Government Systems Group

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DATE: August 7, 1995 PPM-95-169

TO: G. Kramer/311.0
FROM: K. Sahu/300.1 KS
SUBJECT: Radiation Report on TOMS
Part No. FM28C256
Control No. 13358

cc: A. Sharma/311.0
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A radiation evaluation was performed on FM28C256 (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 Co^{60} gamma ray source. During the radiation testing, four parts were irradiated under bias (see Figure 1 for bias configuration), and two parts were used as control samples. The total dose radiation levels were 2.5, 5, 7.5, 10, 20 and 30 krads*. The dose rate was between 0.08 and 0.59 krads/hour, depending on the total dose level (see Table II for radiation schedule). In previous testing of these parts (Report # PPM-95-147), parts were irradiated at extremely low dose rates (0.02-0.30 krads/hour), to a total dose of 30 krads over a period of 48 days, compared to a total dose of 30 krads over a period of 9 days in this report. After each radiation exposure and annealing treatment, 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 irradiated parts passed all electrical tests up to and including the 10 krad level. At the 15 krad irradiation level, all irradiated parts exceeded the maximum specification limit of 350 µA for ICCL3 and ICCH3 with readings in the range of 786 µA to 1716 µA. In addition S/N 1231 exceeded the maximum specification limit of 3 mA for ICCL2 and ICCH2 with a reading of 3.2 mA.

At the 20 krad irradiation level, all parts continued to exceed the maximum specification limit for ICCL3 and ICCH3 with readings in the range of 1891 µA to 7139 µA. In addition S/N 1231 exceeded the maximum specification limit of ±10 µA for IOZH with a reading of 18 µA and all parts exceeded the maximum specification limit for ICCL2 and ICCH2 with readings in the range of 3.3mA to 8.5 mA respectively.

After the 30 krad irradiation, all parts continued to exceed the maximum specification limit for ICCL3 and ICCH3, ICCL2 and ICCH2 with readings in the range of 1891 µA to 7139 µA and 12.4 mA to 16 mA respectively. In addition, all parts exceeded the maximum specification limit for IOZH with readings in the range of 38 µA and 104 µA. In addition S/N 1231 and S/N 1257 exceeded the maximum specification limit of ±10 µA for IOZL with readings in the range of 13 mA to -21mA respectively.

*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.

After annealing for 168 hours at 25°C, all parts continued to exceed the maximum specification limit for ICCL3 and ICCH3 with readings in the range of 768 μA to 3331 μA respectively and S/N 1231 and S/N 1236 continued to exceed the maximum specification limit for ICCL2 and ICCH2 with readings in the range of 3.5 mA to 4.7 mA. In addition S/N 1231 continued to exceed the maximum specification limit for IOZH with a reading of 13 μA and S/N 1252 and S/N 1257 exceeded the maximum specification limit for TAVQVLH with readings in the range of 280 nS to 1000nS respectively.

After annealing for 168 hours at 100°C, no rebound effects were observed in the parts.

In summary, comparing results from the previous report, in which the overall mean dose rate was approximately 0.6 krad/day to results in this report, in which the overall mean dose rate was approximately 3.3 krads/day, results in the parametric tests were, in most cases, approximately the same, and some functional failures (2 out of 4 parts) were observed at the 25 and 30 krad levels in the previous report, whereas in this case, at a 5-times higher dose rate, no functional failures were observed. It should be noted that the functional failures in the previous report may be due to variations in parts performance from the same lot, rather than directly due to dose rate effects.

Table IV provides a summary of the mean and standard deviation values for each parameter after different irradiation exposures 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.

TABLE I. Part Information

Generic Part Number:	28C256
TOMS Part Number:	5962-8852503ZC
TOMS Control Number:	13358
Charge Number:	C52822
Manufacturer:	Seeq Technology Inc
Lot Date Code:	9133B
Quantity Tested:	6
Serial Number of Control Samples:	1242, 1245
Serial Numbers of Radiation Samples:	1231, 1236, 1252, 1257
Part Function:	EEPROM
Part Technology:	CMOS
Package Style:	FP-28 pin
Test Equipment:	S-50
Test Engineer:	Ki Kim

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

TABLE II. Radiation Schedule for 28C256

EVENTS	DATE
1) INITIAL ELECTRICAL MEASUREMENTS	06/05/95
2) 2.5 KRAD IRRADIATION (0.15 KRADS/HOUR)	06/05/95
POST-2.5 KRAD ELECTRICAL MEASUREMENT	06/06/95
3) 5 KRAD IRRADIATION (0.15 KRADS/HOUR)	06/06/95
POST-5 KRAD ELECTRICAL MEASUREMENT	06/07/95
4) 7.5 KRAD IRRADIATION (0.15 KRADS/HOUR)	06/07/95
POST-7.5 KRAD ELECTRICAL MEASUREMENT	06/08/95
5) 10 KRAD IRRADIATION (0.15 KRADS/HOUR)	06/08/95
POST-10 KRAD ELECTRICAL MEASUREMENT	06/09/95
6) 15 KRAD IRRADIATION (0.08 KRADS/HOUR)	06/09/95
POST-15 KRAD ELECTRICAL MEASUREMENT	06/12/95
7) 20 KRAD IRRADIATION (0.29 KRADS/HOUR)	06/12/95
POST-20 KRAD ELECTRICAL MEASUREMENT	06/13/95
8) 30 KRAD IRRADIATION (0.59 KRADS/HOUR)	06/13/95
POST-30 KRAD ELECTRICAL MEASUREMENT	06/14/95
9) 168-HOUR ANNEALING @25°C	06/14/95
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	06/21/95
10) 168-HOUR ANNEALING @100°C*	06/21/95
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	06/28/95

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
IIH	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
ICC1	5.5V	0.0V	5.5V	FREQ = 5.0MHZ	VCC	> 0MA , < 80MA
ICCL2	5.5V	0.8V	2.0V	CE=VIH, VI&OE=VIL	VCC	> 0MA , < 3MA
ICCH2	5.5V	0.8V	2.0V	VI&CE=VIH, OE=VIL	VCC	> 0MA , < 3MA
ICCL3	5.5V	0.0V	5.2V	CE=VIH, VI=VIL	VCC	> 0UA , < 350UA
ICCH3	5.5V	0.0V	5.2V	CE=VIH, VI=VIH	VCC	> 0UA , < 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 (FUNC1 and FUNC2) 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

Test			Spec. Lim./2				Total Dose Exposure (krads)																Annealing			
					Initial		2.5		5		7.5		10		15		20		30				168 hrs @25°C		168 hrs @100°C	
#	Parameters	Units	min	max	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd			mean	sd	mean	sd
1	VOL	mV	0	450	79.4	2.04	80.2	2.67	78.6	2.16	78.7	1.98	77.0	1.97	75.9	1.84	75.6	1.92	77.3	2.90			75.0	2.64	75.2	2.22
2	VOH	V	2.4	4.5	3.68	0.01	3.68	0.02	3.69	0.01	3.69	0.01	3.71	0.01	3.73	0.02	3.73	0.03	3.66	0.07			3.69	0.06	3.75	0.02
3	IIL	nA	-10000	10000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-49.0	69.7	-0.14	0.19	-339	528			-298	455	-193	264
4	IIH	nA	-10000	10000	0.33	2.0	0.73	2.82	1.14	3.76	1.33	4.34	1.42	4.42	1.85	5.69	2.18	6.74	3.09	8.63			2.68	8.07	1.88	5.92
5	IOZL	nA	-10000	10000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.3	209	234	1668	-366	10.1			-97.4	8317	-992	2051
6	IOZH	nA	-10000	10000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	257	479	3364	4398	30994	33347			22973	25077	1100	2509
7	IOE	uA	-10	100	6.38	0.49	6.52	0.45	6.61	0.51	6.70	0.51	6.87	0.51	7.27	0.56	7.47	0.55	7.76	0.58			7.80	0.57	7.69	0.52
8	ICC1	mA	0	80	6.51	0.28	6.56	0.31	6.75	0.28	6.87	0.29	7.07	0.26	8.81	0.24	12.4	1.92	28.4	5.11			21.9	4.03	10.1	0.97
9	ICCL2	mA	0	3	1.75	0.02	1.71	0.03	1.68	0.02	1.66	0.02	1.67	0.04	2.72	0.34	5.78	1.95	15.2	1.54			12.6	2.89	3.26	0.97
10	ICCH2	mA	0	3	1.75	0.02	1.70	0.03	1.68	0.02	1.65	0.02	1.68	0.04	2.72	0.35	5.78	1.95	15.2	1.54			12.6	2.88	3.27	0.97
11	ICCL3	uA	0	350	41.7	7.01	44.8	3.92	39.7	6.01	46.0	3.46	85.7	22.8	1239	330	4363	1945	14792	2093			11636	3296	1953	939
12	ICCH3	uA	0	350	44.0	4.0	39.8	5.38	44.0	4.0	46.2	7.01	85.5	25.3	1244	331	4366	1946	14791	2088			11638	3289	1946	941
13	TAVQVLH	nS	0	250	86.3	5.89	86.9	6.61	85.3	5.69	85.3	5.66	84.1	5.46	82.9	4.75	82.9	4.30	85.9	4.37			84.8	4.01	31355	173970
14	TAVQVHL	nS	0	250	80.7	2.71	81.1	3.0	80.1	2.80	80.2	2.79	79.4	2.83	79.6	2.69	80.5	2.28	90.2	14.2			31332	173980	75.6	13.6
15	FUNC1, VCC=4.5V, VIL=0V, VIH=4.5V, 0.5MHz				P		P		P		P		P		P		P		P				P		P	
16	FUNC2, VCC=4.5V, VIL=0V, VIH=4.5V, 0.5MHz				P		P		P		P		P		P		P		P				P		P	

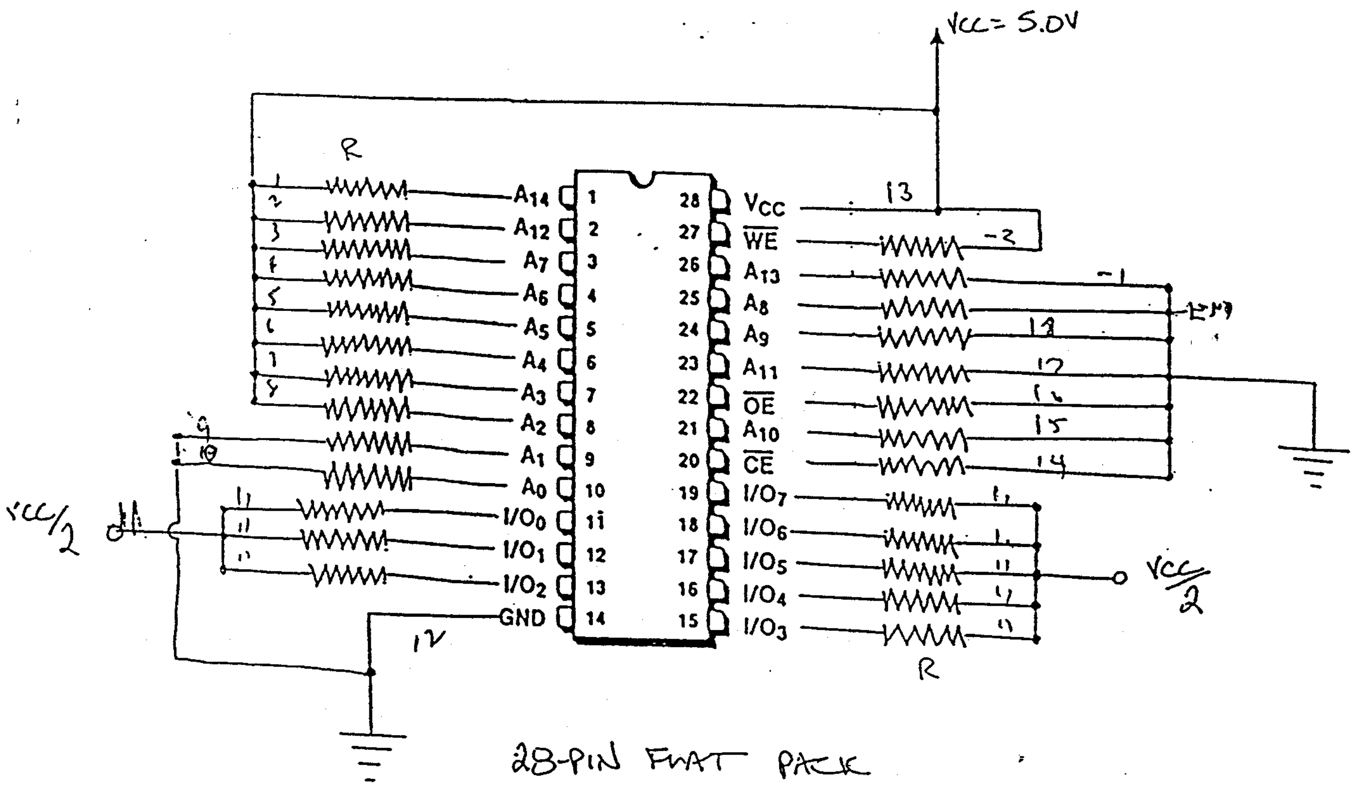
Notes:

1/ The mean and standard deviation values were calculated over the four parts irradiated in this testing. The control samples remained constant throughout the 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.

Radiation-sensitive parameters: IOZL, IOZH, ICCL2, ICCH2, ICCL3, ICCH3, TAVQVLH and TAVQVHL.

Figure 1. Radiation Bias Circuit for 28C256



1) Vcc = +5.0 VDC ± 0.5 VDC, Vcc/2 = 2.5 VDC ± 0.25 VDC

2) All resistors R = 2.0K Ohms ± 10%, 1/4 W