7821 test results, 1/2.

run#	dut#	Vin (V)	Ion	Angle	Eff LET (MeVcm2/mg)	eff. Fluence (#/cm2)	time (s)	SEL	SEU high DB7 to DB4	SEU low DB3,DB2,DB1	SEU total	Cross Section SEU (cm2/dev)
90	1	0.5	Kr	0	20.0	5.00E+05	137	0	47	22	**69**	1.38E-04
91	1	2.5	Kr	0	20.0	5.00E+05	143	0	57	7	**64**	1.28E-04
92	1	4.5	Kr	0	20.0	5.00E+05	143	0	55	5	**60**	1.20E-04
93	1	4.5	Kr	45	28.3	5.00E+05	92	0	59	9	**68**	1.36E-04
94	1	2.5	Kr	45	28.3	5.00E+05	107	0	67	13	**80**	1.60E-04
95	1	0.5	Kr	45	28.3	5.00E+05	109	0	86	33	**119**	2.38E-04
96	1	0.5	Kr	60	40.0	5.00E+05	168	0	81	24	**105**	2.10E-04
97	1	2.5	Kr	60	40.0	5.00E+05	169	0	91	16	**107**	2.14E-04
98	1	4.5	Kr	60	40.0	5.00E+05	182	0	85	20	**105**	2.10E-04
99	2	4.5	Kr	0	20.0	5.00E+05	82	0	50	7	**57**	1.14E-04
100	2	2.5	Kr	0	20.0	5.00E+05	79	0	61	2	**63**	1.26E-04
101	2	0.5	Kr	0	20.0	5.00E+05	76	0	50	5	**55**	1.10E-04
102	2	0.5	Kr	45	28.3	5.00E+05	124	0	99	13	**112**	2.24E-04
103	2	2.5	Kr	45	28.3	5.00E+05	124	0	66	5	**71**	1.42E-04
104	2	4.5	Kr	45	28.3	5.00E+05	126	0	72	10	**82**	1.64E-04
105	2	4.5	Kr	60	40.0	5.00E+05	187	0	93	17	**110**	2.20E-04
106	2	2.5	Kr	60	40.0	5.00E+05	190	0	93	15	**108**	2.16E-04
107	2	0.5	Kr	60	40.0	5.00E+05	96	0	103	46	**149**	2.98E-04
147	1	4.5	Xe	0	39.8	5.00E+05	38	0	86	16	**102**	2.04E-04
148	1	4.5	Xe	0	39.8	5.00E+05	42	0	87	16	**103**	2.06E-04
149	1	2.5	Xe	0	39.8	1.00E+06	86	0	166	39	**205**	2.05E-04
150	1	0.5	Xe	0	39.8	1.00E+06	86	0	180	37	**217**	2.17E-04
151	1	0.5	Xe	45	56.3	1.00E+06	127	0	233	57	**290**	2.90E-04
152	1	2.5	Xe	45	56.3	1.00E+06	116	0	264	64	**328**	3.28E-04
153	1	4.5	Xe	45	56.3	1.00E+06	113	0	244	51	**295**	2.95E-04
154	1	4.5	Xe	60	79.6	1.00E+06	174	0	248	79	**327**	3.27E-04
155	1	0.5	Xe	60	79.6	1.00E+06	172	0	238	84	**322**	3.22E-04
156	1	2.5	Xe	60	79.6	1.00E+06	160	0	269	72	**341**	3.41E-04
157	2	2.5	Xe	60	79.6	1.00E+06	153	0	305	93	**398**	3.98E-04
158	2	4.5	Xe	60	79.6	1.00E+06	146	0	269	86	**355**	3.55E-04
159	2	0.5	Xe	60	79.6	1.00E+06	152	0	332	73	**405**	4.05E-04
160	2	0.5	Xe	0	39.8	1.00E+06	80	0	192	27	**219**	2.19E-04
161	2	2.5	Xe	0	39.8	1.00E+06	80	0	192	41	**233**	2.33E-04
162	2	4.5	Xe	0	39.8	1.00E+06	89	0	160	44	**204**	2.04E-04
163	2	4.5	Xe	45	56.3	1.00E+06	128	0	234	43	**277**	2.77E-04
164	2	2.5	Xe	45	56.3	1.00E+06	108	0	223	59	**282**	2.82E-04
165	2	0.5	Xe	45	56.3	1.00E+06	118	0	233	60	**293**	2.93E-04

Table 3: AD7821 test results, 2/2.

The device tested did not exhibit SEL sensitivity up to a the maximum tested LET of 79.6 MeVcm^2/mg.

The input voltage value does not have any effect on the device SEU sensitivity.

The LET threshold of the 4 Most Significant Bits (MSBs) and the 3 Least Significant Bits (LSBs) is the same, but the SEU sensitivity of the MSBs is significantly more important than the sensitivity of the LSBs (ratio >2).

The total SEU cross section curve for the 7 tested bits is shown in Figure 1.

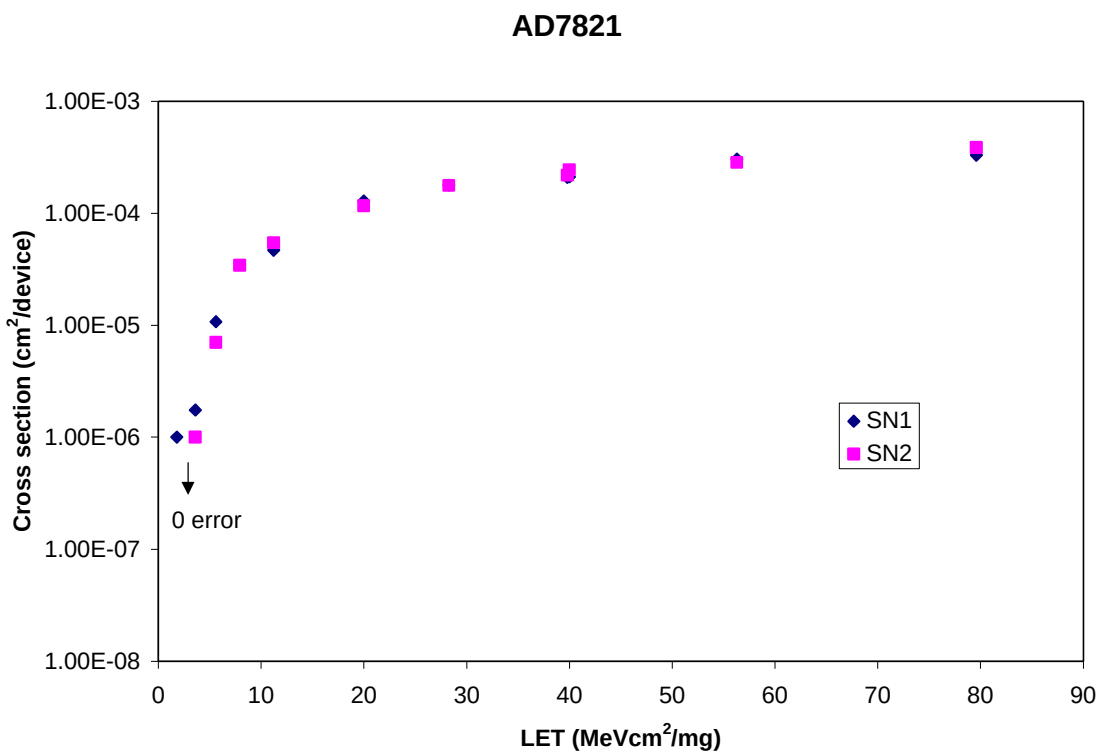

Figure 1: AD7821, SEU cross section curve.

4.2 AD9223

The test results are presented in Table 4.

run#	dut#	Vin (V)	Ion	Angle	Eff LET (MeVcm^2/mg)	Fluence (#/cm^2)	Time (s)	SEL	SEU high BIT1 to 4	SEU medium BIT 5,6,7	SEU total	Cross Section SEL (cm^2/dev)	Cross Section SEU (cm^2/dev)
8	1	2.5	Ne	0	1.8	1.00E+06	217	0	0	0	0	0.00E+00	0.00E+00
9	1	4.5	Ne	0	1.8	1.00E+06	23	0	0	1	1	0.00E+00	1.00E-06
10	1	2.5	Ne	60	3.6	1.00E+06	46	0	0	1	1	0.00E+00	1.00E-06
11	1	4.5	Ne	60	3.6	1.00E+06	47	0	0	0	0	0.00E+00	0.00E+00
12	2	2.5	Ne	60	3.6	1.00E+06	51	0	0	1	1	0.00E+00	1.00E-06
13	2	4.5	Ne	60	3.6	1.00E+06	48	0	0	1	1	0.00E+00	1.00E-06
64	1	4.5	Ar	0	5.6	1.00E+06	100	0	0	3	3	0.00E+00	3.00E-06
65	1	2.5	Ar	0	5.6	1.00E+06	100	0	0	3	3	0.00E+00	3.00E-06
66	1	0.5	Ar	0	5.6	1.00E+06	95	0	0	4	4	0.00E+00	4.00E-06
67	1	0.5	Ar	60	11.2	1.00E+06	175	0	0	19	19	0.00E+00	1.90E-05
68	1	2.5	Ar	60	11.2	1.00E+06	180	0	1	16	17	0.00E+00	1.70E-05
69	1	4.5	Ar	60	11.2	8.17E+05	144	0	1	14	15	0.00E+00	1.84E-05
70	2	4.5	Ar	60	11.2	1.00E+06	176	0	1	13	14	0.00E+00	1.40E-05
71	2	2.5	Ar	60	11.2	1.00E+06	69	0	0	19	19	0.00E+00	1.90E-05
72	2	0.5	Ar	60	11.2	1.00E+06	67	0	1	19	20	0.00E+00	2.00E-05
108	1	0.5	Kr	0	20.0	4.00E+05	46	1	1	13	14	2.50E-06	3.50E-05
109	1	0.5	Kr	0	20.0	2.59E5	30	1	1	12	13	3.86E-06	5.02E-05
110	1	0.5	Kr	0	20.0	5.00E+05	55	0	9	30	39	0.00E+00	7.80E-05
111	1	2.5	Kr	0	20.0	4.00E+05	44	1	1	22	23	2.50E-06	5.75E-05
112	1	2.5	Kr	0	20.0	3.00E+05	39	1	3	24	27	3.33E-06	9.00E-05
113	1	2.5	Kr	0	20.0	5.00E+05	51	0	1	20	21	0.00E+00	4.20E-05
114	1	4.5	Kr	0	20.0	5.00E+05	50	0	2	26	28	0.00E+00	5.60E-05
115	1	4.5	Kr	0	20.0	5.00E+05	52	0	7	30	37	0.00E+00	7.40E-05
116	1	4.5	Kr	45	28.3	2.30E+04	3	1	0	4	4	4.35E-05	1.74E-04
117	1	4.5	Kr	45	28.3	4.20E+05	55	1	8	30	38	2.38E-06	9.05E-05
118	1	4.5	Kr	45	28.3	5.00E+05	65	0	5	40	45	0.00E+00	9.00E-05
119	1	2.5	Kr	45	28.3	9.70E+04	12	1	3	1	4	1.03E-05	4.12E-05
120	1	2.5	Kr	45	28.3	4.70E+05	57	1	1	27	28	2.13E-06	5.96E-05
121	1	0.5	Kr	45	28.3	3.40E+04	4	1	0	7	7	2.94E-05	2.06E-04
122	1	0.5	Kr	45	28.3	3.40E+04	4	1	1	0	1	2.94E-05	2.94E-05
123	1	0.5	Kr	45	28.3	4.40E+05	56	1	5	29	34	2.27E-06	7.73E-05
124	1	0.5	Kr	60	40.0	2.00E+05	31	1	2	27	29	5.00E-06	1.45E-04
125	1	0.5	Kr	60	40.0	3.00E+04	6	1	1	7	8	3.33E-05	2.67E-04
126	1	0.5	Kr	60	40.0	1.90E+05	28	1	1	18	19	5.26E-06	1.00E-04
127	1	0.5	Kr	60	40.0	4.50E+04	6	1	0	3	3	2.22E-05	6.67E-05
128	1	2.5	Kr	60	40.0	6.00E+03	1	1	0	0	0	1.67E-04	0.00E+00
129	1	2.5	Kr	60	40.0	5.00E+03	1	1	0	2	2	2.00E-04	4.00E-04
130	1	4.5	Kr	60	40.0	8.60E+03	1	1	0	1	1	1.16E-04	1.16E-04
131	1	4.5	Kr	60	40.0	2.20E+03	0	1	0	0	0	4.55E-04	0.00E+00
132	2	4.5	Kr	0	20.0	5.00E+05	29	0	2	22	24	0.00E+00	4.80E-05
133	2	2.5	Kr	0	20.0	1.60E+05	9	1	0	8	8	6.25E-06	5.00E-05
134	2	2.5	Kr	0	20.0	5.00E+05	27	0	2	38	40	0.00E+00	8.00E-05
135	2	0.5	Kr	0	20.0	5.00E+05	25	0	2	25	27	0.00E+00	5.40E-05
136	2	0.5	Kr	0	20.0	1.80E+05	9	1	2	8	10	5.56E-06	5.56E-05

Table 4: AD9223 test results (1/2)

run#	dut#	Vin (V)	Ion	Angle	Eff LET ($MeVcm^2/mg$)	Fluence ($\#/cm^2$)	Time (s)	SEL	SEU high BIT1 to 4	SEU med BIT 5,6,7	SEU total	Cross Section SEL (cm^2/dev)	Cross Section SEU (cm^2/dev)
168	1	0.5	Xe	0	39.8	1.16E+04	8	1	0	1	1	8.62E-05	8.62E-05
169	1	0.5	Xe	0	39.8	5.30E+04	36	1	2	8	10	1.89E-05	1.89E-04
170	1	0.5	Xe	0	39.8	6.16E+04	43	1	0	9	9	1.62E-05	1.46E-04
172	1	2.5	Xe	0	39.8	3.29E+04	24	1	0	5	5	3.04E-05	1.52E-04
173	1	2.5	Xe	0	39.8	1.61E+04	14	1	0	3	3	6.21E-05	1.86E-04
174	1	2.5	Xe	0	39.8	8.00E+04	70	1	3	10	13	1.25E-05	1.63E-04
175	1	4.5	Xe	0	39.8	1.16E+04	9	1	0	1	1	8.62E-05	8.62E-05
176	1	4.5	Xe	0	39.8	7.50E+04	64	1	0	12	12	1.33E-05	1.60E-04
177	1	4.5	Xe	0	39.8	3.70E+04	34	1	1	2	3	2.70E-05	8.11E-05
180	2	4.5	Xe	0	39.8	7.90E+03	6	1	0	1	1	1.27E-04	1.27E-04
181	2	4.5	Xe	0	39.8	9.40E+03	8	1	0	0	0	1.06E-04	0.00E+00
182	2	4.5	Xe	0	39.8	5.58E+04	48	1	0	9	9	1.79E-05	1.61E-04
183	2	2.5	Xe	0	39.8	1.06E+04	9	1	0	1	1	9.43E-05	9.43E-05
184	2	2.5	Xe	0	39.8	2.67E+04	23	1	0	0	0	3.75E-05	0.00E+00
185	2	2.5	Xe	0	39.8	1.02E+04	9	1	0	2	2	9.80E-05	1.96E-04
186	2	2.5	Xe	0	39.8	1.75E+04	16	1	0	0	0	5.71E-05	0.00E+00
188	2	0.5	Xe	0	39.8	4.18E+02	0	1	0	0	0	2.39E-03	0.00E+00
189	2	0.5	Xe	0	39.8	3.27E+04	34	1	0	2	2	3.06E-05	6.12E-05
190	2	0.5	Xe	0	39.8	1.13E+04	12	1	0	0	0	8.85E-05	0.00E+00
191	2	0.5	Xe	0	39.8	1.03E+04	11	1	0	1	1	9.71E-05	9.71E-05
192	2	0.5	Xe	0	39.8	1.34E+04	14	1	0	0	0	7.46E-05	0.00E+00

Table 4: AD9223 test results (2/2).

The device tested did not exhibit SEL up to a LET of 11.4 $MeVcm^2/mg$, then it is sensitive to SEL at the LET of 20 $MeVcm^2/mg$..

The input voltage value does not have any effect on the device SEU sensitivity or the device SEL sensitivity. At the maximum LET (40 $MeVcm^2/mg$), the SEL cross section is about 6E-5 $cm^2/device$.

The SEU sensitivity of the 4 MSBs is very low. The LET threshold is about 11.2 $MeVcm^2/mg$ and only a few SEU have been observed. The LET threshold of the 3 medium bits (bits 5,6,7) is about 1.8 $MeVcm^2/mg$ and the SEU sensitivity of the three medium bits (bits 5,6,7) dominate the SEU response of the 7 tested bits. We could expect a higher sensitivity of the 5 LSBs that have not been tested.

The SEL cross section curve and the total SEU cross section curve for the 7 tested bits are shown in Figure 2.

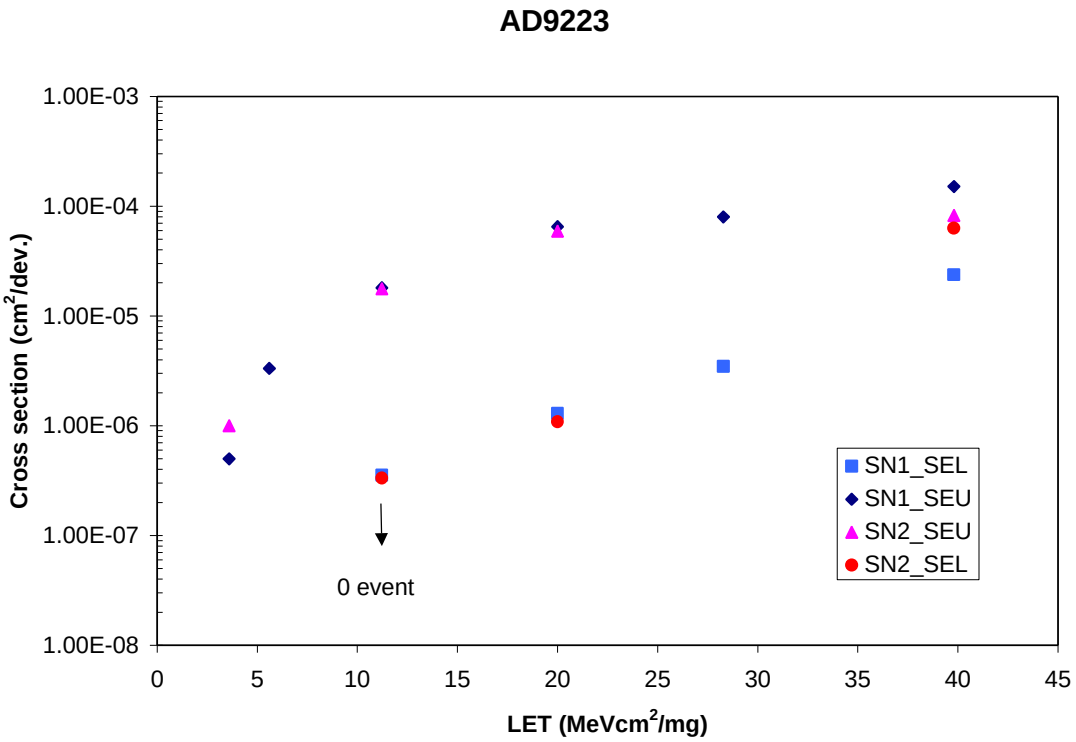

Figure 2: AD9223 SEL&SEU cross section curves.

4.3 LTC1272

The test results are presented in Table 5.

run#	dut#	Vin (V)	Ion	Angle	Eff LET (MeVcm^2/mg)	Fluence (#/cm^2)	time (s)	SEL	SEU high D11 to D8	SEU med D7,D6,D5	SEU total	Cross Section SEL (cm^2/dev)	Cross Section SEU (cm2/dev)
14	1	2.5V	Ne	0	1.8	1.00E+06	27	0	0	157	157	0.00E+00	1.57E-04
16	1	2.5V	Ne	0	1.8	1.00E+06	182	0	0	163	163	0.00E+00	1.63E-04
18	1	4.5	Ne	0	1.8	1.00E+06	195	0	0	275	275	0.00E+00	2.75E-04
19	1	0.5	Ne	0	1.8	1.00E+06	211	0	0	25	25	0.00E+00	2.50E-05
20	1	0.5	Ne	60	3.6	1.00E+06	510	0	1	58	59	0.00E+00	5.90E-05
21	1	2.5	Ne	60	3.6	1.00E+06	145	0	0	214	214	0.00E+00	2.14E-04
23	1	4.5	Ne	60	3.6	1.00E+06	150	0	1	564	565	0.00E+00	5.65E-04
24	3	4.5	Ne	0	1.8	1.00E+06	62	0	0	315	315	0.00E+00	3.15E-04
25	3	2.5	Ne	0	1.8	1.00E+06	63	0	0	96	96	0.00E+00	9.60E-05
26	3	0.5	Ne	0	1.8	1.00E+06	65	0	0	25	25	0.00E+00	2.50E-05
27	3	0.5	Ne	60	3.6	1.00E+06	146	0	0	63	63	0.00E+00	6.30E-05
29	3	2.5	Ne	60	3.6	1.00E+06	169	0	0	376	376	0.00E+00	3.76E-04
30	3	4.5	Ne	0	1.8	1.00E+06	177	0	2	766	768	0.00E+00	7.68E-04

Table 5: LTC1272 test results (1/2).

run#	dut#	Vin (V)	Ion	Angle	Eff LET (MeVcm2/mg)	Fluence (#/cm2)	time (s)	SEL	SEU high D11 to D8	SEU med D7,D6,D5	SEU total	Cross Section SEL (cm2/dev)	Cross Section SEU (cm2/dev)
31	3	4.5	Ar	0	5.6	1.03E+05	26	1	0	79	79	9.71E-06	7.67E-04
32	3	4.5	Ar	0	5.6	8.00E+04	20	1	2	97	99	1.25E-05	1.24E-03
33	3	4.5	Ar	0	5.6	1.00E+06	281	0	13	1063	1076	0.00E+00	1.08E-03
34	3	2.5	Ar	0	5.6	4.58E+05	142	1	1	148	149	2.18E-06	3.25E-04
35	3	2.5	Ar	0	5.6	2.55E5	83	1	0	101	101	3.92E-06	3.96E-04
36	3	0.5	Ar	0	5.6	4.07E+05	126	1	0	76	76	2.46E-06	1.87E-04
37	1	0.5	Ar	45	7.9	7.50E+04	25	1	0	24	24	1.33E-05	3.20E-04
38	3	0.5	Ar	45	7.9	9.78E+03	4	1	0	2	2	1.02E-04	2.04E-04
39	3	2.5	Ar	45	7.9	7.13E4	27	1	0	43	43	1.40E-05	6.03E-04
40	3	2.5	Ar	45	7.9	5.07E+03	2	1	0	10	10	1.97E-04	1.97E-03
41	3	4.5	Ar	45	7.9	3.16E+04	12	1	0	56	56	3.16E-05	1.77E-03
42	3	4.5	Ar	45	7.9	1.86E+05	65	1	2	301	303	5.38E-06	1.63E-03
43	3	4.5	Ar	60	11.2	2.47E+04	12	1	2	33	35	4.05E-05	1.42E-03
44	3	4.5	Ar	60	11.2	3.62E+03	2	1	0	26	26	2.76E-04	7.18E-03
45	3	2.5	Ar	60	11.2	4.30E+03	2	1	0	6	6	2.33E-04	1.40E-03
46	3	2.5	Ar	60	11.2	1.53E+04	7	1	0	6	6	6.54E-05	3.92E-04
47	3	0.5	Ar	60	11.2	1.80E+04	9	1	0	11	11	5.56E-05	6.11E-04
48	3	0.5	Ar	60	11.2	1.93E+04	9	0	0	13	13	0.00E+00	6.74E-04
49	3	0.5	Ar	60	11.2	1.81E+04	8	1	1	8	9	5.52E-05	4.97E-04
50	1	0.5	Ar	60	11.2	7.37E+02	0	1	0	0	0	1.36E-03	0.00E+00
51	1	0.5	Ar	60	11.2	0.00E+00	0	1	1	1	2		
52	1	0.5	Ar	60	11.2	4.54E+04	24	1	0	22	22	2.20E-05	4.85E-04
53	1	2.5	Ar	60	11.2	1.85E+05	44	1	0	5	5	5.41E-06	2.70E-05
54	1	2.5	Ar	60	11.2	1.19E+04	6	1	0	9	9	8.40E-05	7.56E-04
55	1	2.5	Ar	60	11.2	3.09E+04	16	1	0	22	22	3.24E-05	7.12E-04
56	1	4.5	Ar	60	11.2	1.98E+04	10	1	1	21	22	5.05E-05	1.11E-03
57	1	4.5	Ar	60	11.2	3.18E+04	18	1	3	42	45	3.14E-05	1.42E-03
58	1	4.5	Ar	0	5.6	2.59E+05	73	1	1	172	173	3.86E-06	6.68E-04
59	1	4.5	Ar	0	5.6	1.72E+05	46	1	2	102	104	5.81E-06	6.05E-04
60	1	2.5	Ar	0	5.6	2.34E+05	63	1	0	71	71	4.27E-06	3.03E-04
62	1	0.5	Ar	0	5.6	3.90E+04	10	1	2	8	10	2.56E-05	2.56E-04
63	1	0.5	Ar	0	5.6	1.19E+05	29	1	0	24	24	8.40E-06	2.02E-04
137	1	0.5	Kr	0	20.0	5.60E+04	2	1	0	0	0	1.79E-05	0.00E+00
138	1	0.5	Kr	0	20.0	1.30E+04	0	1	0	0	0	7.69E-05	0.00E+00
139	1	0.5	Kr	0	20.0	9.40E+03	0	1	0	0	0	1.06E-04	0.00E+00
140	1	2.5	Kr	0	20.0	6.00E+04	2	1	0	0	0	1.67E-05	0.00E+00
141	1	2.5	Kr	0	20.0	9.60E+03	0	1	0	0	0	1.04E-04	0.00E+00
142	1	4.5	Kr	0	20.0	9.70E+03	0	1	0	0	0	1.03E-04	0.00E+00
143	1	4.5	Kr	0	20.0	0.00E+00	0	1	0	0	0		
144	3	4.5	Kr	0	20.0	1.6E4	0	1	0	0	0	6.25E-05	0.00E+00
145	3	2.5	Kr	0	20.0	1.5E4	0	1	0	0	0	6.67E-05	0.00E+00
146	3	0.5	Kr	0	20.0	0.00E+00	0	1	0	0	0		

Table 5: LTC1272 test results (2/2).

The device tested is very sensitive to SEL, the SEL LET threshold is lower than 5.6 MeVcm^2/mg and the cross section at the maximum tested LET is 1E-4 cm^2/device. The SEL cross section curve is shown in Figure 3.

The SEU sensitivity of the 3 medium bits tested dominates the SEU response of the 7 tested bits. The LET threshold of the 4 MSBs is about 4 MeVcm^2/mg and the number of errors is low. The LET threshold of the 3 medium bits (bits 5,6,7) is less than 1.8 MeVcm^2/mg and the number of errors is very high. We could expect a higher sensitivity of the 5 LSBs that have not been tested.

The input voltage value does have an effect on the device SEU sensitivity but has no significant effect on the device SEL sensitivity. Higher is the input voltage, higher the SEU sensitivity is.

The total SEU cross section curve for the 7 tested bits is shown in Figure 4.

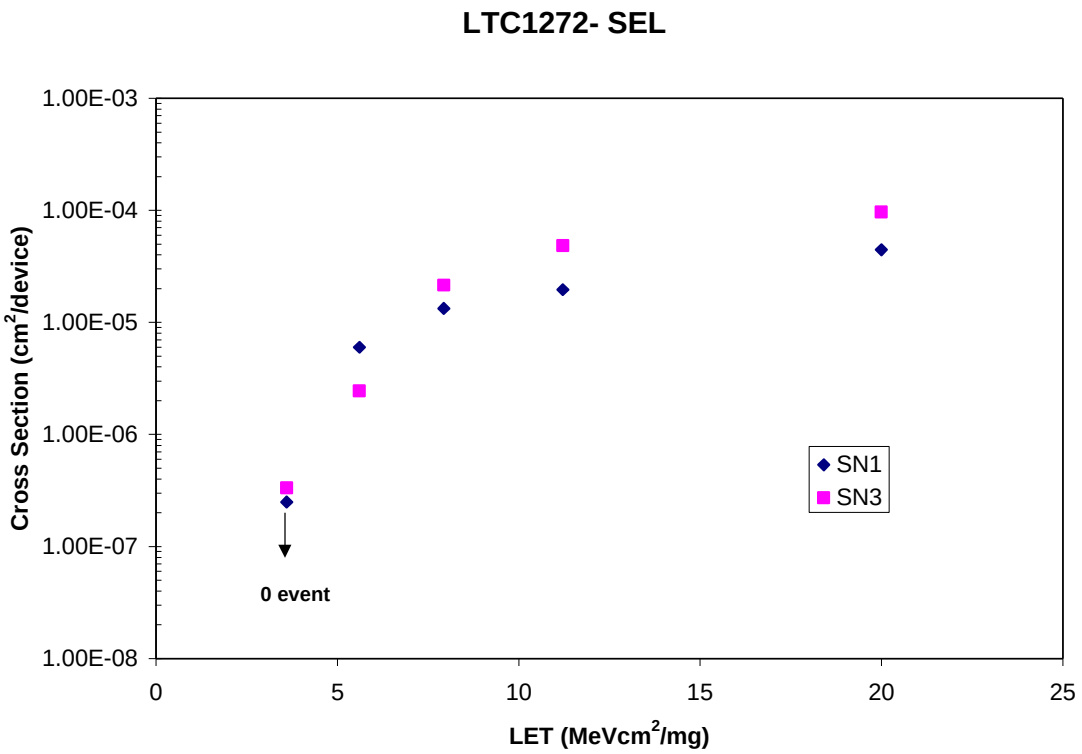

Figure 3: LTC1272 SEL cross-section.

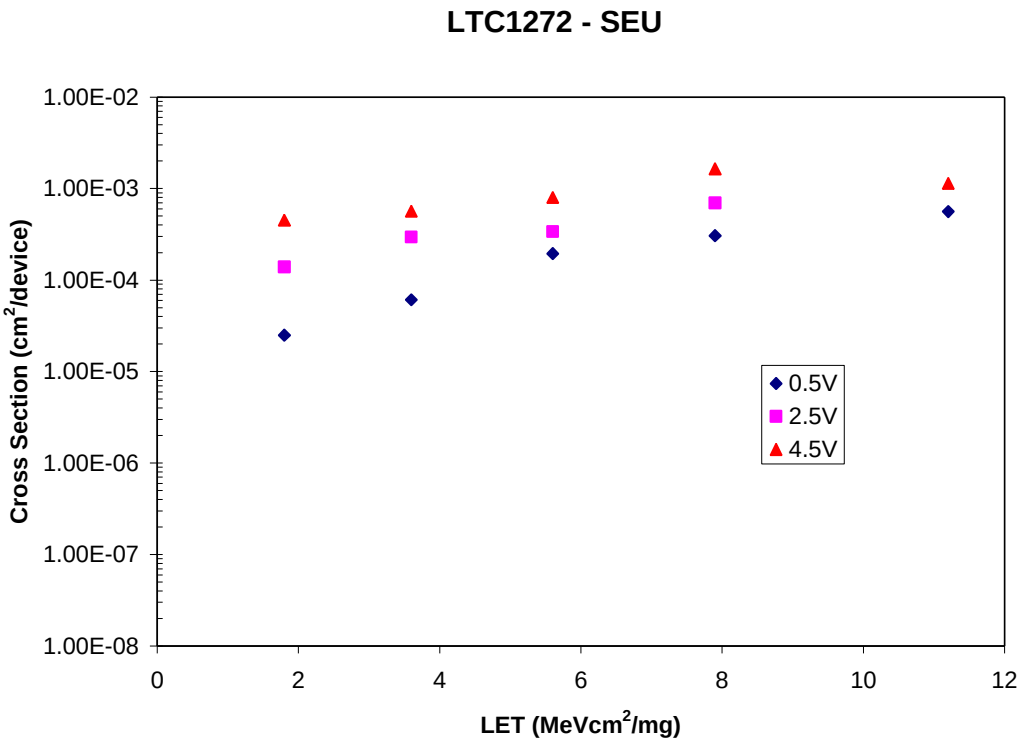

Figure 4: LTC1272 SEU cross section.

5 Conclusions

The test results show that the 8 bits ADC AD7821 is the less SEE sensitive of the 3 tested devices. The AD7821 is not sensitive to SEL up the maximum tested LET of 80 MeVcm^2/mg. The SEU LET threshold is about 4 MeVcm^2/mg and the cross section at the maximum tested LET is about 4E-4 cm^2 for the 7 tested bits.

The heavy ion induced upset rates in the ST5 environment are shown in Table 6. For the 3 months ST5 mission, the number of SEU induced by the GCR will be negligible. During one large solar event, one upset could be observed.

Because of the low heavy ion LET threshold, this device should be sensitive to proton induced SEUs. As the ST5 proton environment is very harsh, we should expect proton induced SEUs on the AD7821 during the ST5 mission. A proton SEU characterization is necessary to quantify the number of these proton induced SEUs.

	Number of upsets/device-day
GCRs- CRÈME96 solar minimum	6E-4
Solar heavy ions, CRÈME 96 worst day	1.4

Table 6: AD7821 upset rate in the ST5 heavy ion environment.