Unisys

DATE: January 08, 1999 PPM-99-013
TO: B. Forsbacka/562
FROM: K. Sahu/S. Kniffin/300.1
SUBJECT: Radiation Report on **KM684002AJ-17 (Samsung) (LDC 9826)**
PROJECT: COS

cc: R. Reed/562, A. Sharma/562, OFA Library/300.1

A radiation evaluation was performed on **KM684002AJ-17 (KM684002) 512k x 8 Bit High Speed CMOS SRAM (Samsung)** to determine the total ionizing dose (TID) tolerance of these parts. The TID testing was performed using a Co^{60} gamma ray source. During the radiation testing, four parts were irradiated under bias (see Figure 1 for bias configuration) and one part was used as a control sample. The TID radiation levels were 2.5, 5.0, 7.5, 10.0, 13.0, 16.0, 20.0, 30.0, 50.0, 75.0, and 100.0kRads.[1] The dose rate was 0.174kRads/hour (0.05Rads/s). See Table II for the radiation schedule and effective dose rate calculation. After the 100.0kRad irradiation, the parts were annealed under bias at 25°C and tested after 168 and 288 hours.[2] After each radiation exposure and annealing treatment, parts were electrically tested according to the test conditions and the specification limits[3] listed in Table III. These tests included functional tests (Checkerboard and Inverse Checkerboard) at 5MHz and 20MHz. The functional tests were performed in 64k x 8 bit blocks for a total of 8 functional tests per pattern per frequency for the 512k x 8 bit memory. These blocks were: Block 1 = 0k to 64k, Block 2 = 65k to 128k, Block 3 = 129k to 192k, Block 4 = 193k to 256k, Block 5 = 257k to 320k, Block 6 = 321k to 384k, Block 7 = 385k to 448k, and Block 8 = 449k to 512k.

An executive summary of the test results is provided below in bold, followed by a detailed summary of the test results after each radiation level and annealing step. For detailed information, refer to Tables I through IV and Figure 1.

All parts passed all tests initially and upon irradiation to 30kRads. After 50kRads all parts showed one functional failure in one of the blocks in each functional test. After 75 and 100kRads, the parts showed functional failures in many blocks and some degradation in t_{OE}, ISB, ISB1, and Icc. After annealing the parts for 288 hours at 25°C, all parts showed significant recovery in all parameters with all parts passing functional tests in most blocks, but still failing in one or two blocks and only marginal degradation in ISB1.

Initial electrical measurements were made on 5 samples. Four samples (SN's 52, 53, 54, and 55) were used as radiation samples while SN 50 was used as a control sample. All parts passed all tests during initial electrical measurements.

All parts passed all tests up to 30kRads.

After the 50kRad irradiation, all parts failed the 321 to 384k block Functional Test for checkerboard and inverse checkerboard at both 20MHz and 5MHz. **All parts passed all other tests.**

After the 75kRad irradiation, all parts failed a majority of all blocks of all functional tests. SN52 had degraded to the point where t_{OE} could not be reliably measured. All parts exceeded the specification limit of 10.0mA for ISB1 with readings in the range of 17.7 to 33.4mA. **All parts passed all other tests.**

After the 100kRad irradiation, all parts failed all blocks of all functional tests. Four parts had degraded such that t_{OE} could not be reliably measured. Three parts exceeded the specification limit of 50mA for ISB with readings in the

[1] The term Rads, as used in this document, means Rads (silicon). All radiation levels cited are cumulative.
[2] The temperature 25°C as used in this document implies room temperature.
[3] These are manufacturer's pre-irradiation data specification limits. The manufacturer provided no post-irradiation limits at the time these tests were performed.

range of 60.4 to 76.9mA. All parts exceeded the specification limit for ISB1 with readings in the range of 37.8 to75.3mA. SN54 also marginally exceeded the specification limit of 165mA for Icc with a reading of 167.7mA. **All parts passed all other tests.**

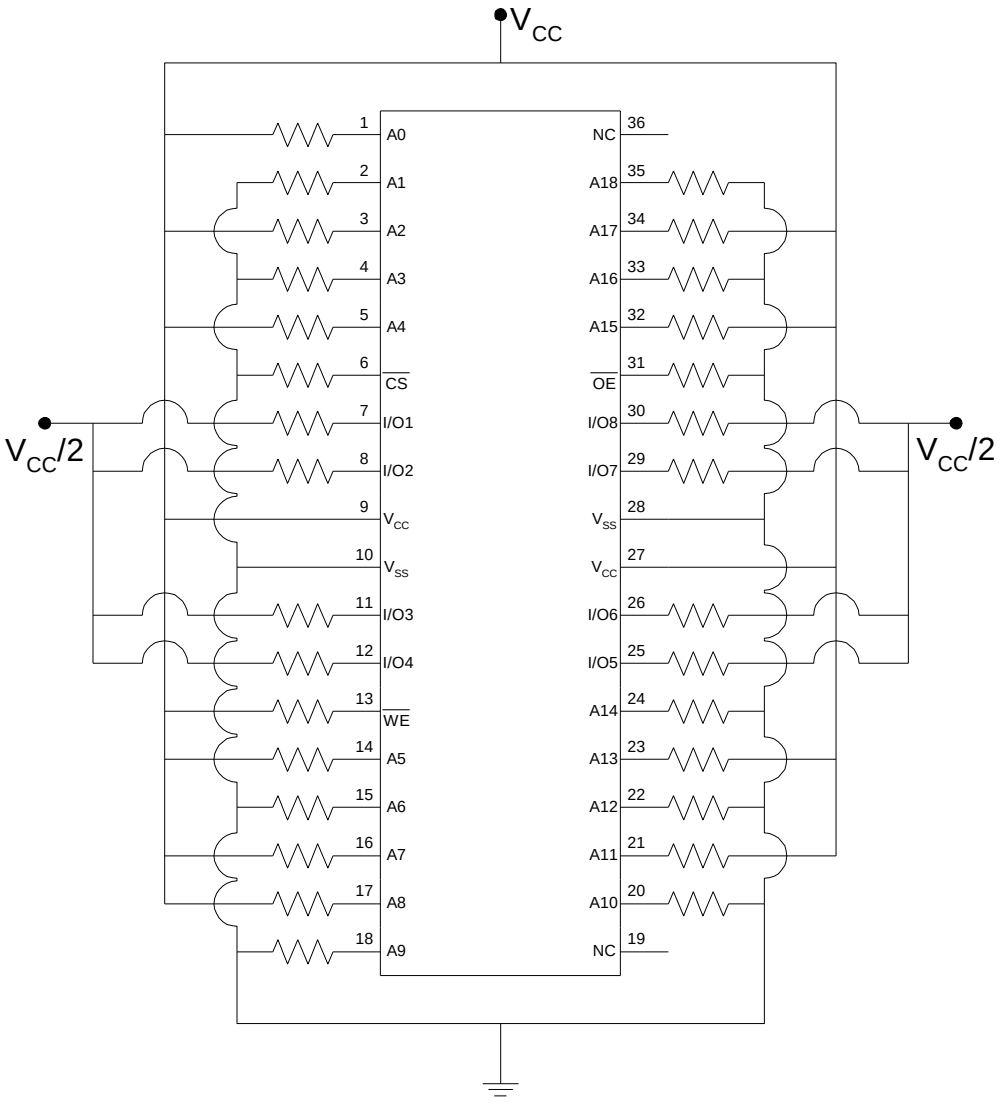
After annealing the parts for 168 hours at 25°C, all parts showed significant recovery in the functional tests with all parts failing only the four 321 to 384k block functional tests as they did at 50kRads. All parts showed significant recovery in all other sensitive parameters. All parts had readings within specification limits for t_{OE}, ISB and Icc. All parts showed some recovery in ISB1 with readings in the range of 19.0 to 38.7mA.

After annealing the parts for 288 hours at 25°C, all parts continued to show significant recovery in the functional tests. Only 3 parts (SN 52, 54, 55) failed the 321 to 384k block functional test for Checkerboard at 5MHz and 20MHz and 3 parts (SN 52, 53, 55) failed the 321 to 384k block functional test for Inverse Checkerboard at 5MHz and 20MHz. Only 3 parts exceeded the specification limit for ISB1 with readings in the range of 10.7 to 13.2mA.

Table IV provides a summary of the test results with the mean and standard deviation values for each parameter after each irradiation exposure and annealing step.

Any further details about this evaluation can be obtained upon request. If you have any questions, please call us at (301) 731-8954.

Figure 1. Radiation Bias Circuit for KM684002AJ-17



Notes:
1. V_{CC} = 5.0V ±0.5V.
2. $V_{CC}/2$ = 2.5V ±0.25V.
3. R = 2kΩ ±5%, ¼W.

TABLE I. Part Information

Generic Part Number:	KM684002A
COS Part Number:	KM684002AJ-17
Charge Number:	M99501
Manufacturer:	Samsung
Lot Date Code (LDC):	9826
Quantity Tested:	5
Serial Number of Control Samples:	50
Serial Numbers of Radiation Samples:	52, 53, 54, and 55
Part Function:	512k x 8 Bit High Speed CMOS SRAM
Part Technology:	CMOS
Package Style:	36 Pin SOJ
Test Equipment:	A540
Test Engineer:	S. Archer-Davies

- The manufacturer for this part guaranteed no radiation tolerance/hardness.

TABLE II. Radiation Schedule for KM684002AJ-17

EVENT	DATE
1) INITIAL ELECTRICAL MEASUREMENTS	11/16/98
2) 2.5 KRAD IRRADIATION (0.147 KRADS/HOUR)	11/17/98
POST-2.5 KRAD ELECTRICAL MEASUREMENT	11/18/98
3) 5.0 KRAD IRRADIATION (0.147 KRADS/HOUR)	11/18/98
POST-5.0 KRAD ELECTRICAL MEASUREMENT	11/19/98
4) 7.5 KRAD IRRADIATION (0.147 KRADS/HOUR)	11/19/98
POST-7.5 KRAD ELECTRICAL MEASUREMENT	11/20/98
5) 10.0 KRAD IRRADIATION (0.038 KRADS/HOUR)	11/20/98
POST-10.0 KRAD ELECTRICAL MEASUREMENT	11/23/98
6) 13.0 KRAD IRRADIATION (0.075 KRADS/HOUR)	11/23/98
POST-13.0 KRAD ELECTRICAL MEASUREMENT	11/25/98
7) 16.0 KRAD IRRADIATION (0.026 KRADS/HOUR)	11/25/98
POST-16.0 KRAD ELECTRICAL MEASUREMENT	11/30/98
8) 20.0 KRAD IRRADIATION (0.250 KRADS/HOUR)	11/30/98
POST-20.0 KRAD ELECTRICAL MEASUREMENT	12/01/98
9) 30.0 KRAD IRRADIATION (0.153 KRADS/HOUR)	12/01/98
POST-30.0 KRAD ELECTRICAL MEASUREMENT	12/04/98
10) 50.0 KRAD IRRADIATION (0.307 KRADS/HOUR)	12/04/98
POST-50.0 KRAD ELECTRICAL MEASUREMENT	12/07/98
11) 75.0 KRAD IRRADIATION (0.609 KRADS/HOUR)	12/07/98
POST-75.0 KRAD ELECTRICAL MEASUREMENT	12/09/98
12) 100.0 KRAD IRRADIATION (0.609 KRADS/HOUR)	12/09/98
POST-100.0 KRAD ELECTRICAL MEASUREMENT	12/11/98
13) 168 HOUR ANNEALING @25°C	12/11/98
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	12/18/98
14) 288 HOUR ANNEALING @25°C	12/18/98
POST-288 HOUR ANNEAL ELECTRICAL MEASUREMENT	12/23/98

Effective Dose Rate = 100,000 RADS/24 DAYS=173.6 RADS/HOUR=0.05 RADS/SEC

PARTS WERE IRRADIATED AND ANNEALED UNDER BIAS, SEE FIGURE 1.

Table III. Electrical Characteristics of KM684002AJ-17 /1

Test #	Parameter	Units	Test Conditions /2	Spec. Lim. min	Spec. Lim. max
			Functional Tests		
A	**Checkerboard 20MHz**	**P/F**	**Write/Read Checkerboard in 64k steps, f = 20MHz, V_{IL} = 0.8V, V_{IH} = 2.2V, V_{OH} = 0.5V, V_{OL} = 0.5V**	**/3**	
B	**Checkerboard 5MHz**	**P/F**	**Write/Read Checkerboard in 64k steps, f = 5MHz, V_{IL} = 0.8V, V_{IH} = 2.2V, V_{OH} = 0.5V, V_{OL} = 0.5V**	**/3**	
C	**Inverse Checkerboard 20MHz**	**P/F**	**Write/Read Inverse Checkerboard in 64k steps, f = 20MHz, V_{IL} = 0.8V, V_{IH} = 2.2V, V_{OH} = 0.5V, V_{OL} = 0.5V**	**/3**	
D	**Inverse Checkerboard 5MHz**	**P/F**	**Write/Read Inverse Checkerboard in 64k steps, f = 5MHz, V_{IL} = 0.8V, V_{IH} = 2.2V, V_{OH} = 0.5V, V_{OL} = 0.5V**	**/3**	
			Parametric Tests		
1-8	**OE to Valid Output**	**ns**	**OE to Valid Output, V_{CC} = 5V**		**8**
11-18	**VOL /4**	**V**	**I_{OL} = 4mA, V_{CC} = 5V, V_{IL} = 0.8V, V_{IH} = 2.2V**		**0.4**
21-28	**VOH**	**V**	**I_{OH} = -4mA, V_{CC} = 5V, V_{IL} = 0.8V, V_{IH} = 2.2V**	**2.4**	
30-51	**IIL**	**nA**	**V_{CC} = 5.0V, V_{IN} = 0V**	**-2000**	**2000**
60-81	**IIH**	**nA**	**V_{CC} = 5.0V, V_{IN} = 5V**	**-2000**	**2000**
91-98	**ILO_IOZL**	**nA**	**V_{CC} = 5.0V, WE = 0V, CS = 5V, V_{OUT} = 0V**	**-2000**	**2000**
100	**ISB**	**mA**	**V_{CC} = 5.0V, CS = 2.2V, f = 5MHz**		**50**
101	**ISB1**	**mA**	**V_{CC} = 5.0V, CS = 2.2V, V_{IL} = 0.2V, V_{IH} = 4.8V**		**10**
102	**ICC**	**mA**	**V_{CC} = 5.0V, CS = 0.8V, f = 5MHz**		**165**

Notes:

1/ These are the manufacturer's non-irradiated data sheet specification limits. The manufacturer provided no post-irradiation limits at the time the tests were performed.

2/ Functional tests and AC parameters were done without output loading.

3/ The functional tests were performed in 64k x 8 bit blocks for a total of 8 functional tests per pattern per frequency for the 512k x 8 bit memory. See below for the sizing of the blocks for the functional tests.

4/ VOL was performed at I_{OL} = 4mA instead of 8mA because of problems with oscillations.

Each of the four (A - D) functional tests included these blocks.
Block 1 0k to 64k
Block 2 65k to 128k
Block 3 129k to 192k
Block 4 193k to 256k
Block 5 257k to 320k
Block 6 321k to 384k
Block 7 385k to 448k
Block 8 449k to 512k

TABLE IVa: Summary of Functional Tests after Total Dose Exposures and Annealing for KM684002AJ-17

				Total Dose Exposure (kRads Si)																						Annealing			
				Initial		2.5		5.0		7.5		10.0		13.0		16.0		20.0		30.0		50.0		75.0		100.0		168 hours @25°C		288 hours @25°C	
Test	Memory Block /1	Parameters	Units	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
		Functional Tests /2																													
A	1	Checkerboard 20MHz	P/F	P		P		P		P		P		P		P		P		P		P		3P/1F		F		P		P	
A	2	Checkerboard 20MHz	P/F	P		P		P		P		P		P		P		P		P		P		2P/2F		F		P		P	
A	3	Checkerboard 20MHz	P/F	P		P		P		P		P		P		P		P		P		P		2P/2F		F		P		P	
A	4	Checkerboard 20MHz	P/F	P		P		P		P		P		P		P		P		P		P		3P/1F		F		P		P	
A	5	Checkerboard 20MHz	P/F	P		P		P		P		P		P		P		P		P		P		F		F		P		P	
A	6	Checkerboard 20MHz	P/F	P		P		P		P		P		P		P		P		P		F		F		F		F		1P/3F	
A	7	Checkerboard 20MHz	P/F	P		P		P		P		P		P		P		P		P		P		1P/3F		F		P		P	
A	8	Checkerboard 20MHz	P/F	P		P		P		P		P		P		P		P		P		P		1P/3F		F		P		P	
B	1	Checkerboard 5MHz	P/F	P		P		P		P		P		P		P		P		P		P		P		F		P		P	
B	2	Checkerboard 5MHz	P/F	P		P		P		P		P		P		P		P		P		P		2P/2F		F		P		P	
B	3	Checkerboard 5MHz	P/F	P		P		P		P		P		P		P		P		P		P		3P/1F		F		P		P	
B	4	Checkerboard 5MHz	P/F	P		P		P		P		P		P		P		P		P		P		3P/1F		F		P		P	
B	5	Checkerboard 5MHz	P/F	P		P		P		P		P		P		P		P		P		P		1P/3F		F		P		P	
B	6	Checkerboard 5MHz	P/F	P		P		P		P		P		P		P		P		P		F		F		F		F		1P/3F	
B	7	Checkerboard 5MHz	P/F	P		P		P		P		P		P		P		P		P		P		2P/2F		F		P		P	
B	8	Checkerboard 5MHz	P/F	P		P		P		P		P		P		P		P		P		P		1P/3F		F		P		P	
C	1	Inverse Checkerboard 20MHz	P/F	P		P		P		P		P		P		P		P		P		P		1P/3F		F		P		P	
C	2	Inverse Checkerboard 20MHz	P/F	P		P		P		P		P		P		P		P		P		P		2P/2F		F		P		P	
C	3	Inverse Checkerboard 20MHz	P/F	P		P		P		P		P		P		P		P		P		P		F		F		P		P	
C	4	Inverse Checkerboard 20MHz	P/F	P		P		P		P		P		P		P		P		P		P		1P/3F		F		P		P	
C	5	Inverse Checkerboard 20MHz	P/F	P		P		P		P		P		P		P		P		P		P		1P/3F		F		P		P	
C	6	Inverse Checkerboard 20MHz	P/F	P		P		P		P		P		P		P		P		P		F		F		F		F		1P/3F	
C	7	Inverse Checkerboard 20MHz	P/F	P		P		P		P		P		P		P		P		P		P		F		F		P		P	
C	8	Inverse Checkerboard 20MHz	P/F	P		P		P		P		P		P		P		P		P		P		F		F		P		P	
D	1	Inverse Checkerboard 5MHz	P/F	P		P		P		P		P		P		P		P		P		P		1P/3F		F		P		P	
D	2	Inverse Checkerboard 5MHz	P/F	P		P		P		P		P		P		P		P		P		P		2P/2F		F		P		P	
D	3	Inverse Checkerboard 5MHz	P/F	P		P		P		P		P		P		P		P		P		P		2P/2F		F		P		P	
D	4	Inverse Checkerboard 5MHz	P/F	P		P		P		P		P		P		P		P		P		P		1P/3F		F		P		P	
D	5	Inverse Checkerboard 5MHz	P/F	P		P		P		P		P		P		P		P		P		P		1P/3F		F		P		P	
D	6	Inverse Checkerboard 5MHz	P/F	P		P		P		P		P		P		P		P		P		F		F		F		F		1P/3F	
D	7	Inverse Checkerboard 5MHz	P/F	P		P		P		P		P		P		P		P		P		P		1P/3F		F		P		P	
D	8	Inverse Checkerboard 5MHz	P/F	P		P		P		P		P		P		P		P		P		P		1P/3F		F		P		P	

Notes:

1/ The blocks are: Block 1 = 0k to 64k, Block 2 = 65k to 128k, Block 3 = 129k to 192k, Block 4 = 193k to 256k, Block 5 = 257k to 320k, Block 6 = 321k to 384k, Block 7 = 385k to 448k, and Block 8 = 449k to

2/ For the functional tests, P (F) indicates that all parts passed (failed) this test at this level. mP/nF implies that m parts passed and n parts failed this test at this lev

TABLE IVb: Summary of Parametric Electrical Measurements after Total Dose Exposures and Annealing for KM684002AJ-17 /1

					Total Dose Exposure (kRads Si)																								Annealing			
					Initial		2.5		5.0		7.5		10.0		13.0		16.0		20.0		30.0		50.0		75.0		100.0		168 hours @25°C		288 hours @25°C	
Test #	Parameters	Units	Spec. Lim. /2 min	max	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
	Parametric Tests																															
1-8	tOE to Valid Output	ns		8	6.2	0	6.2	0.1	6.0	0.1	6.1	0.2	6.3	0.1	6.0	0.1	5.8	0.1	5.9	0.2	5.8	0.2	6.3	0.2	85	67	3/		6.0	0.3	5.9	0.2
11-18	VOL	V		0.4	0.38	0.08	0.38	0.01	0.36	0.01	0.38	0.03	0.30	0.01	0.29	0.01	0.24	0.01	0.24	0.01	0.24	0.01	0.23	0.01	0.23	0.01	0.23	0.01	0.27	0.01	0.27	0.01
21-28	VOH	V	2.4		2.79	0.08	2.79	0.08	2.80	0.09	2.79	0.10	2.78	0.09	2.80	0.09	2.85	0.09	2.85	0.08	2.85	0.08	2.80	0.13	2.82	0.09	2.84	0.09	2.81	0.10	2.77	0.10
30-51	IIL	nA	-2000	2000	12	1	13	1	13	0	13	0	13	0	13	0	13	0	13	0	13	0	13	0	13	0	13	0	13	0	13	0
60-81	IIH	nA	-2000	2000	14	0	12	0	14	1	14	1	14	1	14	1	14	0	14	1	14	1	14	0	14	0	14	1	14	1	13	1
91-98	ILO	nA	-2000	2000	11	0	11	0	12	1	11	0	12	1	11	0	12	1	12	1	13	1	14	1	13	1	13	1	12	1	12	1
100	ISB	mA		50	7	0.4	7	0.4	7	0.4	7	0.4	7	0.4	7	0.4	7	0.4	7	0.4	7	0.4	10	0.7	28	7	63	15	32	8	12	2
101	ISB1	mA		10	6	0.4	6	0.4	6	0.4	6	0.4	6	0.4	6	0.4	6	0.4	6	0.4	6	0.4	9	0.7	27	7	61	15	31	8	11	2
102	ICC	mA		165	116	4	114	5	115	9	115	5	114	6	114	7	110	8	116	9	114	9	116	11	133	9	160	7	137	9	119	5

Notes:

1/ The mean and standard deviation values were calculated over the four parts irradiated in this testing. The control samples remained constant throughout testing and are not included in this table.

2/ These are manufacturer's pre-irradiation data sheet specification limits. No post-irradiation limits were provided by the manufacturer at the time the tests were performed.

3/ No reliable measurements of this parameter could be made at this level.

Radiation sensitive parameters: tOE, ISB, ISB1, Icc.