

UNISYS

DATE: June 6, 1995
 TO: A. Mecum/311
 FROM: K. Sahu/300.1 *KS*
 SUBJECT: Radiation Report on: 28C256
 Project: TOMS
 Control #: 12996
 Job #: ER52818
 Project part #: 5962-8852503ZC

PPM-95-147

cc: A. Sharma/311
 G. Kramer/311
 P. Suppa/405
 V. DiMarco/300.1
 OFA Library/300.1

A radiation evaluation was performed on 28C256 (EEPROM) to determine the total dose tolerance of these parts. A brief summary of the test results is provided below. For detailed information, refer to Tables I through IV and Figure 1.

The total dose testing was performed using a ⁶⁰Co gamma ray source. During the radiation testing, four parts were irradiated under bias (see Figure 1 for bias configuration), two parts were irradiated unbiased and two parts were used as control samples. The total dose radiation levels were 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 20, 25 and 30 krad*. The dose rate was between 0.02 and 0.30 krad/hour (see Table II for radiation schedule). After the 30 krad exposure, the parts were annealed for 264 hours at 25°C. After each radiation exposure, parts were electrically tested according to the test conditions and the specification limits** listed in Table III. These tests included two functional tests (READ CHKBD) at 0.5 Mhz, one with Vcc and Vih = 4.5 V and one with Vcc and Vih = 5.5 V.

All parts passed initial electrical measurements. The initial electrical measurements included six functional tests: three with Vcc = 4.5 V (WR/RD ZEROES, WR/RD ONES, WR/RD CHKBD) and the same three with Vcc = 5.5 V. Prior to the first irradiation, a checkerboard pattern was written into the parts to be irradiated. However, after the start of the radiation exposures, only the reading of the checkerboard pattern was performed after each irradiation step. No writing of zeroes, ones or the checkerboard was done after the start of the radiation. The tests were performed this way in order to determine if the parts retained the checkerboard pattern during the irradiation steps.

All parts passed all functional and parametric tests throughout all irradiation steps up to and including the 8 krad irradiation level. After the 9 krad irradiation, two of the biased parts (S/N 1313 and 1323) exceeded the maximum specification limit of 350 µA for ICCL3 and ICCH3, with readings of 1.031 and 1.023 mA, respectively, for S/N 1313 and 847 and 838 µA, respectively, for S/N 1323. All biased parts passed all other functional and parametric tests at this level. Both unbiased parts passed all functional and parametric tests at this level.

After the 10 krad irradiation, S/N 1313, 1323 and 1234 (all biased) exceeded the maximum specification limits for ICCL3 and ICCH3, with readings of 1180, 960 and 390 µA, respectively, for ICCL3 and 1180, 969 and 390 µA, respectively, for ICCH3. All biased parts passed all other functional and parametric tests at this level. Both unbiased parts passed all functional and parametric tests at this level.

* The term rads, as used in this document, means rads(silicon). All radiation levels cited are cumulative.

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

Between the 11 krad and 15 krad irradiation levels, degradation continued to be observed in ICCL3 and ICCH3, with readings increasing to as high as 6779 μA . In addition, S/N 1313 and 1323 (biased) exceeded the maximum specification limit of 3.00 μA for ICCL2 and ICCH2, with readings of up to 8139 μA .

After the 15 krad irradiation, all biased parts continued to exceed specification limits for ICCL3 and ICCH3, with readings ranging from 1093 to 8815 μA and S/N 1313 and 1323 (biased) exceeded specification limits for ICCL2 and ICCH2, with readings ranging from 7754 to 10140 μA . In addition, S/N 1313 exceeded the maximum specification limit of 10.0 μA for IOZH, with readings ranging from 15.2 to 18.4 μA . All biased parts passed all other functional and parametric tests at this level. Both unbiased parts passed all functional and parametric tests at this level.

After the 20 krad irradiation, all biased parts exceeded specification limits for ICCL2, ICCH2, ICCL3 and ICCH3, with readings ranging from 7.8 mA to 16 mA (the maximum the test setup could measure) for ICCL2 and ICCH2, and from 6490 to 16000 μA (the maximum the test setup could measure). In addition, S/N 1234 and 1313 exceeded specification limits for IOZH, with readings ranging from 11.0 to 57.8 μA , and S/N 1313 fell below the minimum specification limit of -10.0 μA for IOZL, with a reading of -18.5 μA . Data for the unbiased parts were not available at this level.

After the 25 krad irradiation, two biased samples (S/N 1313 and 1323) and one unbiased sample (S/N 1238) failed Functional Tests # 1 and 2. All biased parts exceeded specification limits for ICCL2, ICCH2, ICCL3 and ICCH3, with readings ranging from 8.6 mA to 16 mA (the maximum the test setup could measure) for ICCL2 and ICCH2, and from 7324 to 16000 μA (the maximum the test setup could measure) for ICCL3 and ICCH3. In addition, all biased parts exceeded specification limits for IOZH, with readings ranging from 14.0 to 120 μA . S/N 1313 and 1323 (biased) and S/N 1238 (unbiased) fell below the minimum specification limit for IOZL, with readings ranging from -15.9 to -37.4 μA (biased) and a reading of -107 μA (unbiased). S/N 1323 (biased) fell below the minimum specification limit for VOH, with a reading of 0.0 V. S/N 1238 (unbiased) fell below the minimum specification limit of 0.0 V for VOL, with a reading of -1.0 V and fell below the minimum specification limit of 2.4 V for VOH, with a reading of 1.2 V. S/N 1238 also fell below the minimum specification limit of -10.0 μA for IIL, with a reading of -41.7 μA . S/N 1241 (unbiased) passed all functional and parametric tests at this level.

After the 30 krad irradiation, S/N 1313 and 1323 (biased) continued to fail Functional Tests # 1 and 2, while S/N 1238 (unbiased) passed both functional tests at this level. S/N 1238 also read within specification limits for all other parametric tests. All biased parts exceeded specification limits for ICCL2, ICCH2, ICCL3 and ICCH3, with readings ranging from 13.4 mA to 16 mA (the maximum the test setup could measure) for ICCL2 and ICCH2, and from 12130 to 16000 μA (the maximum the test setup could measure) for ICCL3 and ICCH3. In addition, all biased parts exceeded specification limits for IOZH, with readings ranging from 36.0 to 188 μA . S/N 1234, 1313 and 1323 (biased) fell below the minimum specification limit for IOZL, with readings ranging from -11.1 to -55.5 μA . Both unbiased parts passed all functional and parametric tests at this level.

After annealing for 264 hours at 25°C, no recovery was observed.

Table IV provides a summary of the functional test results and the mean and standard deviation values for each parameter for both biased and unbiased parts after each irradiation exposure and annealing step.

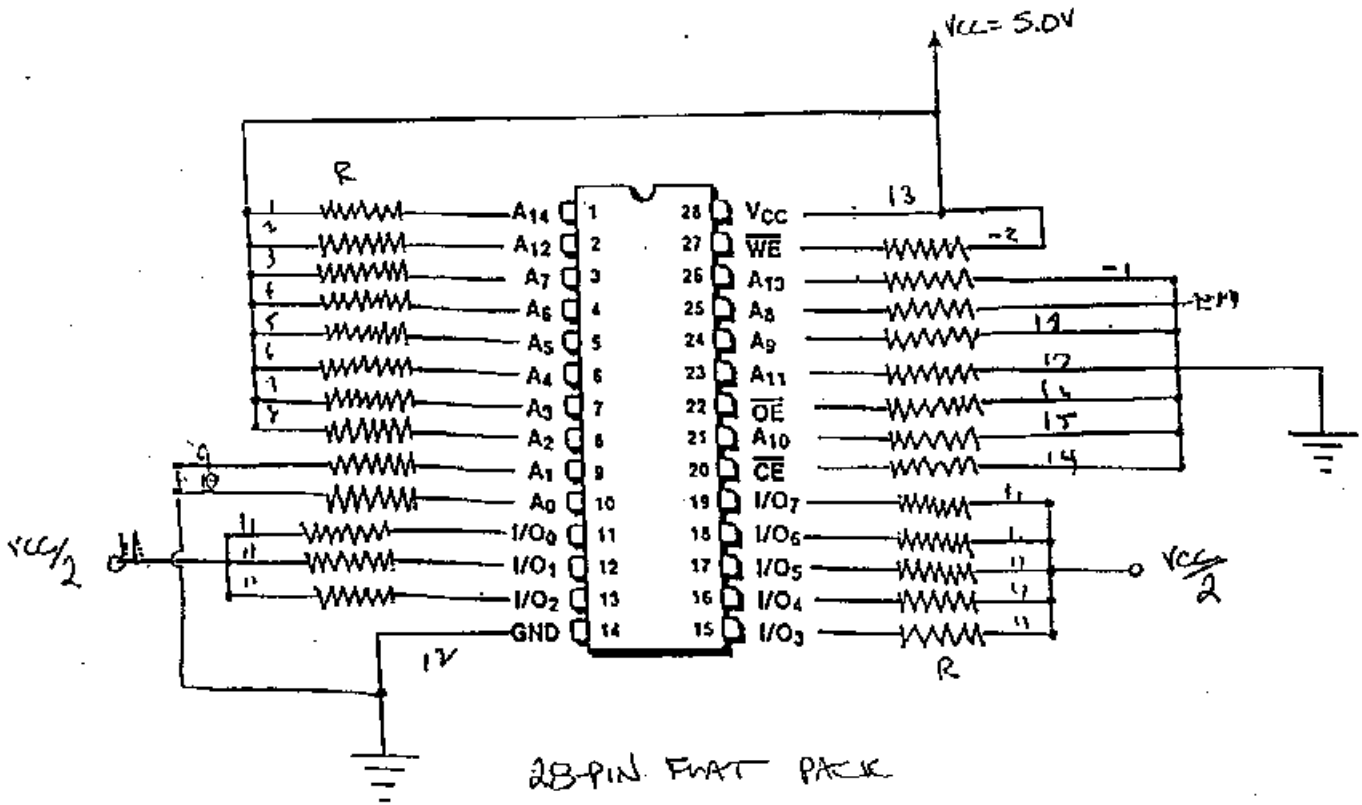
Any further details about this evaluation can be obtained upon request. If you have any questions, please call me at (301) 731-8954.

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Figure 1. Radiation Bias Circuit for 28C256



- 1) $V_{cc} = +5.0 \text{ VDC} \pm 0.5 \text{ VDC}$, $V_{cc}/2 = 2.5 \text{ VDC} \pm 0.25 \text{ VDC}$
- 2) All resistors $R = 2.0\text{K Ohms} \pm 10\%$, $1/4 \text{ W}$

TABLE I. Part Information

Generic Part Number:	28C256*
TOMS Part Number	5962-8852503ZC
TOMS Control Number:	12996
Charge Number:	ER52818
Manufacturer:	SEEQ
Lot Date Code (LDC):	9133B
Quantity Tested:	8
Serial Number of Control Samples:	1245, 1242
Serial Numbers of Biased Radiation Samples:	1313, 1323, 1321, 1234
Serial Numbers of Unbiased Radiation Samples:	1238, 1241
Part Function:	EEPROM
Part Technology:	MOSFET
Package Style:	28-pin Flatpack
Test Equipment:	S-50
Engineer:	K. Kim

* No radiation tolerance/hardness was guaranteed by the manufacturer for this part.

TABLE II. Radiation Schedule for 28C256

EVENT	DATE
1) INITIAL ELECTRICAL MEASUREMENTS	04/18/95
2) 0.5 KRAD IRRADIATION (0.029 KRADS/HOUR)*	04/18/95
POST-0.5 KRAD ELECTRICAL MEASUREMENT	04/19/95
3) 1.0 KRAD IRRADIATION (0.029 KRADS/HOUR)	04/19/95
POST-1.0 KRAD ELECTRICAL MEASUREMENT	04/20/95
4) 1.5 KRAD IRRADIATION (0.029 KRADS/HOUR)	04/20/95
POST-1.5 KRAD ELECTRICAL MEASUREMENT	04/21/95
5) 2.0 KRAD IRRADIATION (0.026 KRADS/HOUR)	04/21/95
POST-2.0 KRAD ELECTRICAL MEASUREMENT	04/22/95
6) 2.5 KRAD IRRADIATION (0.027 KRADS/HOUR)	04/22/95
POST-2.5 KRAD ELECTRICAL MEASUREMENT	04/23/95
7) 3.0 KRAD IRRADIATION (0.03 KRADS/HOUR)	04/23/95
POST-3.0 KRAD ELECTRICAL MEASUREMENT	04/24/95
8) 3.5 KRAD IRRADIATION (0.03 KRADS/HOUR)	04/24/95
POST-3.5 KRAD ELECTRICAL MEASUREMENT	04/25/95
9) 4.0 KRAD IRRADIATION (0.03 KRADS/HOUR)	04/25/95
POST-4.0 KRAD ELECTRICAL MEASUREMENT	04/26/95
10) 4.5 KRAD IRRADIATION (0.02 KRADS/HOUR)	04/26/95
POST-4.5 KRAD ELECTRICAL MEASUREMENT	04/27/95
11) 5.0 KRAD IRRADIATION (0.03 KRADS/HOUR)	04/27/95
POST-5.0 KRAD ELECTRICAL MEASUREMENT	04/28/95
12) 6.0 KRAD IRRADIATION (0.06 KRADS/HOUR)	05/02/95
POST-6.0 KRAD ELECTRICAL MEASUREMENT	05/03/95
13) 7.0 KRAD IRRADIATION (0.06 KRADS/HOUR)	05/03/95
POST-7.0 KRAD ELECTRICAL MEASUREMENT	05/04/95
14) 8.0 KRAD IRRADIATION (0.06 KRADS/HOUR)	05/04/95
POST-8.0 KRAD ELECTRICAL MEASUREMENT	05/05/95
15) 9.0 KRAD IRRADIATION (0.02 KRADS/HOUR)	05/05/95
POST-9.0 KRAD ELECTRICAL MEASUREMENT	05/08/95
16) 10.0 KRAD IRRADIATION (0.06 KRADS/HOUR)	05/08/95
POST-10.0 KRAD ELECTRICAL MEASUREMENT	05/09/95
17) 11.0 KRAD IRRADIATION (0.06 KRADS/HOUR)	05/10/95
POST-11.0 KRAD ELECTRICAL MEASUREMENT	05/12/95

18) 12.0 KRAD IRRADIATION (0.02 KRADS/HOUR)	05/12/95
POST-12.0 KRAD ELECTRICAL MEASUREMENT.....	05/15/95
19) 13.0 KRAD IRRADIATION (0.06 KRADS/HOUR)	05/15/95
POST-13.0 KRAD ELECTRICAL MEASUREMENT.....	05/16/95
20) 14.0 KRAD IRRADIATION (0.06 KRADS/HOUR)	05/16/95
POST-14.0 KRAD ELECTRICAL MEASUREMENT.....	05/17/95
21) 15.0 KRAD IRRADIATION (0.06 KRADS/HOUR)	05/17/95
POST-15.0 KRAD ELECTRICAL MEASUREMENT.....	05/18/95
22) 20 KRAD IRRADIATION (0.30 KRADS/HOUR)	05/22/95
POST-20 KRAD ELECTRICAL MEASUREMENT.....	05/23/95
23) 25 KRAD IRRADIATION (0.29 KRADS/HOUR)	05/23/95
POST-25 KRAD ELECTRICAL MEASUREMENT.....	05/24/95
24) 30 KRAD IRRADIATION (0.29 KRADS/HOUR)	05/24/95
POST-30 KRAD ELECTRICAL MEASUREMENT.....	05/25/95
25) 264-HOUR ANNEALING @25°C.....	05/25/95
POST-264 HOUR ANNEAL ELECTRICAL MEASUREMENT	06/05/95

*The radiation steps were performed in increments as small as 0.5 krad due to the fact that, in an earlier test (report no. PPM-95-141), parts from a similar LDC showed degradation at less than 2.5 krad.

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

Table III. Electrical Characteristics of 28C256

INITIAL EM'S FUNCTIONAL TESTS PERFORMED									
PARAMETER	VCC	VIL	VIH	PATTERN	CONDITIONS	PINS	LIMITS		
FUNCT # 1	4.5V	0.0V	4.5V	WR/RD ZEROS	FREQ=0.5 MHZ	I/O'S	VOL<1.0V	VOH>2.0V	
FUNCT # 2	4.5V	0.0V	4.5V	WR/RD ONES	FREQ=0.5 MHZ	I/O'S	VOL<1.0V	VOH>2.0V	
FUNCT # 3	4.5V	0.0V	4.5V	WR/RD CHKBD	FREQ=0.5 MHZ	I/O'S	VOL<1.0V	VOH>2.0V	
FUNCT # 4	5.5V	0.0V	5.5V	WR/RD ZEROS	FREQ=0.5 MHZ	I/O'S	VOL<1.0V	VOH>2.0V	
FUNCT # 5	5.5V	0.0V	5.5V	WR/RD ONES	FREQ=0.5 MHZ	I/O'S	VOL<1.0V	VOH>2.0V	
FUNCT # 6	5.5V	0.0V	5.5V	WR/RD CHKBD	FREQ=0.5 MHZ	I/O'S	VOL<1.0V	VOH>2.0V	
POST RADIATION/ANNEALING EM'S FUNCTIONAL TESTS PERFORMED									
PARAMETER	VCC	VIL	VIH	PATTERN	CONDITIONS	PINS	LIMITS		
FUNCT # 1	4.5V	0.0V	4.5V	READ CHKBD	FREQ=0.5 MHZ	I/O'S	VOL<1.0V	VOH>2.0V	
FUNCT # 2	5.5V	0.0V	5.5V	READ CHKBD	FREQ=0.5 MHZ	I/O'S	VOL<1.0V	VOH>2.0V	
DC PARAMETRIC TESTS PERFORMED									
PARAMETER	VCC	VIL	VIH	CONDITIONS	PINS	LIMITS @ +25C			
VOL	4.5V	0.8V	2.0V	LOAD = +2.1MA	OUTS	> 0.0V	< 0.45V		
VOH	4.5V	0.8V	2.0V	LOAD = -400UA	OUTS	> 2.4V	< 4.5V		
IIL	5.5V	0.1V	5.5V	TSTV = +0.1V	INS	> -10UA	< +10UA		
IIL	5.5V	0.0V	5.5V	TSTV = +5.5V	INS	> -10UA	< +10UA		
IOZL	5.5V	0.1V	5.5V	TSTV = +0.1V	OUTS	> -10UA	< +10UA		
IOZH	5.5V	0.0V	5.5V	TSTV = +5.5V	OUTS	> -10UA	< +10UA		
IOE	5.5V	0.0V	5.5V	TSTV = +13.0V	OE	> -10UA	< +100UA		
ICCL1	5.5V	0.0V	5.5V	FREQ = 5.0MHZ	VCC	> OMA	< 80MA		
ICCL2	5.5V	0.8V	2.0V	CE=VIH, VI&OE=VIL	VCC	> OMA	< 3MA		
ICCH2	5.5V	0.8V	2.0V	VI&CE=VIH, OE=VIL	VCC	> OMA	< 3MA		
ICCL3	5.5V	0.0V	5.2V	CE=VIH, VI=VIL	VCC	> OUA	< 350UA		
ICCH3	5.5V	0.0V	5.2V	CE=VIH, VI=VIH	VCC	> OUA	< 350UA		
AC PARAMETRIC TESTS									
PARAMETER	VCC	VIL	VIH	CONDITIONS	PINS	LIMITS @ +25C			
TAVQVLH	4.5V	0.4V	2.4V	VCOMP = 2.0V	A->Q	>0NS	<250NS		
TAVQVHL	4.5V	0.4V	2.4V	VCOMP = 0.8V	A->Q	>0NS	<250NS		

The initial electrical measurements included six functional tests: three with Vcc = 4.5 V (WR/RD ZEROES, WR/RD ONES, WR/RD CHKBD) and the same three with Vcc = 5.5 V. Prior to the first irradiation, a checkerboard pattern was written into the parts to be irradiated. However, after the start of the radiation exposures, only the reading of the checkerboard pattern (FUNCT1 and FUNCT2) was performed after each irradiation step. No writing of zeroes, ones or the checkerboard was done after the start of the radiation. The tests were performed this way in order to determine if the parts retained the checkerboard pattern during the irradiation steps. This was done at the request of the project.

TABLE IV: Summary of Electrical Measurements after Total Dose Exposures and Annealing for 28C256 /1

# Functional Tests /2		Pattern		Total Dose Exposure (krads)																
				Initial				0.5				1.0				1.5				
				Biased		Unbiased		Biased		Unbiased		Biased		Unbiased		Biased		Unbiased		
1	V _{cc} =4.5V, V _I =0.1V, V _{ih} =4.5V, F _{req} =0.5MHz	READ CHECKED		P		P		P		P		P		P		P		P		
2	V _{cc} =5.5V, V _I =0.1V, V _{ih} =5.5V, F _{req} =0.5MHz	READ CHECKED		P		P		P		P		P		P		P		P		
# Parameters		Spec. Lim./3		Initial				0.5				1.0				1.5				
		Units	min	max	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
1	VOL	mV	0	450	84.0	1.9	77.6	2.0	79.0	1.8	77.4	1.8	78.9	1.9	77.3	1.8	79.0	2.0	77.2	2.0
2	VOH	V	2.4	4.5	3.69	.01	3.68	0	3.69	.01	3.69	.01	3.69	.01	3.69	.01	3.69	.01	3.69	.01
3	IL	µA	-10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	I _{ih}	µA	-10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	IOZL	µA	-10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	IOZH	µA	-10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	IOE	µA	-10	100	6.86	.50	6.08	.07	6.90	.50	6.10	.07	6.95	.51	6.16	.06	6.96	.50	6.18	.08
8	ICC1	mA	0	80	6.67	.28	6.34	.02	6.78	.29	6.39	.04	6.79	.31	6.44	.04	6.81	.29	6.49	.02
9	ICCL2	mA	0	3	1.70	.03	1.74	.01	1.68	.03	1.74	.01	1.67	.03	1.72	.01	1.66	.02	1.71	.02
10	ICCH2	mA	0	3	1.69	.03	1.73	.02	1.69	.03	1.73	.01	1.68	.02	1.73	.01	1.67	.02	1.71	.01
11	ICCL3	µA	0	350	40.0	3.5	46.0	0	39.5	2.4	39.0	0	39.0	0	39.0	0	41.0	3.5	47.0	0
12	ICCH3	µA	0	350	35.8	3.9	38.0	0	37.3	3.7	38.2	0	41.0	3.5	39.0	0	43.0	4.0	43.0	4.0
13	TAVQVLH /4	ns	0	250	93.8	.29	83.4	6.3	84.4	6.2	85.1	6.0	88.5	7.7	87.0	6.1	85.8	31	86.9	6.0
14	TAVQVHL /4	ns	0	250	31.3	.17	78.9	1.2	78.5	3.5	80.0	1.1	78.1	14	82.4	1.2	78.7	15	82.2	1.2

Notes:

- 1/ The mean and standard deviation values were calculated over the four biased and two unbiased parts irradiated in this testing. The control samples remained constant throughout the testing and are not included in this table.
- 2/ "P" indicates that all parts passed this test at this irradiation or annealing level. "F" indicates that all parts failed this test at this irradiation or annealing level. "nPmF" indicates that n parts passed and m parts failed this test at this irradiation or annealing level.
- 3/ These are manufacturer's pre-irradiation data sheet specification limits. No post-irradiation limits were provided by the manufacturer at the time these tests were performed.
- 4/ Due to fluctuations in the test equipment, some parts, including the control samples, failed these tests randomly after some radiation steps. These readings are not included in the statistics.
- 5/ Data for these parts at this level were not available.

TABLE IV (Cont'd.): Summary of Electrical Measurements after Total Dose Exposures and Annealing for 28C256 /1

# Functional Tests /2		Pattern		Total Dose Exposure (krads)																
				2.0				2.5				3.0				3.5				
				Biased		Unbiased		Biased		Unbiased		Biased		Unbiased		Biased		Unbiased		
1	V _{cc} =4.5V, V _{ih} =0.0V, V _{ih} =4.5V, Freq.=4.5MHz	READ	CHKBD	P		F		P		P		P		P		P		P		
2	V _{cc} =5.5V, V _{ih} =0.0V, V _{ih} =5.5V, Freq.=4.5MHz	READ	CHKBD	P		F		P		P		P		P		P		P		
# Parameters		Units	Spec. Lim./3		2.0				2.5				3.0				3.5			
			min	max	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
1	VOL	mV	0	450	80.3	1.9	78.7	2.1	79.9	1.8	78.2	1.8	79.2	1.8	77.3	1.8	79.1	1.8	77.3	2.1
2	VOH	V	2.4	4.5	3.69	.01	3.68	0	3.69	.01	3.69	.01	3.69	.01	3.69	0	3.70	.01	3.69	0
3	IIL	μA	-10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	IIH	μA	-10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	IOZL	μA	-10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	IOZH	μA	-10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	IOE	μA	-10	100	6.92	.50	6.14	.08	6.99	.52	6.19	.06	7.06	.53	6.30	.09	7.09	.51	6.30	.07
8	ICC1	mA	0	80	6.78	.32	6.40	.04	6.83	.31	6.49	.02	6.91	.30	6.55	.04	6.93	.30	6.56	.02
9	ICCL2	mA	0	3	1.64	.02	1.69	.02	1.63	.02	1.69	.01	1.63	.02	1.69	.01	1.63	.02	1.68	.01
10	ICCH2	mA	0	3	1.64	.02	1.69	.02	1.63	.02	1.69	.02	1.63	.02	1.69	.02	1.62	.03	1.68	.01
11	ICCL3	μA	0	350	41.0	3.5	34.5	4.5	38.8	6.0	47.0	0	38.8	6.0	43.0	4.0	36.5	7.1	39.0	0
12	ICCH3	μA	0	350	41.0	3.5	39.0	0	43.0	4.0	39.0	0	45.0	3.5	34.5	4.5	41.0	3.5	43.0	4.0
13	TAVQVLH /4	ns	0	250	84.9	8.7	83.8	6.2	85.2	7.9	83.4	6.1	85.3	7.2	83.1	5.9	85.3	6.9	83.3	5.9
14	TAVQVHL /4	ns	0	250	80.2	2.7	79.0	1.3	80.0	2.5	78.6	1.3	79.8	2.4	78.2	1.2	79.9	2.3	78.3	1.3

otes:

- 1/ The mean and standard deviation values were calculated over the four biased and two unbiased parts irradiated in this testing. The control samples remained constant throughout the testing and are not included in this table.
- 2/ "P" indicates that all parts passed this test at this irradiation or annealing level. "F" indicates that all parts failed this test at this irradiation or annealing level. "nPmF" indicates that n parts passed and m parts failed this test at this irradiation or annealing level.
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- 4/ Due to fluctuations in the test equipment, some parts, including the control samples, failed these tests randomly after some radiation steps. These readings are not included in the statistics.
- 5/ Data for these parts at this level were not available.

TABLE IV (Cont'd.): Summary of Electrical Measurements after Total Dose Exposures and Annealing for 28C256 /1

		Total Dose Exposure (krads)																		
		4.0				4.5				5.0				6.0						
# Functional Tests /2	Pattern	Biased		Unbiased		Biased		Unbiased		Biased		Unbiased		Biased		Unbiased				
1	V _{cc} =4.5V, V _I =-0.9V, V _{Ih} =4.5V, F _{req.} =0.5MHz	READ	CHK	BKD	P		P		P		P		P		P		P			
2	V _{cc} =5.5V, V _I =-0.9V, V _{Ih} =5.5V, F _{req.} =0.5MHz	READ	CHK	BKD	P		P		P		P		P		P		P			
# Parameters	Units	Spec. Lim./3		4.5				5.0				6.0								
		min	max	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd			
1	VOL	mV	0	450	79.1	2.1	78.7	2.0	78.6	2.0	76.4	1.9	78.6	2.0	76.4	1.9	78.4	2.0	76.6	2.0
2	VOH	V	2.4	4.5	3.70	.01	3.69	.01	3.70	.01	3.70	0	3.70	.01	3.70	0	3.70	.01	3.70	0
3	IIL	μA	-10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	IIH	μA	-10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	IOZL	μA	-10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	IOZH	μA	-10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	IOE	μA	-10	100	7.14	.50	6.28	.08	7.17	.49	6.41	.05	7.17	.49	6.41	.05	7.27	.51	6.47	.09
8	ICC1	mA	0	80	6.96	.31	6.58	.04	7.02	.29	6.71	.02	7.02	.29	6.71	.02	7.14	.27	6.78	.02
9	ICCL2	mA	0	3	1.62	.02	1.66	.02	1.61	.02	1.68	.01	1.61	.02	1.68	.01	1.62	.02	1.65	.02
10	ICCH2	mA	0	3	1.62	.02	1.66	.02	1.61	.01	1.68	.02	1.61	.01	1.70	.02	1.61	.02	1.66	.01
11	ICCL3	μA	0	350	38.8	6.0	39.0	0	43.0	4.0	39.0	0	43.0	4.0	39.0	0	69.5	33	34.5	4.5
12	ICCH3	μA	0	350	45.0	3.5	43.0	4.0	40.8	7.0	43.0	4.0	40.8	7.0	43.0	4.0	75.5	32	30.0	0
13	TAVQVLH /4	ns	0	250	85.3	6.7	83.5	6.0	85.3	6.4	82.7	5.6	85.3	6.4	82.7	5.6	85.6	5.6	83.1	5.3
14	TAVQVHL /4	ns	0	250	79.6	2.3	78.5	1.3	79.5	2.3	77.6	1.2	79.5	2.3	77.6	1.2	79.2	2.2	77.8	1.2

otes:

1/ The mean and standard deviation values were calculated over the four biased and two unbiased parts irradiated in this testing.

The control samples remained constant throughout the testing and are not included in this table.

2/ "P" indicates that all parts passed this test at this irradiation or annealing level. "F" indicates that all parts failed this test at this irradiation or annealing level. "nPmF" indicates that n parts passed and m parts failed this test at this irradiation or annealing level.

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

4/ Due to fluctuations in the test equipment, some parts, including the control samples, failed these tests randomly after some radiation steps. These readings are not included in the statistics.

5/ Data for these parts at this level were not available.

TABLE IV (Cont'd.): Summary of Electrical Measurements after Total Dose Exposures and Annealing for 28C256 /1

# Functional Tests /2		Pattern		Total Dose Exposure (krads)																
				7.0				8.0				9.0				10.0				
				Biased		Unbiased		Biased		Unbiased		Biased		Unbiased		Biased		Unbiased		
1	V _{cc} =4.5V, V _I =0.0V, V _{ih} =4.5V, Freq.=0.5MHz	READ	CHKBD	P		P		P		P		P		P		P		P		
2	V _{cc} =5.5V, V _I =0.0V, V _{ih} =5.5V, Freq.=0.5MHz	READ	CHKBD	P		P		P		P		P		P		P		P		
# Parameters		Units	Spec. Lim./3		7.0				8.0				9.0				10.0			
			min	max	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
1	VOL	mV	0	450	79.2	1.9	77.3	1.7	77.5	1.9	76.1	1.8	79.1	2.0	76.6	1.9	195	281	86.3	1.7
2	VOH	V	2.4	4.5	3.70	.02	3.70	0	3.71	.01	3.71	.01	3.71	.01	3.71	.01	3.14	.01	3.14	.01
3	IIL	μA	-10	10	0	0	0	0	0	0	0	0	-0.02	.04	0	0	-0.03	.06	0	0
4	IIH	μA	-10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	.01	0	0
5	IOZL	μA	-10	10	0	0	0	0	0	0	0	0	-0.01	.02	0	0	0	.07	0	0
6	IOZH	μA	-10	10	0	0	0	0	0	0	0	0	0.01	.02	0	0	0.04	.11	0	0
7	IOE	μA	-10	100	7.23	.52	6.44	.06	7.39	.51	6.56	.07	7.43	.49	6.65	.08	7.50	.50	6.72	.07
8	ICC1	mA	0	80	7.19	.29	6.76	.04	7.38	.25	6.89	.05	7.87	.32	7.01	.04	7.64	.36	6.67	.02
9	ICCL2	mA	0	3	1.62	.04	1.62	.01	1.70	.10	1.64	.01	2.06	.35	1.61	.02	1.53	.40	0.96	.01
10	ICCH2	mA	0	3	1.62	.04	1.63	.02	1.69	.10	1.65	.02	2.05	.35	1.60	.02	1.53	.40	0.96	.01
11	ICCL3	μA	0	350	100	61	34.5	4.5	173	116	40.0	0	582	369	35.5	4.5	675	410	39.0	0
12	ICCH3	μA	0	350	97.8	58	43.0	4.0	173	116	40.0	0	584	359	44.0	4.0	677	412	34.5	4.5
13	TAVQVLH /4	ns	0	250	85.9	5.8	83.3	5.8	84.9	5.3	83.1	5.1	85.3	5.1	83.5	5.1	/4		/4	
14	TAVQVHL /4	ns	0	250	79.6	2.3	78.3	1.3	79.0	2.0	77.5	1.2	79.3	2.2	77.8	1.2	/4		/4	

otes:

- 1/ The mean and standard deviation values were calculated over the four biased and two unbiased parts irradiated in this testing. The control samples remained constant throughout the testing and are not included in this table.
- 2/ "P" indicates that all parts passed this test at this irradiation or annealing level. "F" indicates that all parts failed this test at this irradiation or annealing level. "nPmF" indicates that n parts passed and m parts failed this test at this irradiation or annealing level.
- 3/ These are manufacturer's pre-irradiation data sheet specification limits. No post-irradiation limits were provided by the manufacturer at the time these tests were performed.
- 4/ Due to fluctuations in the test equipment, some parts, including the control samples, failed these tests randomly after some radiation steps. These readings are not included in the statistics.
- 5/ Data for these parts at this level were not available.

TABLE IV (Cont'd.): Summary of Electrical Measurements after Total Dose Exposures and Annealing for 28C256 /1

# Functional Tests /2		Pattern		Total Dose Exposure (krads)																
				11.0				12.0				13.0				14.0				
				Biased		Unbiased		Biased		Unbiased		Biased		Unbiased		Biased		Unbiased		
1	V _{cc} =4.5V, V _D =0.0V, V _{ih} =4.5V, F _{req} =0.5MHz	READ	CHKBD	P		P		P		P		3P1F		P		P		P		
2	V _{cc} =5.5V, V _D =0.0V, V _{ih} =5.5V, F _{req} =0.5MHz	READ	CHKBD	P		P		P		P		3P1F		P		P		P		
# Parameters		Units	Spec. Lim/3		11.0				12.0				13.0				14.0			
			min	max	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
1	VOL	mV	0	450	198	291	87.3	2.7	77.5	2.0	75.8	2.1	309	399	77.3	3.2	78.5	4.3	77.5	4.7
2	VOH	V	2.4	4.5	3.15	.01	3.14	.01	3.73	.02	3.73	.01	2.79	1.6	3.72	0	3.73	.02	3.73	0
3	IIL	μA	-10	10	-0.03	.06	0	0	-0.08	.13	0	0	-0.09	.17	0	0	-0.14	.21	0	0
4	IIH	μA	-10	10	0	0	0	0	0	0	0	0	1.08	2.6	0	0	0	0	0	0
5	IOZL	μA	-10	10	0.01	.10	0	0	-0.01	.57	0	0	0	.99	0	0	-0.04	1.5	0	0
6	IOZH	μA	-10	10	0.03	.20	0	0	0.50	1.2	0	0	0.99	2.3	0	0	1.62	3.6	0	0
7	IOE	μA	-10	100	7.61	.51	6.76	.09	7.68	.52	6.91	.09	7.70	.52	6.87	.10	7.78	.53	6.95	.08
8	ICC1	mA	0	80	7.80	.41	6.76	.04	9.52	1.1	7.32	.05	8.14	5.0	7.38	.04	11.4	2.5	7.43	.02
9	ICCL2	mA	0	3	1.57	.43	0.96	0	3.23	1.1	1.58	.02	3.38	2.5	1.55	.01	4.91	2.4	1.56	.01
10	ICCH2	mA	0	3	1.57	.43	0.96	.01	3.23	1.1	1.58	.01	3.38	2.5	1.55	.01	4.91	2.4	1.55	.01
11	ICCL3	μA	0	350	726	437	34.5	4.5	1808	1130	40.0	0	2331	2066	40.0	0	3515	2417	44.0	4.0
12	ICCH3	μA	0	350	725	443	39.0	0	1812	1134	44.0	4.0	2331	2066	40.0	0	3517	2416	35.5	4.5
13	TAVQVLH /4	ns	0	250	/4		/4		84.3	4.8	82.5	4.8	/4		83.6	4.8	84.5	4.7	83.2	4.7
14	TAVQVHL /4	ns	0	250	/4		76.9	20	79.3	2.2	77.2	1.1	/4		77.9	1.2	79.7	2.6	77.4	1.2

Notes:

1/ The mean and standard deviation values were calculated over the four biased and two unbiased parts irradiated in this testing.

The control samples remained constant throughout the testing and are not included in this table.

2/ "P" indicates that all parts passed this test at this irradiation or annealing level. "F" indicates that all parts failed this test at this irradiation or annealing level. "nPmF" indicates that n parts passed and m parts failed this test at this irradiation or annealing level.

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

4/ Due to fluctuations in the test equipment, some parts, including the control samples, failed these tests randomly after some radiation steps. These readings are not included in the statistics.

5/ Data for these parts at this level were not available.

TABLE IV (Cont'd.): Summary of Electrical Measurements after Total Dose Exposures and Annealing for 28C256 /1

# Functional Tests /2		Pattern		Total Dose Exposure (krads)																	
				15.0				20.0				25.0				30.0					
				Biased		Unbiased		Biased		Unbiased		Biased		Unbiased		Biased		Unbiased			
1	V _{cc} =4.5V, V _I =0.0V, V _{ih} =4.5V, Freq.=0.5MHz	READ	CHKBD	P		P		P		/5		2P2F		1P1F		2P2F		P			
2	V _{cc} =5.5V, V _I =0.0V, V _{ih} =5.5V, Freq.=0.5MHz	READ	CHKBD	P		P		P		/5		2P2F		1P1F		2P2F		P			
# Parameters		Units		Spec. Lim./3		15.0				20.0				25.0				30.0			
				min	max	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd		
1	VOL	mV		0	450	77.5	2.0	75.8	1.9	78.2	2.4	/5		78.3	2.9	38.0	730	78.3	3.5	74.8	2.0
2	VOH	V		2.4	4.5	3.72	.03	3.73	0	3.70	.05	/5		2.76	1.6	2.48	1.3	1.84	1.8	3.75	.01
3	IIL	μA		-10	10	-0.17	.26	0	0	-0.36	.53	/5		-0.55	.86	-199	1059	-0.73	1.2	0	0
4	I _{IH}	μA		-10	10	0	0	0	0	0	0	/5		0	0	0.86	1.2	0	0	0	0
5	IOZL	μA		-10	10	-0.15	2.2	0	0	-1.38	7.2	/5		-3.47	14	-52.2	52	-5.26	22	0	0
6	IOZH	μA		-10	10	2.52	5.4	0	0	11.0	18	/5		25.5	37	0	0	45.4	59	0	0
7	IOE	μA		-10	100	7.78	.55	6.97	.07	7.95	.54	/5		8.11	.58	7.29	.16	8.24	.58	7.51	.07
8	ICC1	mA		0	80	12.6	3.3	7.48	.04	24.9	6.0	/5		28.2	8.3	7.46	.67	32.7	9.0	8.38	.04
9	ICCL2	mA		0	3	5.90	3.2	1.54	.01	11.0	5.1	/5		13.7	3.0	3.92	2.4	15.3	1.1	1.47	.01
10	ICCH2	mA		0	3	5.90	3.2	1.54	.01	11.0	5.1	/5		13.7	3.0	3.64	2.1	15.3	1.1	1.47	.02
11	ICCL3	μA		0	350	4535	3193	48.0	0	10.3	5.7	/5		1307	3542	48.0	0	1503	1676	48.0	0
12	ICCH3	μA		0	350	4539	3197	44.0	4.0	1033	5697	/5		1308	3540	40.0	0	1504	1668	48.5	8.5
13	TAVQVLH /4	ns		0	250	85.1	4.9	83.5	4.7	85.0	6.3	/5		/4		/4		/4		83.3	4.4
14	TAVQVHL /4	ns		0	250	80.3	3.0	77.6	1.3	81.9	5.8	/5		/4		/4		/4		77.2	1.3

otes:

1/ The mean and standard deviation values were calculated over the four biased and two unbiased parts irradiated in this testing.

The control samples remained constant throughout the testing and are not included in this table.

2/ "P" indicates that all parts passed this test at this irradiation or annealing level. "F" indicates that all parts failed this test at this irradiation or annealing level. "nPmF" indicates that n parts passed and m parts failed this test at this irradiation or annealing level.

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

4/ Due to fluctuations in the test equipment, some parts, including the control samples, failed these tests randomly after some radiation steps. These readings are not included in the statistics.

5/ Data for these parts at this level were not available.

TABLE IV (Cont'd.): Summary of Electrical Measurements after Total Dose Exposures and Annealing for 28C256 /1

# Functional Tests /2		Pattern	Annealing					
			264 hrs@25°C					
			Biased		Unbiased			
1	V _{cc} =4.5V, V _I =0.0V, V _{ih} =4.5V, Freq.=0.5MHz	READ CHKBD	2P2F		P			
2	V _{cc} =5.5V, V _I =0.0V, V _{ih} =5.5V, Freq.=0.5MHz	READ CHKBD	2P2F		P			
# Parameters		Units	Spec. Lim./3		264 hrs@25°C			
			min	max	mean	sd		
1	VOL	mV	0	450	77.5	3.5	74.7	2.0
2	VOH	V	2.4	4.5	2.65	1.7	3.75	.01
3	IIL	μA	-10	10	-0.60	1.0	0	0
4	IIH	μA	-10	10	0	0	0	0
5	IOZL	μA	-10	10	-2.29	15	0	0
6	IOZH	μA	-10	10	37.2	51	0	0
7	IOE	μA	-10	100	8.31	.58	7.50	.07
8	ICC1	mA	0	80	30.4	10	8.34	.04
9	ICCL2	mA	0	3	13.8	2.9	1.48	.02
10	ICCH2	mA	0	3	13.8	2.9	1.47	.02
11	ICCL3	μA	0	350	1318	3402	48.0	0
12	ICCH3	μA	0	350	1319	3398	44.0	4.0
13	TAVQVLH /4	ns	0	250	/4		83.7	4.0
14	TAVQVHL /4	ns	0	250	/4		77.9	1.1

otes:

- 1/ The mean and standard deviation values were calculated over the four biased and two unbiased parts irradiated in this testing. The control samples remained constant throughout the testing and are not included in this table.
- 2/ "P" indicates that all parts passed this test at this irradiation or annealing level. "F" indicates that all parts failed this test at this irradiation or annealing level. "nPmF" indicates that n parts passed and m parts failed this test at this irradiation or annealing level.
- 3/ These are manufacturer's pre-irradiation data sheet specification limits. No post-irradiation limits were provided by the manufacturer at the time these tests were performed.
- 4/ Due to fluctuations in the test equipment, some parts, including the control samples, failed these tests randomly after some radiation steps. These readings are not included in the statistics.
- 5/ Data for these parts at this level were not available.