4th D/TOS-QCA Final Presentation Day, January 30th, 2001.

Radiation Evaluation of Fast 4-Mbit SRAM's for the COROT DPU.

by

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Abstract

This presentation will address radiation behaviour, both TID and SEE, of fast 4Mbit SRAM evaluated for the COROT DPU. Co-60 TID results as well as proton and heavy ion SEE results will be detailed for Samsung K6R4008C1C, Samsung K6R4008V1C and Hitachi HM6216255H.

Objective:

To Radiation Evaluate 4 types of Fast 4-Mbit SRAMs

- Having Samsung "C" Version as the prime candidate
- Preliminary data in year 2000

ESA/ESTEC Space Science (SCI-SO)

- Thierry Beaufort/Bengt Johlander
- 1st October 2000 - Request for Radiation Evaluation
- 23rd October 2000 - Parts Ordered
- 30th October 2000 - Parts at ESTEC
- 17th November 2000 - HIF Testing at UCL, Belgium
- 13th December 2000 - PIF Testing at PSI, Switzerland
- 29th December 2000 - TID Completed at ONERA-CERT, France
- 30th January 2001 - Final Test Reports available at our www page:

https://escies.org/public/radiation/

esa ESTEC - Radiation Effects and Analysis Techniques Section
Ref. : D/TOS-QCA/SRAM

4-Mbit High-Speed SRAM Types Tested:

Manufacturer	Type	Speed	Power	TID Report	SEE Report
Samsung	K6R4008C1C	12 ns	5.0 V	ESA_OCA0102T_C	ESA_OCA0102S_C
Samsung	K6R4008V1C	12 ns	3.3 V	ESA_OCA0103T_C	ESA_OCA0103S_C
Samsung	KM684002AJ	15 ns	5.0 V	-	ESA_OCA0101S_C
Hitachi	MTW32N20E	15 ns	5.0 V	ESA_OCA0104T_C	ESA_OCA0104S_C

Packages: Samsung 36-SOJ, Hitachi 44-SOJ

4-Mbit SRAM - Radiation Evaluation:

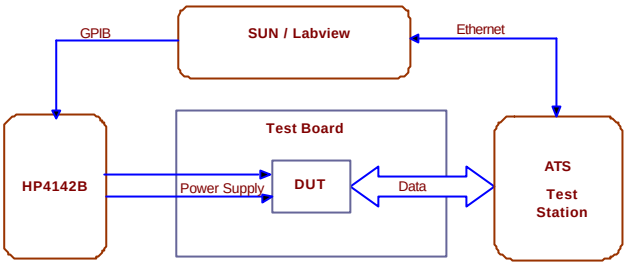
TID Co-60 Dose rate 200 rad(Si)/hour
- Parametric Testing having
- 4 parts/type Biased during irradiation
- 1 part/type as reference

SEE Heavy ion – ^{10}B, ^{20}Ne, ^{40}Ar and ^{84}Kr ions
- Static/Dynamic Testing having
- 2 parts/type Single Event Effect Tested (SEE)
- De-capping – plastic packages

SEE Proton – Energy: 60.9, 40.6, 33.3, 23.3, 17.6, 12.4 & 7.3 MeV
- Static Testing having
- 2 parts/type Single Event Effect Tested (SEE)

esa ESTEC - Radiation Effects and Analysis Techniques Section
Ref. : D/TOS-QCA/SRAM

TID Co-60: Parametric Test Set-Up



HIREX ENGINEERING - Test program principle

TID Co-60: Electrical Parameters I.

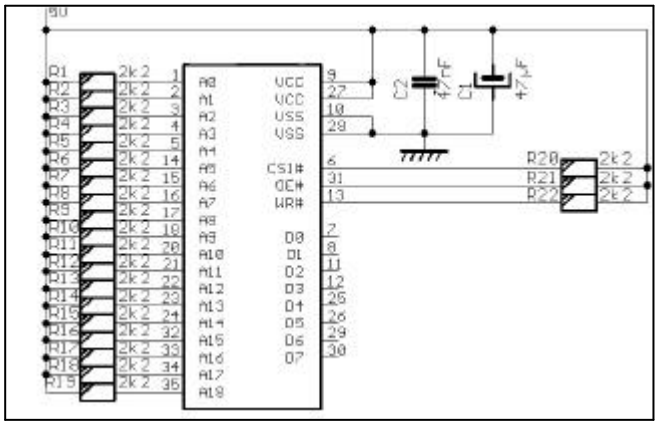
SYMBOL	PARAMETER	TESTS CONDITIONS	LIMIT		UNIT
			Min	Max	
ILLI	Input Leakage Current Low Level	Vin(under test) = VIL Vin (remaining inputs) = VIH output unloaded	-2	2	µA
IHLI	Input Leakage Current High Level	Vin(under test) = V_{IH} Vin (remaining inputs) = V_{IL} output unloaded	-2	2	µA
ILLO	Output Leakage Current Low Level	Vout(under test) = V_{IL} Vout(remaining outputs) = tristate CS* = OE* = V_{IH} Remaining inputs V_{IL} or V_{IH}	-2	2	µA
IHLO	Output Leakage Current High Level	Vout(under test) = V_{IH} Vout (remaining outputs) = tristate CE* = OE* = V_{IH} Remaining inputs V_{IL}	-2	2	µA
VOH	Output Voltage High Level	I_{OH} = -4 mA	2.4		V
VOL	Output Voltage Low Level	I_{OL} = 8 mA		0.4	V

ESTEC - Radiation Effects and Analysis Techniques Section
Ref. : D/TOS-QCA/SRAM

TID Co-60: Electrical Parameters II.

SYMBOL	PARAMETER	TESTS CONDITIONS	LIMIT		UNIT
			Min	Max	
ICC	Operating Power Supply Current	CS* = V^{IL} OE* = V^{IH} F = 80 Mhz outputs unloaded		160	mA
ISB	Standby Power Supply Current	CS* = OE* = V^{IH} Outputs unloaded		10	mA
$t^{AA\ L->H}$	Address Access Time	Output Load : 50 O		12	ns
$t^{AA\ H->L}$	Address Access Time	Output Load : 50 O		12	ns
t^{AS}	Address setup time	Output Load : 50 O	0		ns
Zero	Functional Test 1: , Test Pattern: All 0	Frequency=80MHz			
One	Functional Test 1: , Test Pattern: All 1	Frequency=80MHz			
Checkerboard	Functional Test 1: , Test Pattern: Checkerboard	Frequency=80MHz			
*Checkerboard	Functional Test 1: , Test Pattern: Complementary Checkerboard	Frequency=80MHz			

TID Co-60: 4-Mbit SRAM Bias Conditions



TID Co-60: Source ONERA-CERT/Irradiation Conditions

Irr. Steps Krads(Si)	Dose Rate Krads(Si)/h	Ann. Steps Hours	Temp. °C
0			
4.6	0.2		25
10.0	0.2		25
14.8	0.2		25
19.0	0.2		25
31.8	0.2		25
47.2	0.2	0	25
		24	25
		192	100

TID Co-60: Example of Test Results-Total 108 Parameters/type

Test Step	Initial	5 krads	10 krads	14,8 krads	19 krads	31,8 krads	47,2 krads
Serial #							
0 Ref.	1,560E -02	1,560E -02	1,600E -02	1,570E -02	1,580E -02	1,570E -02	1,550E -02
1	1,650E -02	1,610E -02	1,730E -02	1,670E -02	1,760E -02	1,530E -01	2,000E -01
2	1,600E -02	1,600E -02	1,670E -02	1,620E -02	1,690E -02	1,450E -01	2,000E -01
3	1,580E -02	1,570E -02	1,640E -02	1,580E -02	1,730E -02	1,840E -01	2,000E -01
4	1,620E -02	1,610E -02	1,690E -02	1,630E -02	1,770E -02	1,820E -01	2,000E -01
Statistics							
Min	1,580E -02	1,570E -02	1,640E -02	1,580E -02	1,690E -02	1,450E -01	2,000E -01
Max	1,650E -02	1,610E -02	1,730E -02	1,670E -02	1,770E -02	1,840E -01	2,000E -01
Mean	1,613E -02	1,598E -02	1,682E -02	1,625E -02	1,737E -02	1,660E -01	2,000E -01
Sigma	2,986E -04	1,893E -04	3,775E -04	3,697E -04	3,594E -04	1,992E -02	9,505E -11

Test Step	24 hours	192 hours
Serial #		
0 Ref.	1,600E -02	1,540E -02
1	2,000E -01	1,770E -02
2	2,000E -01	1,730E -02
3	2,000E -01	1,690E -02
4	2,000E -01	1,790E -02
Statistics		
Min	2,000E -01	1,690E -02
Max	2,000E -01	1,790E -02
Mean	2,000E -01	1,745E -02
Sigma	9,505E -11	4,435E -04

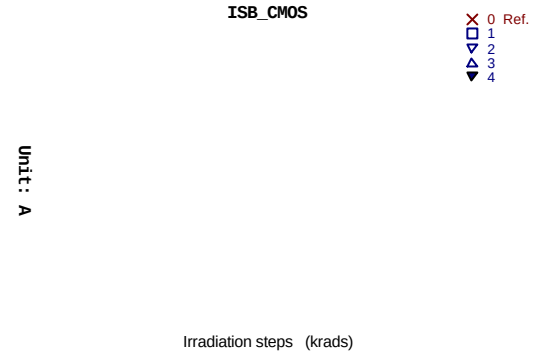
Parameter : Operating Power Supply Current: ICC

Iout=0A ; 15ns Cycle Time ; ; Vin = Vil/Vih

Unit= A,

Spec limit max: 16,0E-2

TID Co-60: Test Results for Hitachi HM6216255H - ISB



Parameter : Standby Power Supply Current: ISB_CMOS
15ns Cycle Time ; Vin = Vil/Vih
Spec limit max: 50,0E-3 A
Spec limits are represented in bold (blue) line on the graph.

TID Co-60: Summary Results - Krad(Si)

Manufacturer	Type	Speed	Power	Failing Parameters	Krad(Si) Level
Samsung	K6R4008C1C	12 ns	5.0 V	None	47.2
Samsung	K6R4008V1C	12 ns	3.3 V	None	47.2
Hitachi	MTW32N20E	15 ns	5.0 V	Functionality #	19.0

 # Fully recovered after annealing (also parametric)

SEE Heavy Ion: HIREX Generic In-house Test Equipment

Test Set-up

- Modular rack/Generic memory test board

Test Configurations

1) Dynamic

- Write the entire memory
- Memory continuously irradiated
- Read/Write sequentially by pages of 128 words

2) Static

- Write the entire memory
- Memory irradiated
- Read the memory outside the beam

SEE Heavy Ion/Proton: HIF & OPTIS

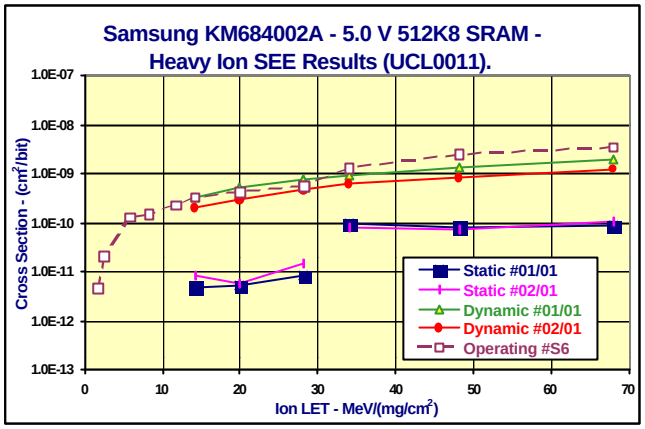
UCL CYCLONE – Heavy-ion Irradiation Facility (HIF)

- $^{84}Kr^{17+}$ at 316 MeV - LET(Si) = 34.0 – 68.0 MeV/(mg/cm^2)
- $^{40}Ar^{8+}$ at 150 MeV - LET(Si) = 14.1 – 28.2 MeV/(mg/cm^2)
- $^{20}Ne^{4+}$ at 78 MeV - LET(Si) = 5.85 – 11.7 MeV/(mg/cm^2)
- $^{10}B^{2+}$ at 41 MeV - LET(Si) = 1.7 – 3.4 MeV/(mg/cm^2)

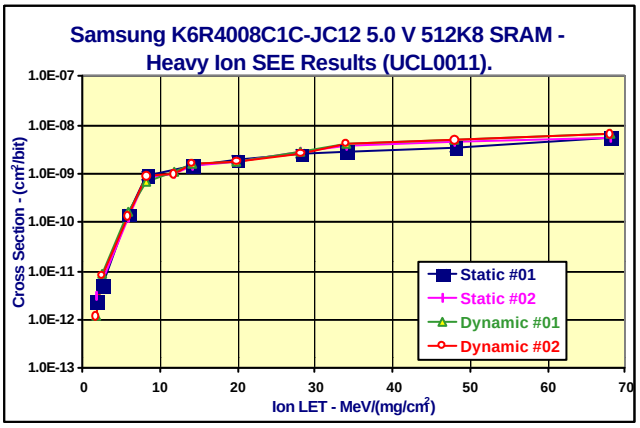
PSI OPTIS – Part of the Proton Irradiation Facility (PIF)

- Energy 60.9 MeV - LET(Si) = 8.50E-03 MeV/(mg/cm^2)
- Energy 40.6 MeV - LET(Si) = 1.17E-02 MeV/(mg/cm^2)
- Energy 33.3 MeV - LET(Si) = 1.36E-02 MeV/(mg/cm^2)
- Energy 23.3 MeV - LET(Si) = 1.80E-02 MeV/(mg/cm^2)
- Energy 17.6 MeV - LET(Si) = 2.25E-02 MeV/(mg/cm^2)
- Energy 12.4 MeV - LET(Si) = 2.95E-02 MeV/(mg/cm^2)
- Energy 07.3 MeV - LET(Si) = 4.43E-02 MeV/(mg/cm^2)

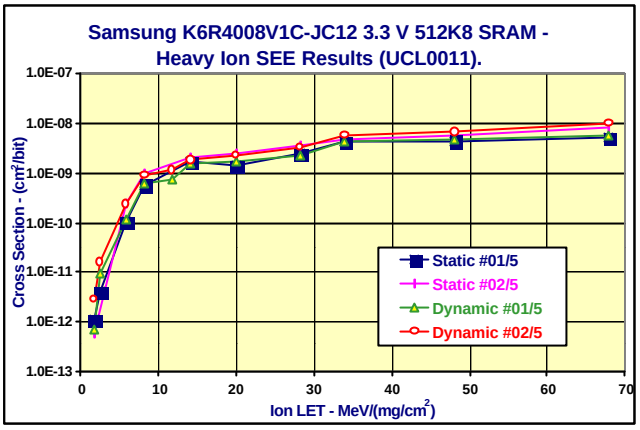
SEE Heavy Ion: KM684002A - Reference



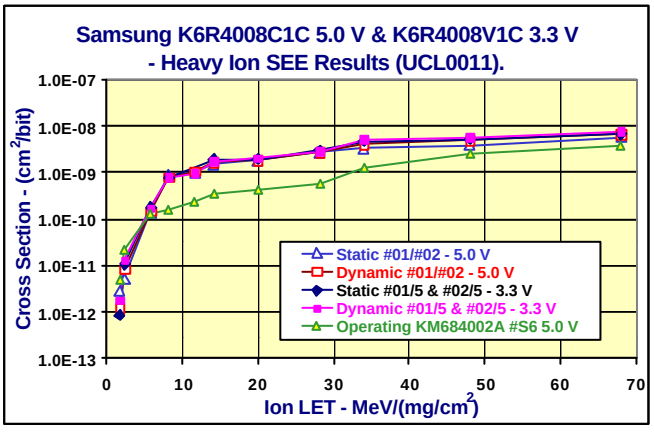
SEE Heavy Ion: K6R4008C1C - 5.0V



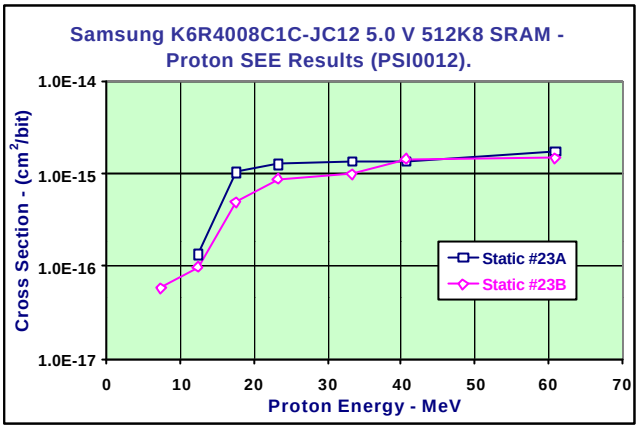
SEE Heavy Ion: K6R4008V1C - 3.3V



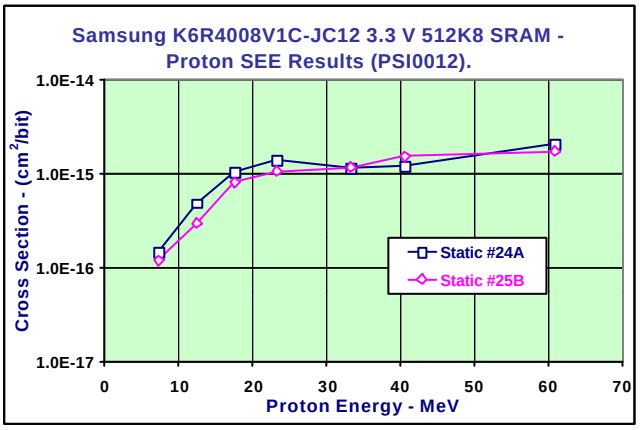
SEE Heavy Ion: K6R4008C1C - 5.0V & K6R4008V1C - 3.3V



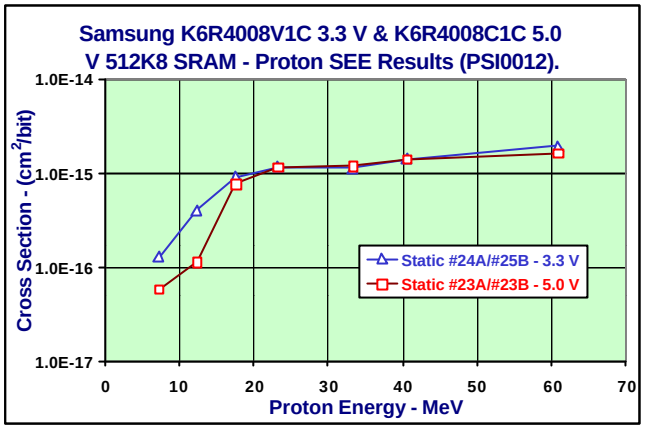
SEE Proton: K6R4008C1C - 5.0V



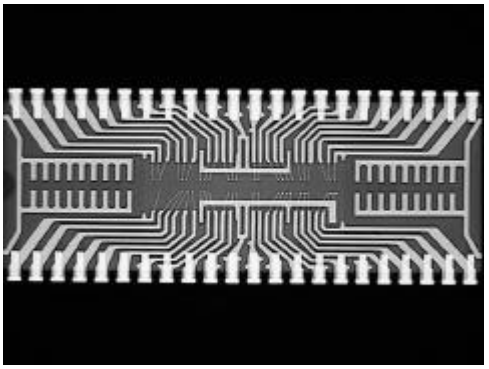
SEE Proton: K6R4008V1C - 3.3V



SEE Proton: K6R4008V1C - 3.3V & K6R4008C1C - 5.0V



SEE Heavy Ion and Proton: Hitachi HM6216255H 5.0 V



SEE Heavy ion: Test not possible - see X-ray

SEE Proton: at 60 MeV – Cross section = 3.7E-18 cm^2/per bit

Radiation Summary: 4M-bit SRAM Evaluation

Radiation Test	K6R4008C1C 5.0 V	K6R4008C1C 3.3 V	HM6216255 5.0 V	Unit
Protr. SEU Sat.*	~2E-15	~2E-15	~3.7E-18	cm^2/per bit
Protr. SEU Th.*	7	7	60	MeV
H-ion SEU Sat.*	~6E-9	~6E-9	N.T.	cm^2/per bit
H-ion SEU Th.*	~2	~2	N.T.	MeV/(mg/cm^2)
TID	>47	>47	>19	Krad(Si)

*** No SEL, row, column, block or word events were observed in any of these tests.**