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To
T. Miccolis
Department
Code 300.1
From
K. Sahu ks
Department
7809
Subject
Radiation Report on 54AC04DMQB
SMEX Common Buy Part No. 5962-8760901CA
Control Number: 1644

PPM-92-009
Date
January 17, 1992
Location
Lanham
Telephone
731-8954
Location
Lanham
cc:
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A. Sharma/311
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A radiation evaluation was performed on 54AC04 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. Also, refer to PPM-91-376 for the test results of an earlier radiation testing on the same part type (however, note that the dose rate and total dose steps were different in the previous evaluation).

The total dose testing was performed using a cobalt-60 gamma ray source. During the radiation testing, eight parts were irradiated under bias (see Figure 1 for bias configuration), and two parts were used as control samples. The total dose radiation steps were 2.5, 5, 10, and 20 krads*. After 20 krads, the parts were allowed to anneal under bias at 25°C for 24 hours. The parts were further irradiated to 25, 55 and 105 krads (cumulative), and then allowed to anneal under bias for 24 and 168 hours at 25°C. The parts were finally annealed under bias at 100°C for 168 hours. The dose rate was between 60 to 500 rads per hour depending on the total dose level (see Table II for the radiation schedule). After each radiation exposure and annealing treatment, the parts were electrically tested at 25°C according to the test conditions and the specification limits listed in Table III. These tests included three functional tests at 1MHz (at VCC levels of 4.5V, 5.0V and 5.5V) after each radiation and annealing step.

All eight parts passed all functional tests throughout the radiation testing and all parametric tests on irradiation to 5 krads. At 10 krads, one part (SN 38) marginally exceeded the maximum specification limit of 80uA for ICCL (the reading was 85uA). At 20 krads, all parts exceeded the same specification limit for ICCH (readings ranged from 99uA to 1.3mA) and seven parts exceeded the specification limit for ICCL (readings ranged from 34uA to 1.6mA); however, all parts continued to pass all other tests. On annealing the parts for 24 hours at 25°C, one part (SN 39) recovered to pass all tests.

ICC readings continued to increase way beyond the specification limits on further irradiation to 25, 55 and 105 krad. No significant recovery was observed after annealing the parts for 24 and 168 hours at 25°C; however, after an additional annealing treatment for 168 hours at 100°C, a significant decrease in average ICC readings occurred and one part passed the ICCL test. Table IV provides the mean and standard deviation values for each parameter after each radiation exposure and annealing treatment. It also provides the functional test results after each radiation exposure and annealing treatment.

A comparison of these test results up to 10 krad at 60 rads/hour with the previous testing, which was performed at 555 rads/hour, shows that average ICCH readings at 10 krad were about 70% less for the parts exposed to the lower dose rate than the parts exposed to the higher dose rate. However, the two evaluations on 54AC04 showed similar degradation characteristics in the ICC tests on higher total doses to 100 krad. Refer to Table IV in both evaluations for a detailed comparison of the radiation degradation characteristics at different dose rates.

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

*In this report, the term "rads" is used as an abbreviation for rads (Si).

Table I. Part Information

Generic Part Number:	54AC04
SMEX Common Buy Part Number:	5962-8760901CA
SMEX Common Buy Control Number:	1644
Charge Number:	C90367
Manufacturer:	National Semiconductor Corp.
Lot Date Code:	9036A
Quantity Tested:	10
Serial Numbers of Radiation Samples:	32, 33, 34, 35 36, 37, 38, 39
Serial Numbers of Control Samples:	30, 31
Part Function:	Hex Inverter
Part Technology:	CMOS
Package Style:	14-pin DIP
Test Engineer:	R. Tosh

TABLE II. Radiation Schedule

EVENTS	DATE
1) Initial Electrical Measurements	09/10/91
2) 2.5 krads irradiation @ 60 rads/hr Post 2.5 krads Electrical Measurements	09/16/91 09/18/91
3) 5 krads irradiation @ 60 rads/hr Post 5 krads Electrical Measurements	09/18/91 09/20/91
4) 10 krads irradiation @ 60 rads/hr Post 10 krads Electrical Measurements	09/20/91 09/23/91
5) 20 krads irradiation @ 500 rads/hr Post 20 krads Electrical Measurements	09/23/91 09/24/91
6) 24 hrs annealing at 25°C Post 24 hr Electrical Measurements	09/24/91 09/25/91
7) 25 krads irradiation @ 120 rads/hr Post 25 krads Electrical Measurements	09/25/91 09/27/91
8) 55 krads irradiation @ 200 rads/hr Post 55 krads Electrical Measurements	09/27/91 10/03/91
9) 105 krads irradiation @ 180 rads/hr Post 105 krads Electrical Measurements	10/03/91 10/15/91
10) 24 hrs annealing at 25°C Post 24 hr Electrical Measurements	10/15/91 10/16/91
11) 168 hrs annealing at 25°C Post 168 hr Electrical Measurements	10/15/91 10/25/91
12) 168 hrs annealing at 100°C Post 168 hr Electrical Measurements	10/25/91 11/08/91

Notes:

- All parts were radiated under bias at the cobalt-60 gamma ray facility at GSFC.
- All electrical measurements were performed off-site at 25°C.
- All annealing performed under bias.

Table III. Electrical Characteristics of 54AC04 1)

Tests Performed						
Parameter	VCC	VIL	VIH	Conditions	Pins	Limits at 25°C
Funct #1	4.5V	0.0V	4.5V	Freq = 1MHz	All I/O	VOL<1.5V , VOH>1.5V
Funct #2	5.0V	0.0V	5.0V	Freq = 1MHz	All I/O	VOL<2.5V , VOH>2.5V
Funct #3	5.5V	0.0V	5.5V	Freq = 1MHz	All I/O	VOL<2.5V , VOH>2.5V
VOH1	3.0V	0.9V	2.1V	Load = -50uA	Outs	>2.9V , <3.0V
VOH2	3.0V	0.9V	2.1V	Load = -24mA	Outs	>2.4V , <3.0V
VOH3	4.5V	1.35V	3.15V	Load = -50mA	Outs	>4.4V , <4.5V
VOH4	4.5V	1.35V	3.15V	Load = -24mA	Outs	>3.7V , <4.5V
VOH5	5.5V	1.65V	3.85V	Load = -50mA	Outs	>5.4V , <5.5V
VOH6	5.5V	1.65V	3.85V	Load = -24mA	Outs	>4.7V , <5.5V
VOH7	5.5V	1.65V	3.85V	Load = -50mA	Outs	>3.85V , <5.5V
VOL1	3.0V	0.9V	2.1V	Load = +50uA	Outs	>0.0V , <0.1V
VOL2	3.0V	0.9V	2.1V	Load = +12mA	Outs	>0.0V , <0.5V
VOL3	4.5V	1.35V	3.15V	Load = +50mA	Outs	>0.0V , <0.1V
VOL4	4.5V	1.35V	3.15V	Load = +24mA	Outs	>0.0V , <0.5V
VOL5	5.5V	1.65V	3.85V	Load = +50mA	Outs	>0.0V , <0.1V
VOL6	5.5V	1.65V	3.85V	Load = +24mA	Outs	>0.0V , <0.5V
VOL7	5.5V	1.65V	3.85V	Load = +50mA	Outs	>0.0V , <1.65V
IIH	5.5V	0.0V	5.5V	VIN = 5.5V	INS	>0.0uA , <+1.0uA
IIL	5.5V	0.0V	5.5V	VIN = 0.0V	INS	>-1.0uA , < 0.0uA
ICCL	5.5V	0.0V	5.5V	VIN = 0.0V	VCC	>0A , < 80uA
ICCH	5.5V	0.0V	5.5V	VIN = 5.5V	VCC	>0A , < 80uA
Timing Tests Performed						
Parameter	VCC	VIL	VIH	Pins		Limits at 25°C
TPHL	4.5V	0.0V	4.5V	Out		>1ns , <7ns
TPLH	4.5V	0.0V	4.5V	Out		>1ns , <7ns
Note						
1) VIL & VIH were tested during VOL & VOH tests as GO/NOGO.						

TABLE IV: Summary of Electrical Measurements
after Total Dose Exposures and Annealing for 54AC04 1/, 2/

Parameters	Spec. Limits min max		Total Dose Exposure (krads)										Annealing at 25°C		
			Pre-Rad		2.5		5		10		20		24 hrs		
			mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	
Func1 VCC=4.5V			Pass		Pass		Pass		Pass		Pass		Pass		
Func2 VCC=5.0V			Pass		Pass		Pass		Pass		Pass		Pass		
Func3 VCC=5.5V			Pass		Pass		Pass		Pass		Pass		Pass		
VOH1	V	2.9	3.0	2.99	0	2.99	0	2.99	0	2.99	0	2.99	0	2.99	0
VOH2	V	2.4	3.0	2.93	0	2.93	0	2.92	.01	2.93	.01	2.93	0	2.93	.01
VOH3	V	4.4	4.5	4.49	0	4.49	0	4.49	.01	4.49	0	4.49	0	4.49	0
VOH4	V	3.7	4.5	4.19	.03	4.18	.03	4.15	.05	4.18	.02	4.18	.02	4.18	.02
VOH5	V	5.4	5.5	5.49	0	5.49	0	5.48	.01	5.49	0	5.49	0	5.49	0
VOH6	V	4.7	5.5	5.22	.03	5.21	.03	5.19	.04	5.21	.03	5.21	.02	5.21	.02
VOH7	V	3.85	5.5	4.91	.04	4.90	.04	4.85	.08	4.90	.04	4.90	.03	4.90	.04
VOL1	mV	0	100	0	0	0	0	0	0	0	0	0	0	0	0
VOL2	mV	0	500	150	8	154	9	158	11	149	8	150	6	148	7
VOL3	mV	0	100	0	0	1.1	1.8	1.4	2.5	0	0	0.9	1.9	0.8	1.7
VOL4	mV	0	500	216	16	227	19	238	30	218	15	218	11	214	12
VOL5	mV	0	100	3.0	2.4	3.3	3.6	4.8	3.9	1.6	2.3	3.9	3.0	2.4	3.0
VOL6	mV	0	500	192	16	201	20	212	37	192	15	193	12	189	12
VOL7	mV	0	1650	410	35	428	43	451	69	409	34	409	24	401	24
IIL	nA	-1000	0	0	0	0	0	0	0	0	0	0	0	0	0
IIH	nA	0	1000	0	0	0.4	1.6	0	0	0	0	0	0	0	0
ICCL	uA	0	80	0	0	0	0	.04	.04	41.1	33.2	1.0E3	497	975	483
ICCH	uA	0	80	0	0	0	0	0.2	0.2	42.8	26.4	862	381	815	374
TPLH	ns	1	7.0	5.9	0.3	4.5	0.3	4.5	0.3	4.6	0.3	4.6	0.3	4.5	0.3
TPHL	ns	1	7.0	6.4	0.3	5.0	0.3	5.0	0.3	5.0	0.3	4.9	0.3	4.9	0.3

<Table IV continued on next page>

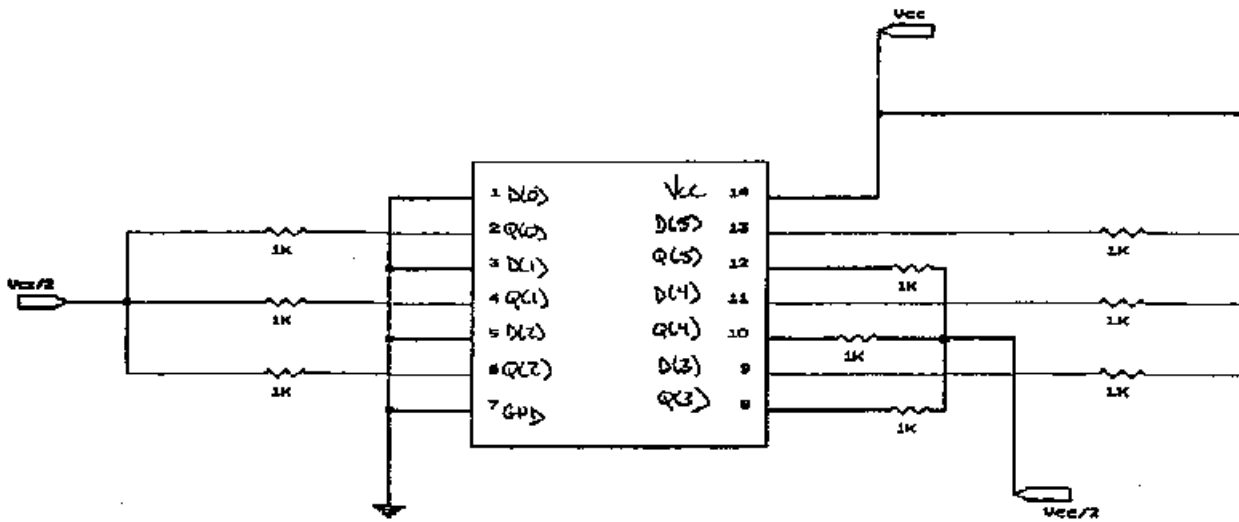
TABLE IV. (continued)

Parameters	Spec. Limits min max		Pre-Rad mean sd		Total Dose (krads)						Annealing at 25°C				Annealing at 100°C		
					25		55		105		24 hrs		168 hrs		168 hrs		
					mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean
Func1 VCC=4.5V			Pass		Pass		Pass		Pass		Pass		Pass		Pass		
Func2 VCC=5.0V			Pass		Pass		Pass		Pass		Pass		Pass		Pass		
Func3 VCC=5.5V			Pass		Pass		Pass		Pass		Pass		Pass		Pass		
VOH1	V	2.9	3.0	2.99	0	2.99	0	2.99	0	2.98	.01	2.98	.01	2.98	.01	2.99	.01
VOH2	V	2.4	3.0	2.93	0	2.92	.01	2.91	.01	2.91	.01	2.91	.01	2.91	.01	2.93	0
VOH3	V	4.4	4.5	4.49	0	4.49	.01	4.49	.01	4.48	.01	4.48	.01	4.48	.01	4.49	0
VOH4	V	3.7	4.5	4.19	.03	4.17	.02	4.16	.02	4.16	.02	4.16	.02	4.16	.03	4.20	.01
VOH5	V	5.4	5.5	5.49	0	5.48	.01	5.48	.01	5.48	.01	5.48	.01	5.48	.01	5.49	0
VOH6	V	4.7	5.5	5.22	.03	5.21	.02	5.20	.02	5.20	.02	5.20	.02	5.20	.03	5.24	.01
VOH7	V	3.85	5.5	4.91	.04	4.83	.12	4.80	.15	4.87	.04	4.88	.03	4.87	.07	4.94	.02
VOL1	mV	0	100	0	0	0.8	1.6	6.0	4.7	12	8	12	8	8.2	8	1.1	2.1
VOL2	mV	0	500	150	8	156	20	172	28	161	13	161	15	159	18	136	7
VOL3	mV	0	100	0	0	3.6	2.6	8.8	6.4	16	8	16	9	11	8	1.1	2.2
VOL4	mV	0	500	218	16	252	43	263	59	238	21	238	25	236	33	195	10
VOL5	mV	0	100	3.0	2.4	7.7	2.7	12.5	8.1	20	9	20	10	13	9	1.2	2.3
VOL6	mV	0	500	192	16	228	44	241	61	217	21	216	27	213	34	170	10
VOL7	mV	0	1650	410	35	466	111	531	183	443	40	441	49	442	73	362	19
IIL	nA	-1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
I IH	nA	0	1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ICCL	uA	0	80	0	0	1.7E3	740	6.4E3	1.9E3	13E3	2.7E3	13E3	2.7E3	12E3	2.8E3	3.0E3	2.4E3
ICCH	uA	0	80	0	0	1.5E3	614	6.9E3	1.9E3	14E3	2.8E3	14E3	2.8E3	14E3	2.8E3	4.0E3	2.6E3
TPLH	ns	1	7.0	5.9	0.3	4.6	0.3	4.8	0.3	4.3	0.4	4.4	0.7	4.0	0.4	3.3	0.3
TPHL	ns	1	7.0	6.4	0.3	4.9	0.3	4.9	0.2	4.3	0.3	4.5	0.5	4.7	0.3	3.7	0.3

Notes:

- 1/ The mean and standard deviation values were calculated over the eight parts irradiated in this testing. The control samples remained constant throughout the testing and are not included in this table.
- 2/ After pre-irradiation measurements, the software for AC testing was modified to speed up the propagation delay times, to reset the calibration of the S-50.

Figure 1. Radiation Bias Circuit for 54AC04



Vcc = 5.0 volts +/- .5 volts
 Vcc/2 = 2.5 volts +/- .25 volts
 ALL RESISTORS ARE 1/4 WATT