SAVE inc Survivability And Vulnerability Engineering

SAVE-R-RK50

Report # H20036

Dose Rate and Total Dose Test Report for the P1750 (171320-01) CMOS µProcessor

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1. ABSTRACT

The P1750 CMOS Microprocessor (SI P/N 171320-01) was tested for its response in dose rate (G) and total dose (D) environment. The characterization test on the device was done using samples from lots C5B9518D1 and C5B9518A3, manufactured by Performance Semiconductor Inc. This test was prompted because Performance Semiconductor changed fabrication facilities from their Sunnyvale facility to those of American Microsystems Inc. (AMI) in Pocatello, Idaho. This is a "major change", and re-characterization in radiation environment was required.

The G test was conducted at the Rockwell International (RI) radiation lab located in Anaheim, California on March 19, 1996. A Febetron 705 operating in Bremsstrahlung mode provided the x-ray environment. Six samples were tested to find the Upset (U), Latchup (LU), and Burnout (BO) threshold levels. The 0.50/90% log-normal U and LU threshold levels found were 9.00E+7 and 6.21E+8 rad(Si)/s, respectively. No BO was detected throughout the test for all samples. Using the highest G levels tested, the 0.50/90% log-normal BO threshold level calculated was 1.99E+10 rad(Si)/s. Note that true BO threshold level may be much higher.

The D test was conducted at the RI's Shepherd Model 109 Co60 source on March 19, 1996. Six samples previously used in the G test were tested with static bias configuration. The 0.50/90% log-normal failure threshold level found was 15.35 krad(Si). One parameter, the standby supply current Icc(stby), was monitored throughout the test. It has increased roughly 25 times, on the average, by the failure level.

Table 1-1 summarizes the test requirement for the P1750 microprocessor (μP).

Table 1-1 Part Testing Definition Summary

Generic Part Number: P1750
SI Part Number: 171320-01
Military Designation: 5962-8766501YX
Function Description: CMOS Microprocessor
Manufacturer: PSI
Part Lot Date Code: C5B9518D1 and C5B9518A3

TEST TO BE PERFORMED:

Total Dose & Dose Rate Test

Perform dose rate test first, then total dose test

EXPOSURE ENVIRONMENT LEVELS & CRITERIA FOR TEST:

Dose Rate

Upset and Latchup Threshold

Exposure Sample Size: 6

Max. Rate of Exposure: 1E+10rad(Si)/s

Prompt Pulse Width: 20 ns

Total Dose

Exposure Levels: Discrete Levels up to 100 krad(Si) or functional failure, whichever occurs first

Max Rate of Exposure: MIL-STD-883, Method 1019

Exposure Sample Size: 6

4. TEST RESULTS

This section presents the test results in summary form. The raw data is presented in Appendix A. The data is also compiled in Smith Industries standard data base file format in Appendix D. The test plan (general) is included as Appendix C.

4.1 Dose Rate Test

The dose rate test results are summarized in Table 4.1-1. The Log Normal Adjusted Mean (0.50/90%) upset and latchup threshold levels calculated were 9.00E+7 rad(Si)/sec and 6.21E+08 rad(Si)/sec, respectively. All six samples survived the facility max dose rate levels. The threshold level calculated based on the highest levels tested was 1.99E+10 rad(Si)/sec.

Table 4.1-1 The P1750 μP Dose Rate Test Results Summary

SN	HNU [rad(Si)/s]	ln(HNU)	HNLU [rad(Si)/s]	ln(HNU)	HNBO† [rad(Si)/s]	ln(HNBO)
2	1.14E+08	18.552	6.89E+08	20.351	2.06E+10	23.749
3	1.11E+08	18.525	7.15E+08	20.388	2.12E+10	23.777
4	9.15E+07	18.332	7.50E+08	20.436	2.00E+10	23.719
5	8.05E+07	18.204	7.20E+08	20.395	1.90E+10	23.668
6	1.12E+08	18.534	5.75E+08	20.170	2.06E+10	23.749
7	8.75E+07	18.287	5.76E+08	20.172	2.14E+10	23.787
min	8.05E+07	18.204	5.75E+08	20.170	1.90E+10	23.668
max	1.14E+08	18.552	7.50E+08	20.436	2.14E+10	23.787
mean	9.94E+07	18.406	6.71E+08	20.318	2.05E+10	23.741
sigma	1.46E+07	0.150	7.63E+07	0.117	8.73E+08	0.043
LN 0.50/90%		9.00E+07		6.21E+08		1.99E+10
LN 0.99/90%		5.22E+07		4.05E+08		1.70E+10

† None actually burned out. The levels are based on the highest level tested.
HNU = Highest No Upset Level
HNLU = Highest No Latchup Level
HNBO = Highest No Burnout Level
ln = natural log

4.2 Total Dose Test

The results of the total dose functionality test are summarized in Table 4.2-1. The log-normal adjusted mean functional failure level of the P1750 μP was 15.35 krad(Si).

Table 4.2-1 The P1750 μP Total Dose Test Results Summary

SN	HNF [krad(Si)]	ln(HNF)	LF [krad(Si)]
2	15.00	2.708	20.00
3	16.00	2.773	17.00
4	15.00	2.708	16.00
5	16.00	2.773	17.00
6	16.00	2.773	17.00
7	16.00	2.773	17.00
min	15.00	2.708	
max	16.00	2.773	
mean	15.67	2.751	
sigma	0.52	0.033	
LN 0.50/90% [krad(Si)]		15.35	
LN 0.99/90% [krad(Si)]		13.59	

HNF = Highest No Failure Level
LF = Lowest Failure Level
ln = natural log
LN = Log-Normal

The standby supply current, Icc(stby) was monitored and recorded at the end of each total dose increment levels until a functional failure occurred. The results are summarized in Table 4.2-2, and the 0.50/90% statistics are plotted in Figure 4.2-1. By the failure levels, the Icc(stby) has increased approximately 25 times the pre values.

Table 4.2-2 Summary of the Parametric Total Dose Test

	ΔIcc(stby) [mA]				
Total Dose	Post 5 krad(Si)	Post 10 krad(Si)	Post 15 krad(Si)	Post 16 krad(Si)	Post 17 krad(Si)
min	9.00E-02	6.84E+00	3.74E+01	4.05E+01	4.60E+01
max	2.50E-01	1.15E+01	5.12E+01	5.55E+01	6.32E+01
mean	1.42E-01	9.57E+00	4.61E+01	5.15E+01	5.71E+01
sigma	5.67E-02	1.83E+00	5.66E+00	6.29E+00	7.60E+00
0.50/90%	1.76E-01	1.07E+01	4.95E+01	5.58E+01	6.33E+01
0.99/90%	3.82E-01	1.73E+01	7.01E+01	8.08E+01	9.84E+01

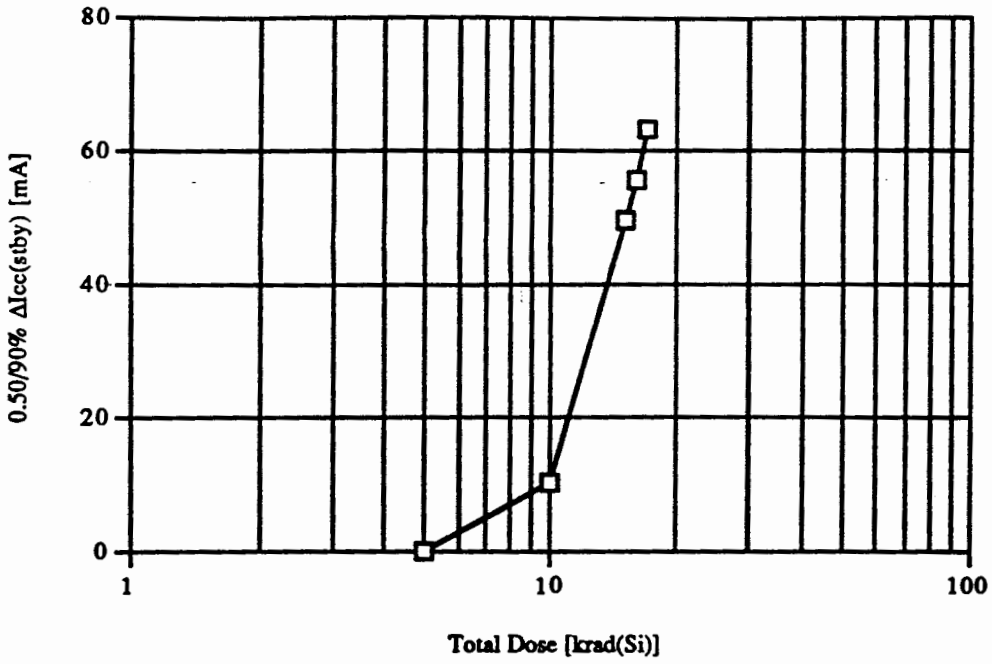

Figure 4.2-1 The Icc(stby) Increase in Total Dose Environment

A.1 Dose Rate Test

Table A.1-1 Dose Rate Test Log

PN: P1750
MFG: PSI
LDC: C5B9518D1 & C5B9518A3
DESC: CMOS µProcessor
ENV: G
Date: 3/19/96

Shot No.	SN	Dosimtr. No.	Dose [rad(Si)	Dose Rate @20ns [rad(Si)/s]	Upset	Latchup	Burnout	Comment
1	2	TLD	411	2.06E+10	yes	yes	no	Ilatch>1A
2		TLD	82.8	4.14E+09	yes	yes	no	Ilatch=0.5A
3		41	18.89	9.45E+08	yes	yes	no	
4		42	5.47	2.74E+08	yes	no	no	
5		43	9.73	4.87E+08	yes	no	no	
6		44	13.78	6.89E+08	yes	no	no	
7		45	2.28	1.14E+08	no	no	no	
8		46			yes	no	no	Dosimeter lost
9		47	0.673	3.37E+07	no	no	no	
10		48	3.26	1.63E+08	yes	no	no	
11	3	49	2.22	1.11E+08	no	no	no	
12		50	2.71	1.36E+08	yes	no	no	
13		51	14.29	7.15E+08	yes	no	no	
14		52	19.72	9.86E+08	yes	yes	no	
15	4	54	2.37	1.19E+08	yes	no	no	
16		55	1.83	9.15E+07	no	no	no	
17		56	15	7.50E+08	yes	no	no	
18		57	18.4	9.20E+08	yes	yes	no	
19	5	58	2.25	1.13E+08	yes	no	no	
20		59	1.61	8.05E+07	no	no	no	
21		60	14.4	7.20E+08	yes	no	no	
22		61	18.89	9.45E+08	yes	yes	no	
23	6	62	2.23	1.12E+08	no	no	no	
24		63	3.18	1.59E+08	yes	no	no	
25		64	14.3	7.15E+08	yes	yes	no	
26		65	11.5	5.75E+08	yes	no	no	
27	7	66	2.37	1.19E+08	yes	no	no	
28		67	1.75	8.75E+07	no	no	no	
29		68	14.97	7.49E+08	yes	yes	no	
30		69	11.51	5.76E+08	yes	no	no	
31	7	TLD	427.53	2.14E+10	yes	yes	no	Survival
32	6	TLD	412.29	2.06E+10	yes	yes	no	Survival
33	5	TLD	380.49	1.90E+10	yes	yes	no	Survival
34	4	TLD	399.7	2.00E+10	yes	yes	no	Survival
35	3	TLD	424.2	2.12E+10	yes	yes	no	Survival

A.2 Total Dose Test

Table A.2-1 P1750 µP Parameter Data

PN: P1750
MFG: PSI
LDC: C5B9518D1 & C5B9518A3
DESC: CMOS µProcessor
ENV: D
DOSE RATE: 3500 rad(Si)/min
DATE: 3/19/96

Icc(stby) [mA]								
SN	Pre	Post 5 krad(Si)	Post 10 krad(Si)	Post 14 krad(Si)	Post 15 krad(Si)	Post 16 krad(Si)	Post 17 krad(Si)	Post 20 krad(Si)
12	2.1	2.2	10.0		42.9			84.9
13	2.5	2.3	9.3		39.9	42.9	48.5	
14	2.2	2.4	13.6		53.3	56.7		
15	2.4	2.3	13.3	44.4	50.7	57.9	65.6	
16	2.3	2.2	12.1		53.0	57.0	62.9	
17	2.3	2.2	12.8		50.6	54.6	60.7	
min	2.14E+00	2.15E+00	9.30E+00		3.99E+01	4.29E+01	4.85E+01	
max	2.46E+00	2.40E+00	1.36E+01		5.33E+01	5.79E+01	6.56E+01	
mean	2.29E+00	2.26E+00	1.19E+01		4.84E+01	5.38E+01	5.94E+01	
sigma	1.33E-01	9.58E-02	1.80E+00		5.62E+00	6.21E+00	7.55E+00	

ΔIcc(stby) [mA]								
SN		Post 5 krad(Si)	Post 10 krad(Si)	Post 14 krad(Si)	Post 15 krad(Si)	Post 16 krad(Si)	Post 17 krad(Si)	Post 20 krad(Si)
12		0.1	7.8		40.8			82.8
13		0.2	6.8		37.4	40.5	46.0	
14		0.3	11.5		51.2	54.5		
15		0.1	10.9	42.0	48.3	55.5	63.2	
16		0.1	9.9		50.7	54.7	60.6	
17		0.1	10.5		48.3	52.3	58.4	
min		9.00E-02	6.84E+00		3.74E+01	4.05E+01	4.60E+01	
max		2.50E-01	1.15E+01		5.12E+01	5.55E+01	6.32E+01	
mean		1.42E-01	9.57E+00		4.61E+01	5.15E+01	5.71E+01	
sigma		5.67E-02	1.83E+00		5.66E+00	6.29E+00	7.60E+00	
0.50/90%		1.76E-01	1.07E+01		4.95E+01	5.58E+01	6.33E+01	
0.99/90%		3.82E-01	1.73E+01		7.01E+01	8.08E+01	9.84E+01	