



SINGLE EVENT EFFECTS RADIATION TEST REPORT

Part Type : K6R4008V1C

Package : 36-SOJ

512Kx8 Bit High Speed Static RAM(3V3 Operating)

Manufacturer : Samsung

Report Reference : ESA_QCA0103S_C

Issue : 01



Date : January 19th, 2001

ESA Contract no. 13528/99/NL/MV CCN N°3 dated 24/11/00

European Space Agency Contract Report

The work described in this report was done under ESA contract.
Responsibility for the contents resides in the author or organization that prepared it

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HIREX Engineering	Single Event Effects Radiation Test Report		Ref : HRX/SEE/0029 Issue : 01
Part Type :	K6R4008V1C	Manufacturer :	Samsung

**SINGLE EVENT EFFECTS RADIATION TEST REPORT
on 512Kx8 Bit High Speed Static RAM(3V3 Operating) ,
K6R4008V1C,
from Samsung**

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1 Abstract

Under ESA Contract no. 13528/99/NL/MV CCN N°3 dated 24/11/00, covering "Radiation Evaluation of COTS semiconductor Components", four different commercially available 4Mb Static RAM device types were radiation assessed. Results from these assessments, primarily focussing on the sensitivity of these devices to Total Ionizing Dose (TID) and Single Event Effects (SEE), are reported in individual TID and SEE reports. The below summary table lists manufacturer and evaluated types, and gives references to the various reports issued.

Manufacturer	Type	TID Report	SEE Report
Hitachi	HM6216255H	ESA_QCA0104T_C	ESA_QCA0104S_C
Samsung	KM684002AJ	-	ESA_QCA0101S_C
Samsung	K6R4008C1C	ESA_QCA0102T_C	ESA_QCA0102S_C
Samsung	K6R4008V1C	ESA_QCA0103T_C	ESA_QCA0103S_C

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2 INTRODUCTION

This report presents the results of a Single Event Effects (SEE) test program carried out on 512Kx8 Bit High Speed Static RAM(3V3 Operating) K6R4008V1C from Samsung.

Test was conducted on commercial samples procured from Samsung and provided to HIREX by ESA.

For heavy ion test, these devices were tested at the European Heavy Ion Irradiation Facility (HIF) at Cyclone, Université Catholique de Louvain, Belgium.

For proton test, these tests took place at the low energy OPTIS area of Paul Scherrer Institute in Villigen, Switzerland.

This work was performed for ESA/ESTEC under ESA Contract no. 13528/99/NL/MV CCN N°3 dated 24/11/00.

3 REFERENCE DOCUMENTS

- RD1. Samsung data sheet
- RD2. Single Event Effects Test method and Guidelines ESA/SCC basic specification No 25100
- RD3. The Heavy Ion Irradiation Facility at CYCLONE, UCL document, Centre de Recherches du Cyclotron (IEEE NSREC'96, Workshop Record, Indian Wells, California, 1996)
- RD4. Radiation Effects Testing Facility in PSI Low Energy OPTIS Area, IEEE 1998, Radiation Effects Data Workshop, p. 152

4 DEVICE INFORMATION

Relevant device identification information is presented here after.

Part type :	K6R4008V1C
Manufacturer :	Samsung
Package :	36-SOJ
Quality Level :	Commercial
Date Code :	-
Die Technology :	CMOS
Top Marking:	SAMSUNG 037 K6R4008V1C-JC12 TZVE04DB KOREA
Die Size :	7 mm x 4.8 mm approximately
Die Marking :	Logo KM616V4002C ©1998

External and Internal Photos are shown in Figure 1.

HIREX Engineering	Single Event Effects Radiation Test Report		Ref. : HRX/SEE/0029 Issue : 01
Part Type :	K6R4008V1C	Manufacturer :	Samsung

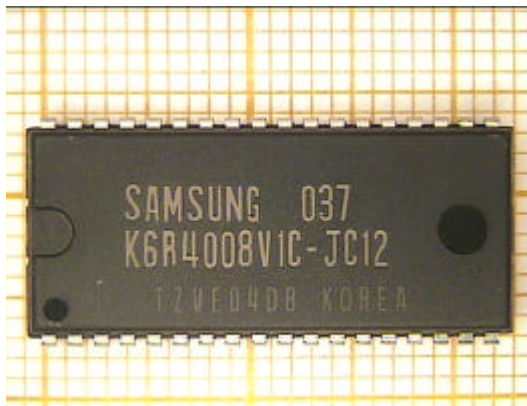


Photo # 1 :
External Visual Inspection
Part Type : K6R4008V1C
S/N -
Magnification : 3.3

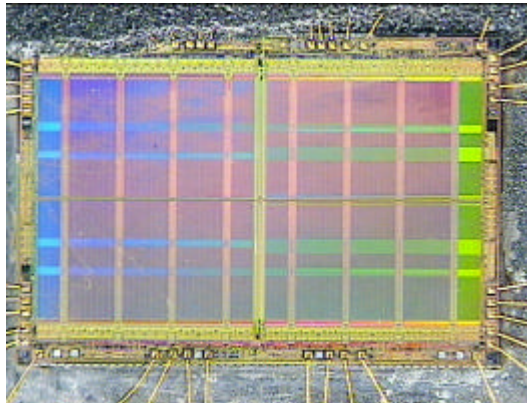


Photo # 2 :
Part Type : K6R4008V1C
S/N 5
Magnification : 11.3

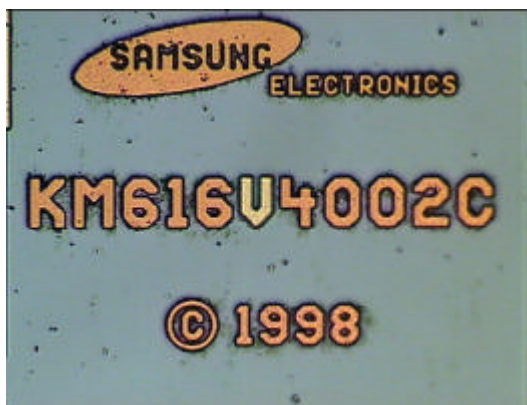


Photo # 3 :
Part Type : K6R4008V1C
S/N 5
Magnification : 432.3

Figure 1 – K6R4008V1C External and Internal Photos

HIREX Engineering	Single Event Effects Radiation Test Report		Ref. : HRX/SEE/0029 Issue : 01
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5 Test Definition

5.1 Test Set-up

Hirex test equipment is composed of a modular rack coupled with a generic memory test board :

This modular rack is derived from Hirex BILT modular instrumentation system and present 8 slots for modular instruments.

In addition to the existing power supply modules which cover the SEE test needs for precision measurements, remote control, LU detection, data storage , scope observation, etc, a specific modular board has been designed to provide :

- A high speed communication link with the test board under vacuum (up to 500 ko/s)
- Management of DUT positioning (mover)
- Particle and test time counting

Dedicated to the test of memories, the generic test board is based on a 12 MIPs on-board processor which controls the test sequence and the communication with the rack.

The board include programmable logic circuits with a total capacity of 30000cells and 960 macrocells. This logic circuitry can work at high speed (up to 100 MHz) while being compatible with thermal requirements imposed by vacuum environment.

Today, the board has a capacity of 50 pin-drivers (this number can be extended if needed), using transceivers able to interface memory devices with voltage supply requirements between 1 and 7 volts. The DUT can have two different power supplies.

A mechanism called mover allows positioning the DUT under or outside the beam within less than 100ms. During translations, particles count and test time is automatically stopped. This solution has been selected mainly for proton tests where the DUT can be translated behind a lead shielding for instance.

5.2 Test Configuration

Two main different test conditions can be used:

Cond 1: Dynamic conditions, which consist in the following test sequence:

Write the entire memory

Then read/write the memory sequentially by page of 128 words

Under dynamic conditions the device is continuously exposed to the beam

Cond 2: Static conditions, which consist in the following cycle, repeated continuously:

Write the entire memory with the device not exposed to the beam

Expose the memory for a given time period

Read the memory outside the beam

An additional condition, cond 3, can also be used, called "full static", which consist in the here above static conditions but with only one cycle. The beam exposure time corresponds then to the run duration.

Advantage of cond 2 over cond 3 is that the occurrence of temporary or permanent stuck bits can be easily detected.

Test principle is based on the use of a rotating pattern, which allows checking that at each cycle every word has been effectively rewritten with new data.

HIREX Engineering	Single Event Effects Radiation Test Report			Ref. : HRX/SEE/0029 Issue : 01
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The table here below provides the repetitive pattern of 14 different words in a 8 bits organisation.

D7	D6	D5	D4	D3	D2	D1	D0
0	0	0	0	0	0	0	0
1	0	1	0	1	0	1	0
0	1	0	1	0	1	0	1
1	1	1	1	1	1	1	1
0	1	0	0	1	0	0	1
1	0	1	1	0	1	1	0
0	1	0	1	0	1	0	1
0	0	0	0	0	0	0	0
1	0	1	0	1	0	1	0
0	1	0	1	0	1	0	1
1	1	1	1	1	1	1	1
0	1	0	0	1	0	0	1
1	0	1	1	0	1	1	0
1	0	1	0	1	0	1	0

At each cycle, the here above table is shifted by three positions :

	address 0	address 1	address 2	address 3	etc.
cycle 1 :	0101...	1010...	0000...	1111...	...
cycle 2 :	0000...	1111...	0110...	1100...	...

Only the 4 first bits of each 8-bit word are represented here above

Errors which can be detected and counted are the following :

- Any single error in the memory block with identification of the transition (1->0 or 0->1)
- Any word with at least one bit flip with the identification of the word address

DUT power supply module is monitored and each time the current consumption exceeds a programmable threshold, a power reset cycle is done and latch-up error counter is incremented. In addition the use of a fast latch-up detection with a high speed comparator avoid the counting of errors which could be induced by the latch-up condition.

DUT power supply is 3V3.

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6 TEST FACILITIES

6.1 Heavy Ions

Test at the cyclotron accelerator was performed at Université de Louvain (UCL) in Louvain-La-Neuve (Belgium) under HIREX Engineering responsibility.

6.1.1 Beam Source

In collaboration with the European Space Agency (ESA), the needed equipment for single events studies using heavy ions has been built and installed on the HIF beam line in the experimental hall of Louvain-La-Neuve cyclotron.

CYCLONE is a multi particle, variable energy, cyclotron capable of accelerating protons (up to 75 MeV), alpha particles and heavy ions. For the heavy ions, the covered energy range is between 0.6 MeV/AMU and 27.5 MeV/AMU. For these ions, the maximal energy can be determined by the formula :

$$110 Q^2/M$$

where Q is the ion charge state, and M is the mass in Atomic Mass Units.

The heavy ions are produced in a double stage Electron Cyclotron Resonance (ECR) source. Such a source allows to produce highly charged ions and ion "cocktails". These are composed of ions with the same or very close M/Q ratios. The cocktail ions are injected in the cyclotron, accelerated at the same time and extracted separately by a fine tuning of the magnetic field or a slight changing of the RF frequency. This method is very convenient for a quick change of ion (in a few minutes) which is equivalent to a LET variation.

6.1.2 Beam Set-up

6.1.2.1 Ion Beam Selection

The LET range was obtained by changing the ion species and incident energy and changing the angle of incidence between the beam and the chip.

For each run, information is provided on the beam characteristics in the detailed results table provided in paragraph 7.1.

6.1.2.2 Flux Range

For each run, the averaged flux value is provided in the detailed results table of paragraph 7.1.

6.1.2.3 Particle Fluence Levels

Maximum fluence level was set to 1 E6 ions/cm²

6.1.2.4 Dosimetry

The current UCL Cyclotron dosimetry system and procedures were used.

6.1.2.5 Accumulated Total Dose

For each run, the computed equivalent cumulated doses received by the DUT sample, are provided in the detailed results table of paragraph 7.1.

6.1.2.6 Test Temperature

Tests have been performed at 22 deg. C.

6.2 Protons

6.2.1 Beam Source

The description of the beam source is given in RD4.
Irradiation is carried out in air.

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6.2.2 Beam Set-up

6.2.2.1 Proton Beam Selection

The following monoenergetic proton beams have been selected

Energy (MeV)	LET(Si) (MeV/mg/cm ²)
60.9	8.5 E-3
40.6	1.17 E-2
33.3	1.36 E-2
23.3	1.8 E-2
17.6	2.25 E-2
12.4	2.95 E-2
7.3	4.43 E-2

For each run, information is provided on the beam characteristics in the detailed results tables provided in paragraph 7.2.

6.2.2.2 Flux Range

Particle flux was set between 1 to 2 E8 protons/cm²/sec under normal operations (tilt 0°).

6.2.2.3 Particle Fluence Levels

Fluence level was set to 1 E10 protons/cm².

6.2.2.4 Dosimetry

The current OPTIS dosimetry system and procedures were used.

6.2.2.5 Accumulated Total Dose

For each run, the computed equivalent cumulated doses received by the DUT sample, are provided in the detailed results tables of paragraph 7.2.

6.2.2.6 Test Temperature

Tests have been performed at 22 deg. C.

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7 RESULTS

7.1 Heavy Ions

The detailed results per run are presented in Table 2.

First occurrences of stuck bits can be observed with Argon. Errors generated by these stuck bits have been retrieved in each run memory file and Table 2 has been updated accordingly.

Runs 105 has been truncated to take into account the limited size of the corresponding run memory file which contains for each error, the word address, the error mask within the word and the iteration number.

Only single events upset (SEU) errors have been detected.

Lastly no SEL was detected for the complete set of runs.

The two test conditions dynamic and static give the same SEU error cross-section as it can be seen in Figure 2 and Table 1.

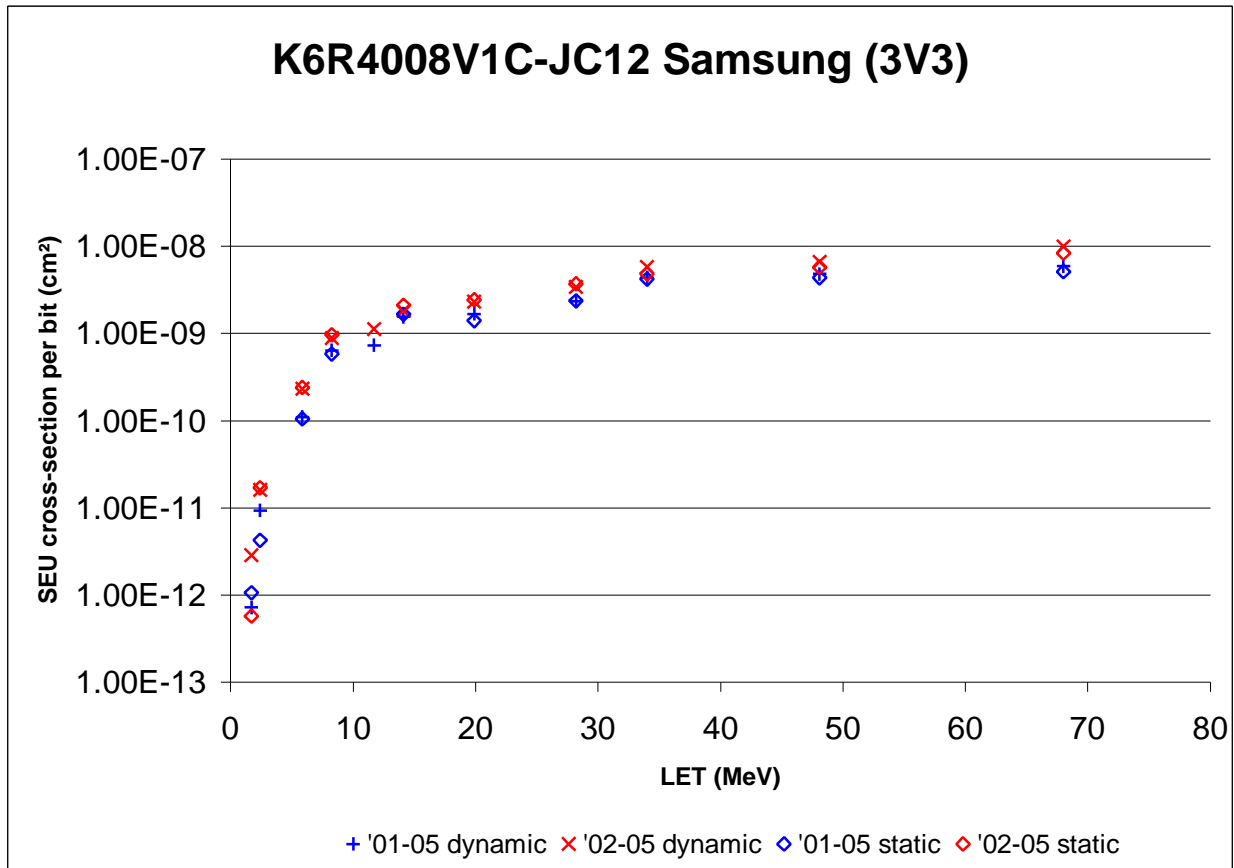


Figure 2 – K6R4008V1C SEU error cross-section per bit versus LET

HIREX Engineering	Single Event Effects Radiation Test Report		Ref. : HRX/SEE/0029 Issue : 01
Part Type :	K6R4008V1C	Manufacturer :	Samsung

Run #	Sample	Eff_Fluence	SEUs	Eff_LET	sigma SEUs
dynamic					
R00060	01-05	1.00E+06	3	1.7	7.15E-13
R00057	01-05	1.00E+06	39	2.4	9.30E-12
R00033	01-05	4.97E+05	229	5.85	1.10E-10
R00036	01-05	3.00E+05	803	8.27	6.38E-10
R00037	01-05	3.00E+05	922	11.7	7.33E-10
R00071	01-05	3.00E+05	1957	14.1	1.56E-09
R00074	01-05	3.00E+05	2112	19.9	1.68E-09
R00075	01-05	3.00E+05	2964	28.2	2.36E-09
R00108	01-05	2.00E+05	3698	34	4.41E-09
R00109	01-05	2.00E+05	4047	48.1	4.82E-09
R00112	01-05	2.00E+05	4988	68	5.95E-09
R00061	02-05	1.00E+06	12	1.7	2.86E-12
R00064	02-05	1.00E+06	67	2.4	1.60E-11
R00038	02-05	5.00E+05	486	5.85	2.32E-10
R00041	02-05	3.00E+05	1123	8.27	8.92E-10
R00042	02-05	3.00E+05	1426	11.7	1.13E-09
R00065	02-05	2.97E+05	2273	14.1	1.83E-09
R00068	02-05	3.00E+05	2907	19.9	2.31E-09
R00069	02-05	3.00E+05	4287	28.2	3.41E-09
R00101	02-05	2.00E+05	4877	34	5.81E-09
R00104	02-05	2.00E+05	5598	48.1	6.67E-09
R00105_tron	02-05	1.41E+05	5923	68	9.98E-09
static					
R00059	01-05	8.97E+05	4	1.7	1.06E-12
R00058	01-05	8.41E+05	15	2.4	4.25E-12
R00034	01-05	3.94E+05	173	5.85	1.05E-10
R00035	01-05	2.46E+05	603	8.27	5.85E-10
R00072	01-05	2.38E+05	1662	14.1	1.66E-09
R00073	01-05	2.80E+05	1659	19.9	1.41E-09
R00076	01-05	2.37E+05	2364	28.2	2.38E-09
R00107	01-05	1.78E+05	3148	34	4.22E-09
R00110	01-05	1.75E+05	3212	48.1	4.38E-09
R00111	01-05	1.85E+05	3976	68	5.13E-09
R00062	02-05	8.37E+05	2	1.7	5.70E-13
R00063	02-05	8.13E+05	58	2.4	1.70E-11
R00039	02-05	3.92E+05	396	5.85	2.41E-10
R00040	02-05	2.28E+05	924	8.27	9.66E-10
R00066	02-05	2.29E+05	2024	14.1	2.11E-09
R00067	02-05	2.28E+05	2337	19.9	2.45E-09
R00070	02-05	2.28E+05	3567	28.2	3.73E-09
R00102	02-05	2.00E+05	4043	34	4.82E-09
R00103	02-05	1.83E+05	4433	48.1	5.78E-09
R00106	02-05	1.79E+05	6286	68	8.40E-09

Table 1 – K6R4008V1C heavy ion SEU error cross-section per bit

HIREX Engineering	Single Event Effects Radiation Test Report			Ref. : HRX/SEE/0029
Part Type :	K6R4008V1C	Manufacturer :	Samsung	
			Issue : 01	

Run #	Test	Sample	Ion	Energy (MeV)	LET MeV/(mg.cm ²)	Range (μm)	Angle (deg.)	Eff_LET MeV/(mg.cm ²)	Time (s)	Eff_Time (s)	Flux (p/cm ² .s)	Run TID (rads (Si))	Sample TID (rads (Si))	Fluence (p/cm ²)	Eff_Fluence (p/cm ²)	Sel	Up (0 to 1)	Down (1 to 0)	Words	Stuck bits	SEUs
R00033	Dynamic	#01-05	20-Ne	78	5.85	45	0	5.85	154	153	3250	46.9	46.9	5.00E+05	4.97E+05	0	120	109	229	0	229
R00034	Static	#01-05	20-Ne	78	5.85	45	0	5.85	161	127	3110	46.9	93.7	5.00E+05	3.94E+05	0	94	79	173	0	173
R00035	Static	#01-05	20-Ne	78	5.85	45	45	8.27	127	104	2360	39.8	133	3.00E+05	2.46E+05	0	294	311	605	1	603
R00036	Dynamic	#01-05	20-Ne	78	5.85	45	45	8.27	130	130	2310	39.8	173	3.00E+05	3.00E+05	0	379	424	803	0	803
R00037	Dynamic	#01-05	20-Ne	78	5.85	45	60	11.7	188	188	1600	56.2	229	3.00E+05	3.00E+05	0	470	452	922	0	922
R00038	Dynamic	#02-05	20-Ne	78	5.85	45	0	5.85	150	150	3330	46.9	46.9	5.00E+05	5.00E+05	0	236	250	486	0	486
R00039	Static	#02-05	20-Ne	78	5.85	45	0	5.85	153	120	3270	46.9	93.7	5.00E+05	3.92E+05	0	196	200	396	0	396
R00040	Static	#02-05	20-Ne	78	5.85	45	45	8.27	121	92	2480	39.8	133	3.00E+05	2.28E+05	0	476	448	924	0	924
R00041	Dynamic	#02-05	20-Ne	78	5.85	45	45	8.27	109	109	2750	39.8	173	3.00E+05	3.00E+05	0	544	579	1123	0	1123
R00042	Dynamic	#02-05	20-Ne	78	5.85	45	60	11.7	164	164	1830	56.2	229	3.00E+05	3.00E+05	0	706	720	1426	0	1426
R00057	Dynamic	#01-05	10-B	41	1.7	80	45	2.4	173	173	5780	38.5	268	1.00E+06	1.00E+06	0	20	19	39	0	39
R00058	Static	#01-05	10-B	41	1.7	80	45	2.4	176	148	5680	38.5	307	1.00E+06	8.41E+05	0	9	6	15	0	15
R00059	Static	#01-05	10-B	41	1.7	80	0	1.7	136	122	7350	27.2	334	1.00E+06	8.97E+05	0	2	2	4	0	4
R00060	Dynamic	#01-05	10-B	41	1.7	80	0	1.7	133	133	7520	27.2	361	1.00E+06	1.00E+06	0	1	2	3	0	3
R00061	Dynamic	#02-05	10-B	41	1.7	80	0	1.7	128	128	7810	27.2	257	1.00E+06	1.00E+06	0	6	6	12	0	12
R00062	Static	#02-05	10-B	41	1.7	80	0	1.7	129	108	7750	27.2	284	1.00E+06	8.37E+05	0	1	1	2	0	2
R00063	Static	#02-05	10-B	41	1.7	80	45	2.4	176	143	5680	38.5	322	1.00E+06	8.13E+05	0	33	25	58	0	58
R00064	Dynamic	#02-05	10-B	41	1.7	80	45	2.4	177	177	5650	38.5	361	1.00E+06	1.00E+06	0	34	33	67	0	67
R00065	Dynamic	#02-05	40-Ar	150	14.1	42	0	14.1	94	93	3190	67.8	429	3.00E+05	2.97E+05	0	1119	1154	2273	0	2273
R00066	Static	#02-05	40-Ar	150	14.1	42	0	14.1	84	64	3570	67.8	497	3.00E+05	2.29E+05	0	1012	1012	2023	0	2024
R00067	Static	#02-05	40-Ar	150	14.1	42	45	19.9	112	85	2680	95.8	592	3.00E+05	2.28E+05	0	1161	1185	2345	4	2337
R00068	Dynamic	#02-05	40-Ar	150	14.1	42	45	19.9	185	185	1620	95.8	688	3.00E+05	3.00E+05	0	1481	1532	3013	2	2907
R00069	Dynamic	#02-05	40-Ar	150	14.1	42	60	28.2	189	189	1590	136	824	3.00E+05	3.00E+05	0	2129	2301	4429	9	4287
R00070	Static	#02-05	40-Ar	150	14.1	42	60	28.2	129	98	2330	136	959	3.00E+05	2.28E+05	0	1814	1782	3594	7	3567
R00071	Dynamic	#01-05	40-Ar	150	14.1	42	0	14.1	78	78	3850	67.8	429	3.00E+05	3.00E+05	0	1003	988	1991	1	1957
R00072	Static	#01-05	40-Ar	150	14.1	42	0	14.1	121	96	2480	67.8	497	3.00E+05	2.38E+05	0	824	845	1669	1	1662
R00073	Static	#01-05	40-Ar	150	14.1	42	45	19.9	123	115	2440	95.8	592	3.00E+05	2.80E+05	0	823	851	1673	3	1659
R00074	Dynamic	#01-05	40-Ar	150	14.1	42	45	19.9	70	70	4290	95.8	688	3.00E+05	3.00E+05	0	1076	1064	2140	1	2112
R00075	Dynamic	#01-05	40-Ar	150	14.1	42	60	28.2	167	167	1800	136	824	3.00E+05	3.00E+05	0	1555	1523	3078	5	2964

HIREX Engineering	Single Event Effects Radiation Test Report		Ref. : HRX/SEE/0029 Issue : 01
Part Type :	K6R4008V1C	Manufacturer :	Samsung

Run #	Test	Sample	Ion	Energy (MeV)	LET MeV/(mg.cm ²)	Range (μm)	Angle (deg.)	Eff_LET MeV/(mg.cm ²)	Time (s)	Eff_Time (s)	Flux (p/cm ² .s)	Run TID (rads (Si))	Sample TID (rads (Si))	Fluence (p/cm ²)	Eff_Fluence (p/cm ²)	Sel	Up (0 to 1)	Down (1 to 0)	Words	Stuck bits	SEUs
R00076	Static	#01-05	40-Ar	150	14.1	42	60	28.2	189	149	1590	136	959	3.00E+05	2.37E+05	0	1226	1149	2375	1	2364
R00101	Dynamic	#02-05	84-Kr	316	34	43	0	34	54	54	3700	109	1070	2.00E+05	2.00E+05	0	2423	2455	4877	17	4877
R00102	Static	#02-05	84-Kr	316	34	43	0	34	51	51	3920	109	1180	2.00E+05	2.00E+05	0	2018	2049	4067	9	4043
R00103	Static	#02-05	84-Kr	316	34	43	45	48.1	70	64	2860	154	1330	2.00E+05	1.83E+05	0	2353	2147	4500	26	4433
R00104	Dynamic	#02-05	84-Kr	316	34	43	45	48.1	78	78	2560	154	1490	2.00E+05	2.00E+05	0	3208	2902	6108	40	5598
R00105 trunc.	Dynamic	#02-05	84-Kr	316	34	43	60	68	101	76.394	1860	204	1690	1.87E+05	1.41E+05	0	3364	3179	6537	49	5923
R00106	Static	#02-05	84-Kr	316	34	43	60	68	121	108	1650	218	1910	2.00E+05	1.79E+05	0	3226	3330	6555	67	6286
R00107	Static	#01-05	84-Kr	316	34	43	0	34	54	48	3700	109	1070	2.00E+05	1.78E+05	0	1617	1606	3221	24	3148
R00108	Dynamic	#01-05	84-Kr	316	34	43	0	34	49	49	4080	109	1180	2.00E+05	2.00E+05	0	2067	2075	4142	33	3698
R00109	Dynamic	#01-05	84-Kr	316	34	43	45	48.1	50	50	4000	154	1330	2.00E+05	2.00E+05	0	2191	2378	4568	37	4047
R00110	Static	#01-05	84-Kr	316	34	43	45	48.1	64	56	3130	154	1490	2.00E+05	1.75E+05	0	1605	1686	3290	24	3212
R00111	Static	#01-05	84-Kr	316	34	43	60	68	104	96	1920	218	1700	2.00E+05	1.85E+05	0	2065	2080	4144	40	3976
R00112	Dynamic	#01-05	84-Kr	316	34	43	60	68	121	121	1650	218	1920	2.00E+05	2.00E+05	0	3022	3251	6272	54	4988

Table 2 – K6R4008V1C heavy ion detailed results per run

HIREX Engineering	Single Event Effects Radiation Test Report		Ref. : HRX/SEE/0029 Issue : 01
Part Type :	K6R4008V1C	Manufacturer :	Samsung

7.2 Protons

Table 4 provides the detailed results per run.
Only static conditions have been considered.
No stuck bit has been observed.

Proton SEU error cross-section per bit versus proton energy is plotted in Figure 3. Corresponding values are provided in Table 3.

The spread observed at 40 and 60MeV is believed to be linked to a dosimetry error. Asymptotic value at 60 MeV is very likely closed to 1.5 E-15 cm².

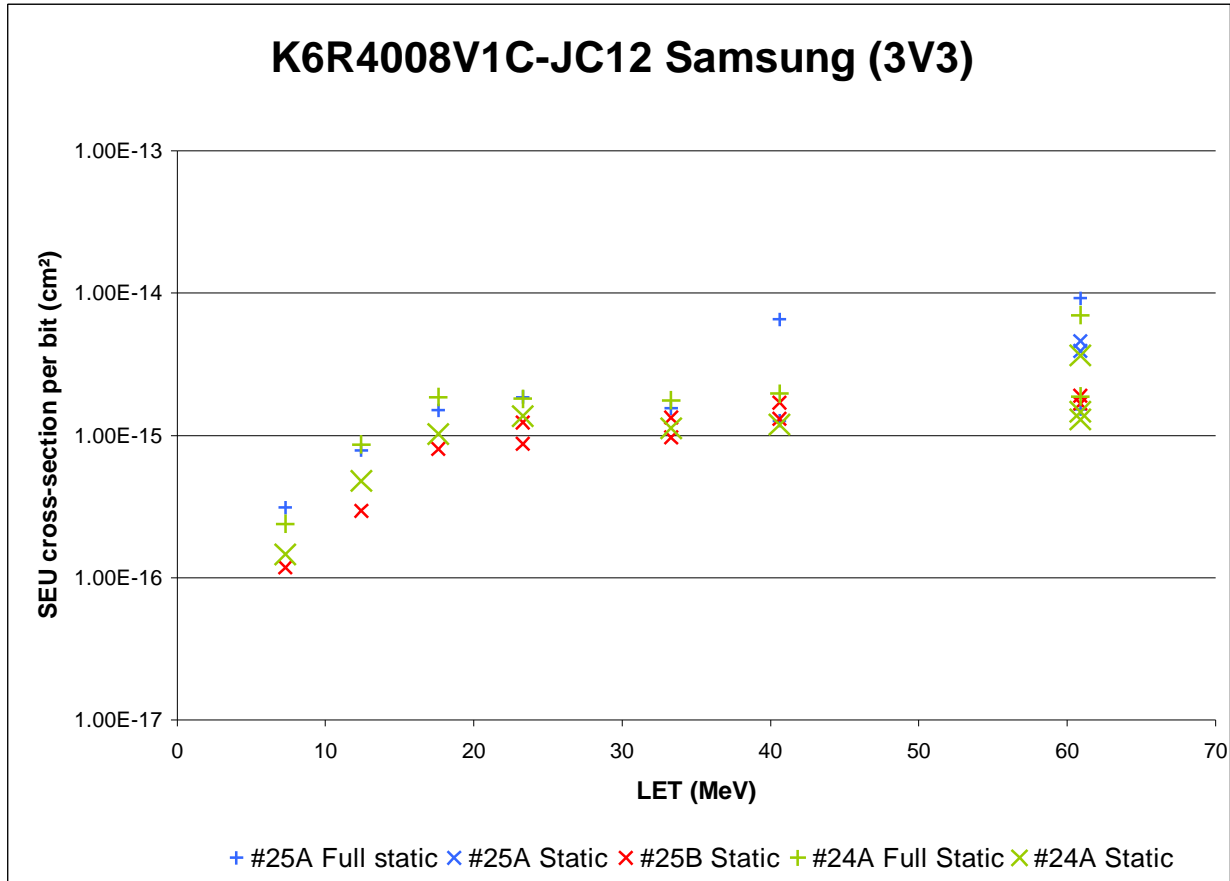


Figure 3 - K6R4008V1C proton error cross-section per bit versus proton incident energy

HIREX Engineering	Single Event Effects Radiation Test Report			Ref. : HRX/SEE/0029
				Issue : 01
Part Type :	K6R4008V1C	Manufacturer :	Samsung	

Run #	Sample	Time	Eff_Time	Fluence	Eff_Fluence	SEUs	Proton Energy	Sigma per bit
Full Static								
R00018	#25A	105	105	1.00E+10	1.00E+10	13	7.3	3.10E-16
R00017	#25A	99	99	1.00E+10	1.00E+10	33	12.4	7.87E-16
R00016	#25A	81	81	1.00E+10	1.00E+10	63	17.6	1.50E-15
R00015	#25A	72	72	1.00E+10	1.00E+10	78	23.3	1.86E-15
R00014	#25A	65	65	1.00E+10	1.00E+10	65	33.3	1.55E-15
R00013	#25A	59	59	1.00E+10	1.00E+10	53	40.6	1.26E-15
R00019	#25A	59	59	1.00E+10	1.00E+10	275	40.6	6.56E-15
R00012	#25A	50	50	1.00E+10	1.00E+10	64	60.9	1.53E-15
R00020	#25A	188	188	1.00E+10	1.00E+10	386	60.9	9.20E-15
R00036	#24A	101	101	1.00E+10	1.00E+10	10	7.3	2.38E-16
R00035	#24A	92	89	1.00E+10	9.67E+09	35	12.4	8.63E-16
R00032	#24A	79	78	1.00E+10	9.87E+09	77	17.6	1.86E-15
R00031	#24A	71	70	1.00E+10	9.86E+09	75	23.3	1.81E-15
R00028	#24A	61	61	1.00E+10	1.00E+10	74	33.3	1.76E-15
R00027	#24A	57	56	1.00E+10	9.82E+09	81	40.6	1.97E-15
R00024	#24A	50	49	1.00E+10	9.80E+09	77	60.9	1.87E-15
R00038	#24A	49	49	1.00E+10	1.00E+10	294	60.9	7.01E-15
Static								
R00021	#25A	51	40	1.00E+10	7.84E+09	151	60.9	4.59E-15
R00022	#25A	53	40	1.00E+10	7.55E+09	124	60.9	3.92E-15
R00007	#25B	99	80	1E+10	8.08E+09	4	7.3	1.18E-16
R00006	#25B	59	48	6.94E+09	5.65E+09	7	12.4	2.96E-16
R00005	#25B	77	64	1E+10	8.31E+09	28	17.6	8.03E-16
R00004	#25B	78	64	1E+10	8.21E+09	30	23.3	8.72E-16
R00008	#25B	69	56	1E+10	8.12E+09	42	23.3	1.23E-15
R00003	#25B	65	48	1E+10	7.38E+09	30	33.3	9.69E-16
R00009	#25B	64	48	1E+10	7.50E+09	42	33.3	1.34E-15
R00002	#25B	753	632	1E+10	8.39E+09	46	40.6	1.31E-15
R00010	#25B	60	48	1E+10	8.00E+09	57	40.6	1.70E-15
R00001	#25B	98	80	2E+09	1.63E+09	13	60.9	1.90E-15
R00011	#25B	52	40	1E+10	7.69E+09	54	60.9	1.67E-15
R00037	#24A	98	48	1.00E+10	4.90E+09	3	7.3	1.46E-16
R00034	#24A	90	72	1.00E+10	8.00E+09	16	12.4	4.77E-16
R00033	#24A	81	64	1.00E+10	7.90E+09	34	17.6	1.03E-15
R00030	#24A	70	56	1.00E+10	8.00E+09	46	23.3	1.37E-15
R00029	#24A	61	48	1.00E+10	7.87E+09	37	33.3	1.12E-15
R00026	#24A	57	40	1.00E+10	7.02E+09	35	40.6	1.19E-15
R00023	#24A	52	45	1.00E+10	8.65E+09	47	60.9	1.29E-15
R00025	#24A	50	40	1.00E+10	8.00E+09	49	60.9	1.46E-15
R00039	#24A	49	40	1.00E+10	8.16E+09	125	60.9	3.65E-15

Table 3 - K6R4008V1C proton SEU error cross-section per bit

HIREX Engineering	Single Event Effects Radiation Test Report			Ref. : HRX/SEE/0029	
				Issue : 01	
Part Type :	K6R4008V1C	Manufacturer :	Samsung		

Run #	Test	Sample	Proton Energy (MeV)	LET (MeV)/(mg.cm ²)	Range (µm)	Angle (deg.)	Time (s)	Eff_Time (s)	Flux (p/cm ² .s)	Run TID rads(Si)	Sample TID rads(Si)	Fluence (p/cm ²)	Eff_Fluence (p/cm ²)	Bits up (0 to 1)	Bits down (1 to 0)	Words	Stuck bits	SEUs
R00001	Static	#25B	60.9	8.50E-03	17300	0	98	80	2.04E+07	272	272	2.00E+09	1.63E+09	8	5	13	0	13
R00002	Static	#25B	40.6	1.70E-02	8410	0	753	632	1.33E+07	2720	3000	1.00E+10	8.39E+09	22	24	46	0	46
R00003	Static	#25B	33.3	1.36E-02	5910	0	65	48	1.54E+08	2180	5180	1.00E+10	7.38E+09	16	14	30	0	30
R00004	Static	#25B	23.3	1.80E-02	3130	0	78	64	1.28E+08	2880	8060	1.00E+10	8.21E+09	16	14	30	0	30
R00005	Static	#25B	17.6	2.25E-02	1910	0	77	64	1.30E+08	3600	11700	1.00E+10	8.31E+09	14	14	28	0	28
R00006	Static	#25B	12.4	2.95E-02	1030	0	59	48	1.18E+08	3280	14900	6.94E+09	5.65E+09	2	5	7	0	7
R00007	Static	#25B	7.3	4.43E-02	411	0	99	80	1.01E+08	7100	22000	1.00E+10	8.08E+09	2	2	4	0	4
R00008	Static	#25B	23.3	1.80E-02	3130	0	69	56	1.45E+08	2880	24900	1.00E+10	8.12E+09	18	24	42	0	42
R00009	Static	#25B	33.3	1.36E-02	5910	0	64	48	1.56E+08	2180	27100	1.00E+10	7.50E+09	19	23	42	0	42
R00010	Static	#25B	40.6	1.70E-02	8410	0	60	48	1.67E+08	2720	29800	1.00E+10	8.00E+09	23	34	57	0	57
R00011	Static	#25B	60.9	8.50E-03	17300	0	52	40	1.92E+08	1360	31200	1.00E+10	7.69E+09	30	24	54	0	54
R00012	Full Static	#25A	60.9	8.50E-03	17300	0	50	50	2.00E+08	1360	1360	1.00E+10	1.00E+10	26	38	64	0	64
R00013	Full Static	#25A	40.6	1.70E-02	8410	0	59	59	1.69E+08	2720	4090	1.00E+10	1.00E+10	27	26	53	0	53
R00014	Full Static	#25A	33.3	1.36E-02	5910	0	65	65	1.54E+08	2180	6260	1.00E+10	1.00E+10	34	31	65	0	65
R00015	Full Static	#25A	23.3	1.80E-02	3130	0	72	72	1.39E+08	2880	9150	1.00E+10	1.00E+10	45	33	78	0	78
R00016	Full Static	#25A	17.6	2.25E-02	1910	0	81	81	1.23E+08	3600	12800	1.00E+10	1.00E+10	31	32	63	0	63
R00017	Full Static	#25A	12.4	2.95E-02	1030	0	99	99	1.01E+08	4730	17500	1.00E+10	1.00E+10	16	17	33	0	33
R00018	Full Static	#25A	7.3	4.43E-02	411	0	105	105	9.52E+07	7100	24600	1.00E+10	1.00E+10	5	8	13	0	13
R00019	Full Static	#25A	40.6	1.70E-02	8410	0	59	59	1.69E+08	2720	27300	1.00E+10	1.00E+10	124	151	275	0	275
R00020	Full Static	#25A	60.9	8.50E-03	17300	0	188	188	5.32E+07	1360	28700	1.00E+10	1.00E+10	180	206	386	0	386
R00021	Static	#25A	60.9	8.50E-03	17300	0	51	40	1.96E+08	1360	30000	1.00E+10	7.84E+09	81	70	151	0	151
R00022	Static	#25A	60.9	8.50E-03	17300	0	53	40	1.89E+08	1360	31400	1.00E+10	7.55E+09	63	61	124	0	124
R00023	Static	#24A	60.9	8.50E-03	17300	0	52	45	1.92E+08	1360	1360	1.00E+10	8.65E+09	18	29	47	0	47
R00024	Full Static	#24A	60.9	8.50E-03	17300	0	50	49	2.00E+08	1360	2720	1.00E+10	9.80E+09	33	44	77	0	77
R00025	Static	#24A	60.9	8.50E-03	17300	0	50	40	2.00E+08	1360	4090	1.00E+10	8.00E+09	22	27	49	0	49
R00026	Static	#24A	40.6	1.70E-02	8410	0	57	40	1.75E+08	2720	6810	1.00E+10	7.02E+09	23	12	35	0	35

HIREX Engineering	Single Event Effects Radiation Test Report			Ref. : HRX/SEE/0029 Issue : 01
Part Type :	K6R4008V1C	Manufacturer :	Samsung	

Run #	Test	Sample	Proton Energy (MeV)	LET (MeV)/(mg.cm ²)	Range (µm)	Angle (deg.)	Time (s)	Eff_Time (s)	Flux (p/cm ² .s)	Run TID rads(Si)	Sample TID rads(Si)	Fluence (p/cm ²)	Eff_Fluence (p/cm ²)	Bits up (0 to 1)	Bits down (1 to 0)	Words	Stuck bits	SEUs
R00027	Full Static	#24A	40.6	1.70E-02	8410	0	57	56	1.75E+08	2720	9530	1.00E+10	9.82E+09	47	34	81	0	81
R00028	Full Static	#24A	33.3	1.36E-02	5910	0	61	61	1.64E+08	2180	11700	1.00E+10	1.00E+10	32	42	74	0	74
R00029	Static	#24A	33.3	1.36E-02	5910	0	61	48	1.64E+08	2180	13900	1.00E+10	7.87E+09	18	19	37	0	37
R00030	Static	#24A	23.3	1.80E-02	3130	0	70	56	1.43E+08	2880	16800	1.00E+10	8.00E+09	22	24	46	0	46
R00031	Full Static	#24A	23.3	1.80E-02	3130	0	71	70	1.41E+08	2880	19700	1.00E+10	9.86E+09	40	35	75	0	75
R00032	Full Static	#24A	17.6	2.25E-02	1910	0	79	78	1.27E+08	3600	23300	1.00E+10	9.87E+09	35	42	77	0	77
R00033	Static	#24A	17.6	2.25E-02	1910	0	81	64	1.23E+08	3600	26900	1.00E+10	7.90E+09	13	21	34	0	34
R00034	Static	#24A	12.4	2.95E-02	1030	0	90	72	1.11E+08	4730	31600	1.00E+10	8.00E+09	8	8	16	0	16
R00035	Full Static	#24A	12.4	2.95E-02	1030	0	92	89	1.09E+08	4730	36300	1.00E+10	9.67E+09	14	21	35	0	35
R00036	Full Static	#24A	7.3	4.43E-02	411	0	101	101	9.90E+07	7100	43400	1.00E+10	1.00E+10	3	7	10	0	10
R00037	Static	#24A	7.3	4.43E-02	411	0	98	48	1.02E+08	7100	50500	1.00E+10	4.90E+09	3	0	3	0	3
R00038	Full Static	#24A	60.9	8.50E-03	17300	0	49	49	2.04E+08	1360	51900	1.00E+10	1.00E+10	136	158	294	0	294
R00039	Static	#24A	60.9	8.50E-03	17300	0	49	40	2.04E+08	1360	53200	1.00E+10	8.16E+09	67	58	125	0	125

Table 4 – K6R4008V1C proton detailed results per run

HIREX Engineering	Single Event Effects Radiation Test Report		Ref. : HRX/SEE/0029 Issue : 01
Part Type :	K6R4008V1C	Manufacturer :	Samsung

8 CONCLUSION

Both heavy ion test and proton test have been conducted on commercial samples of 512Kx8 Bit High Speed Static RAM(3V3 Operating) K6R4008V1C from Samsung, using the heavy ions available at the European Heavy Ion Irradiation Facility (HIF) at Cyclone, Université Catholique de Louvain, Belgium and the OPTIS proton beam at the Paul Scherrer Institut, Switzerland.

K6R4008V1C responses to both heavy ion and proton exposures have been characterized and the corresponding cross-section curves have been plotted.

It may be worthwhile to note that this device does not exhibit Multiple Upset errors (MEUs) nor Single Event Latch-ups (SELs)
