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DATE: September 14, 1994 PPM-94-025

TO: A. Mecum/311.0
FROM: K. Sahu/300.1 KS
SUBJECT: Radiation Report on FUSE
Part No. ADC0816
Control No. 11122

cc: A. Sharma/311
Library/300.1

A radiation evaluation was performed on ADC0816 (8-bit A/D Converter with 16-channel Multiplexer) 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 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 levels were 2.5, 5, 7.5, 10, 15 and 20 krads*. The dose rate was between 0.04 and 0.28 krads/hour, depending on the total dose level (see Table II for radiation schedule). After the 20 krad irradiation, the parts were annealed at 25°C for 168 hours, after which the parts were annealed at 100°C for 168 hours. After each radiation exposure and annealing treatment, parts were electrically tested according to the test conditions and the specification limits** listed in Table III.

All parts passed initial electrical measurements. All irradiated parts passed all electrical tests up to the 2.5 krad level.

At the 5 krad level, S/N 26 exceeded the maximum specification limit of 450 mV for DO1 vol and DO2 vol through DO8 vol, with readings ranging from 613 to 1024 mV and S/N 30 fell below the minimum specification limit of 4.60 V for DO1 voh through DO8 voh, with readings ranging from 0.03 to 0.05 V, and exceeded the maximum specification limit of 450 mV for DO1 vol through DO8 vol, with readings of 1024 mV. A reading of 1024 mV indicates that the actual value is beyond the preset limit of the test equipment. A failure of either vol or voh represents an incorrect output state, which is a functional failure of the part. S/N 26 also exceeded the maximum specification limit of 9.8 mV for TUE (linearity), with a reading of 17.16 mV and exceeded the maximum specification limit of 250 ns for DO4_tI0, DO6_tH0 through DO8_tH0, DO3_t0H, DO4_t0H, DO6_t0H and DO7_t0H, with readings ranging from 116 µs to 1.15 ms.

At the 7.5 krad level, the same functional failures were observed forS/N 26 and S/N 30.

At the 10 krad level, S/N 23, 25, 26 and 30 showed failures in all voh tests and TUE, with the same values as before and in addition, failed various vol and timing tests, indicating functional failure.

At the 15 and 20 krad levels, all irradiated parts showed functional failure.

After annealing for 168 hours at 25°C, no recovery was observed and after annealing for 168 hours at 100°C, no rebound effects were observed.

*The term rads, as used in this document, means rads(silicon). All radiation levels cited are cumulative.
**These are manufacturer's non-irradiation data specification limits. No post-irradiation limits were provided by the manufacturer at the time these tests were performed. No radiation tolerance/hardness was guaranteed by the manufacturer for this part.

Table IV provides a summary of the failures for each parameter after different irradiation exposures and annealing steps.

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:	ADC0816
FUSE Part Number:	ADC0816*
FUSE Control Number:	11122
Charge Number:	C44491
Manufacturer:	National Semiconductor
Lot Date Code:	9242
Quantity Tested:	10
Serial Number of Control Samples:	21, 22
Serial Numbers of Radiation Sample:	23, 24, 25, 26, 27, 28, 29, 30
Part Function:	8-bit A/D Converter with 16-channel Multiplexer
Part Technology:	CMOS
Package Style:	40-pin DIP
Test Equipment:	A540
Test Engineer:	C. Nguyen

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

TABLE II. Radiation Schedule for ADC0816

EVENTS	DATE
1) INITIAL ELECTRICAL MEASUREMENTS	08/06/94
2) 2.5 KRAD IRRADIATION (0.13 KRADS/HOUR)	08/08/94
POST-2.5 KRAD ELECTRICAL MEASUREMENT	08/09/94
3) 5 KRAD IRRADIATION (0.13 KRADS/HOUR)*	08/18/94
POST-5 KRAD ELECTRICAL MEASUREMENT	08/19/94
4) 7.5 KRAD IRRADIATION (0.04 KRADS/HOUR)	08/19/94
POST-7.5 KRAD ELECTRICAL MEASUREMENT	08/22/94
5) 10 KRAD IRRADIATION (0.14 KRADS/HOUR)	08/22/94
POST-10 KRAD ELECTRICAL MEASUREMENT	08/23/94
6) 15 KRAD IRRADIATION (0.28 KRADS/HOUR)	08/23/94
POST-15 KRAD ELECTRICAL MEASUREMENT	08/24/94
7) 20 KRAD IRRADIATION (0.28 KRADS/HOUR)	08/24/94
POST-20 KRAD ELECTRICAL MEASUREMENT	08/25/94
8) 168-HOUR ANNEALING @25°C	08/25/94
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	09/01/94
9) 168-HOUR ANNEALING @100°C**	09/01/94
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	09/08/94

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

*Between 08/09/94 and 08/18/94, parts were stored under bias at room temperature while repairs were being made to the Co-60 Irradiator.

**High temperature annealing is performed to accelerate long term time dependent effects (TDE), namely, the "rebound" effect due to the growth of interface states after the radiation exposure. For more information on the need to perform this test, refer to MIL-STD-883D, Method 1019, Para. 3.10.1.

Table III. Electrical Characteristics of ADC0816

tst	Test name	Min	Max	Condition
1	ICC	0.00 ma	3.00 ma	Fclk = 640KHZ
2	DO1 voh	4.60 v		Iout = 360ua
3	DO2 voh	4.60 v		
4	DO3 voh	4.60 v		
5	DO4 voh	4.60 v		
6	DO5 voh	4.60 v		
7	DO6 voh	4.60 v		
8	DO7 voh	4.60 v		
9	DO8 voh	4.60 v		
10	DO1 vol		450 mv	Iout = 1.6ma
11	DO2 vol		450 mv	
12	DO3 vol		450 mv	
13	DO4 vol		450 mv	
14	DO5 vol		450 mv	
15	DO6 vol		450 mv	
16	DO7 vol		450 mv	
17	DO8 vol		450 mv	
18	EOC vol		450 mv	Iout = 1.2ma
19	Missing codes		0.000	
20	TUE *	-9.80 mv	9.80 mv	1/2 LSB = 9.8mv
21	Conv. time	90 us	116 us	Fclk = 640KHZ
22	DO1_t1H		250.0 ns	
23	DO2_t1H		250.0 ns	
24	DO3_t1H		250.0 ns	
25	DO4_t1H		250.0 ns	
26	DO5_t1H		250.0 ns	
27	DO6_t1H		250.0 ns	
28	DO7_t1H		250.0 ns	
29	DO8_t1H		250.0 ns	
30	DO1_tH1		250.0 ns	
31	DO2_tH1		250.0 ns	
32	DO3_tH1		250.0 ns	
33	DO4_tH1		250.0 ns	
34	DO5_tH1		250.0 ns	
35	DO6_tH1		250.0 ns	
36	DO7_tH1		250.0 ns	
37	DO8_tH1		250.0 ns	
38	DO1_tH0		250.0 ns	
39	DO2_tH0		250.0 ns	
40	DO3_tH0		250.0 ns	
41	DO4_tH0		250.0 ns	
42	DO5_tH0		250.0 ns	
43	DO6_tH0		250.0 ns	
44	DO7_tH0		250.0 ns	
45	DO8_tH0		250.0 ns	

*linearity

Table III (cont.). Electrical Characteristics of ADC0816

46	DO1_t0H		250.0 ns	
47	DO2_t0H		250.0 ns	
48	DO3_t0H		250.0 ns	
49	DO4_t0H		250.0 ns	
50	DO5_t0H		250.0 ns	
51	DO6_t0H		250.0 ns	
52	DO7_t0H		250.0 ns	
53	DO8_t0H		250.0 ns	
54	EXP_iil	-1.00 ua	1.00 ua	Vin = 1.5v
55	ADD1_iil	-1.00 ua	1.00 ua	
56	ADD2_iil	-1.00 ua	1.00 ua	
57	ADD3_iil	-1.00 ua	1.00 ua	
58	ADD4_iil	-1.00 ua	1.00 ua	
59	START_iil	-1.00 ua	1.00 ua	
60	ALE_iil	-1.00 ua	1.00 ua	
61	CLK_iil	-1.00 ua	1.00 ua	
62	OE_iil	-1.00 ua	1.00 ua	
63	EXP_iih	-1.00 ua	1.00 ua	Vin = 3.5v
64	ADD1_iih	-1.00 ua	1.00 ua	
65	ADD2_iih	-1.00 ua	1.00 ua	
66	ADD3_iih	-1.00 ua	1.00 ua	
67	ADD4_iih	-1.00 ua	1.00 ua	
68	START_iih	-1.00 ua	1.00 ua	
69	ALE_iih	-1.00 ua	1.00 ua	
70	CLK_iih	-1.00 ua	1.00 ua	
71	OE_iih	-1.00 ua	1.00 ua	
72	EXP_iil	-1.00 ua	1.00 ua	Vin = 0v
73	ADD1_iil	-1.00 ua	1.00 ua	
74	ADD2_iil	-1.00 ua	1.00 ua	
75	ADD3_iil	-1.00 ua	1.00 ua	
76	ADD4_iil	-1.00 ua	1.00 ua	
77	START_iil	-1.00 ua	1.00 ua	
78	ALE_iil	-1.00 ua	1.00 ua	
79	CLK_iil	-1.00 ua	1.00 ua	
80	OE_iil	-1.00 ua	1.00 ua	
81	EXP_iih	-1.00 ua	1.00 ua	Vin = 15v
82	ADD1_iih	-1.00 ua	1.00 ua	
83	ADD2_iih	-1.00 ua	1.00 ua	
84	ADD3_iih	-1.00 ua	1.00 ua	
85	ADD4_iih	-1.00 ua	1.00 ua	
86	START_iih	-1.00 ua	1.00 ua	
87	ALE_iih	-1.00 ua	1.00 ua	
88	CLK_iih	-1.00 ua	1.00 ua	
89	OE_iih	-1.00 ua	1.00 ua	

Table III (cont.). Electrical Characteristics of ADC0816

90	DO1 iol	-3.00 ua	3.00 ua	Vout = 0v
91	DO2 iol	-3.00 ua	3.00 ua	
92	DO3 iol	-3.00 ua	3.00 ua	
93	DO4 iol	-3.00 ua	3.00 ua	
94	DO5 iol	-3.00 ua	3.00 ua	
95	DO6 iol	-3.00 ua	3.00 ua	
96	DO7 iol	-3.00 ua	3.00 ua	
97	DO8 iol	-3.00 ua	3.00 ua	
98	DO1 ioh	-3.00 ua	3.00 ua	Vout = 5v
99	DO1 ioh	-3.00 ua	3.00 ua	
100	DO1 ioh	-3.00 ua	3.00 ua	
101	DO1 ioh	-3.00 ua	3.00 ua	
102	DO1 ioh	-3.00 ua	3.00 ua	
103	DO1 ioh	-3.00 ua	3.00 ua	
104	DO1 ioh	-3.00 ua	3.00 ua	
105	DO1 ioh	-3.00 ua	3.00 ua	

TABLE IV: Summary of Electrical Measurements after Total Dose Exposures and Annealing for ADC0816 /1

Test #	Parameter/3/	Units	Spec. Lim./2 min	Spec. Lim./2 max	Initials mean	Initials sd	Total Dose Exposure (krads) 2.5 mean	2.5 sd	5 mean	5 sd	7.5 mean	7.5 sd	10 mean	10 sd	15 mean	15 sd	20 mean	20 sd	Annealing 168 hrs @25°C mean	168 hrs @25°C sd	168 hrs @100°C mean	168 hrs @100°C sd
1	ICC	mA	0	3	0.27	.11	0.23	.13	0.25	0.1	0.21	.07	0.24	.09	0.29	.14	0.26	.13	0.17	.09	0.08	.03
2	DO1 voh	V	4.60	-	4.87	.01	4.87	.01	7P1F		6P2F		4P4F		3P5F		3P5F		7P1F		7P1F	
3	DO2 voh	V	4.60	-	4.87	.01	4.87	.01	7P1F		6P2F		4P4F		2P6F		2P6F		6P2F		4.88	.02
4	DO3 voh	V	4.60	-	4.87	.01	4.87	.01	7P1F		6P2F		4P4F		2P6F		2P6F		6P2F		4.87	.01
5	DO4 voh	V	4.60	-	4.87	.01	4.87	.01	7P1F		6P2F		4P4F		2P6F		2P6F		6P2F		4.87	.01
6	DO5 voh	V	4.60	-	4.87	.01	4.87	.01	7P1F		6P2F		4P4F		2P6F		2P6F		6P2F		4.87	.01
7	DO6 voh	V	4.60	-	4.87	.01	4.87	.01	7P1F		6P2F		4P4F		2P6F		2P6F		6P2F		4.87	.01
8	DO7 voh	V	4.60	-	4.87	.01	4.87	.01	7P1F		6P2F		4P4F		2P6F		2P6F		6P2F		4.87	.01
9	DO8 voh	V	4.60	-	4.87	.01	4.87	.01	7P1F		6P2F		4P4F		2P6F		2P6F		6P2F		4.87	.01
10	DO1 vol	mV	-	450	6	.89	6	1.1	4P3F		6P2F		6P2F		5P3F		6P2F		7P1F		4	3.9
11	DO2 vol	mV	-	450	7	1.1	6	.89	7P1F		6P2F		7P1F		5P3F		6P2F		7P1F		7P1F	
12	DO3 vol	mV	-	450	7	.46	7	1.2	5P2F		6P2F		5P2F		5P3F		6P2F		7P1F		7P1F	
13	DO4 vol	mV	-	450	8	.89	8	1.1	7P1F		6P2F		5P2F		5P3F		6P2F		7P1F		7P1F	
14	DO5 vol	mV	-	450	8	1.3	7	1.2	7P1F		6P2F		257	392	4P4F		6P2F		7P1F		7P1F	
15	DO6 vol	mV	-	450	7	.52	7	1.4	5P2F		6P2F		405	429	4P4F		6P2F		7P1F		7P1F	
16	DO7 vol	mV	-	450	6	1.0	6	1.1	7P1F		6P2F		347	388	5P3F		6P2F		7P1F		7P1F	
17	DO8 vol	mV	-	450	3	2.3	2	1.9	7P1F		6P2F		357	415	5P3F		6P2F		7P1F		7P1F	
18	EOC vol	mV	-	450	132	131	37	32	52	137	19.4	117	54	42	7P1F		11.1	21	24	43	29	25
19	Missing codes		-	0	0	0	0	0	4P3F		6P2F		4P4F		2P6F		2P6F		6P2F		7P1F	
20	TUE	mV	-9.80	9.80	4.99	.79	5.37	.81	4P3F		6P2F		4P4F		2P6F		2P6F		6P2F		7P1F	
21	Conv. time	µs	90	116	108	2.5	107	2.4	4P3F		6P2F		4P4F		2P6F		2P6F		6P2F		7P1F	
22	t1H	ns	-	250	P		P		P		P		P		7P1F		3P5F		1P7F		1P7F	
23	tH1	ns	-	250	P		P		P		P		P		7P1F		4P4F		1P7F		1P7F	
24	tH0	ns	-	250	P		P		6P1F		P		4P4F		5P3F		2P6F		1P7F		1P7F	
25	t0H	ns	-	250	P		P		6P1F		P		2P6F		3P5F		1P7F		1P7F		F	
26	Iin_leak	µA	-1	1	P		P		P		P		P		*		*		*		*	
27	Iout_leak	µA	-1	1	P		P		P		P		P		*		*		*		*	

TABLE IV(cont'd.): Summary of Electrical Measurements after Total Dose Exposures and Annealing for ADC0816 /1

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

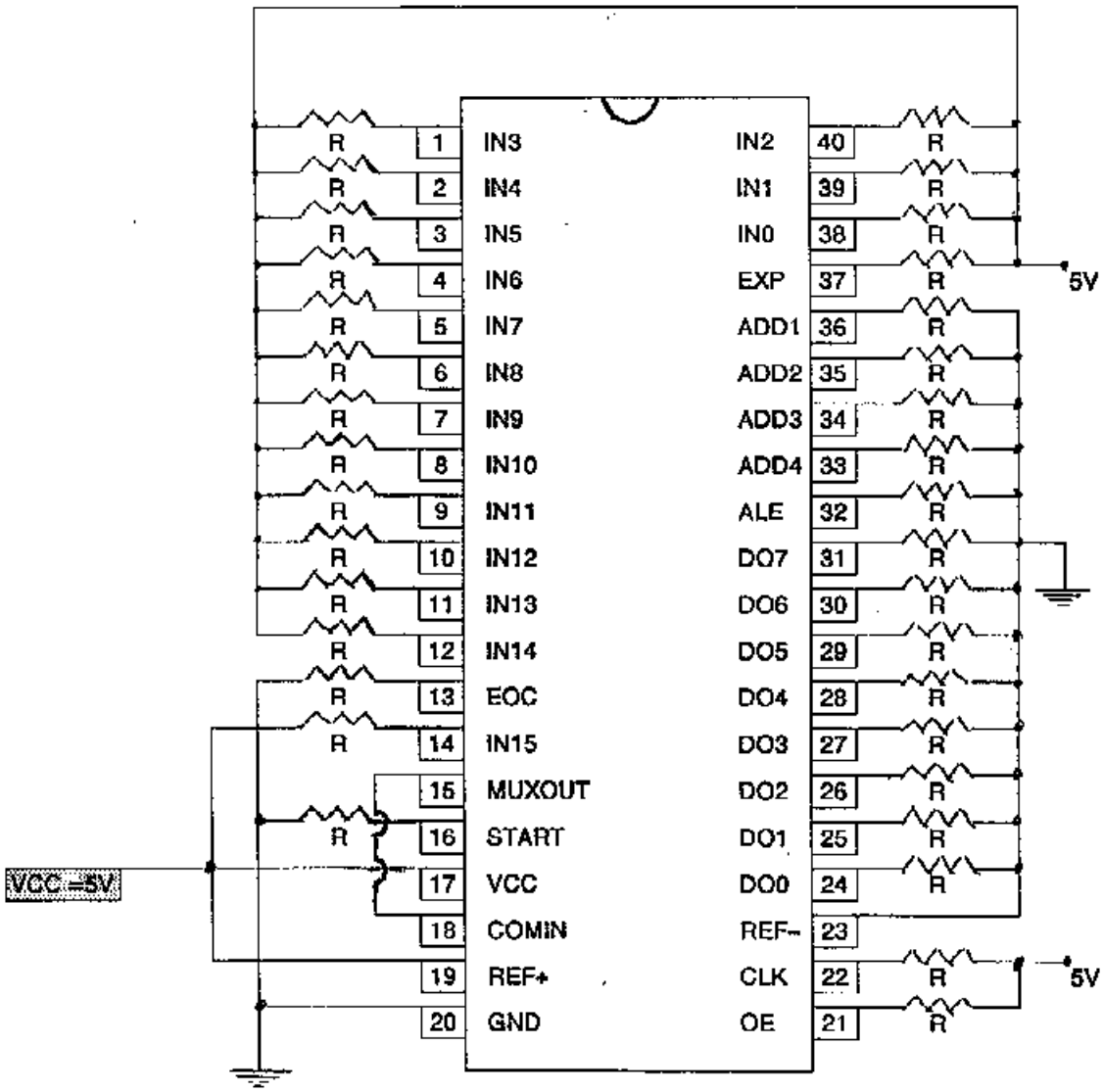
3/ In cases where one or more parts showed readings indicating functional failure, results are shown as "nPmF", where n is the number of parts passing the test and m is the number of parts failing the test. For example, at 5 krads, one part showed readings of 662 to 1024 mV, which are beyond the maximum specification limit of 450 mV for 7 of 8 vol tests and one part read below the minimum specification limit of 4.60 V for 8 voh tests with readings ranging from 0.03 to 0.05 V. These readings are indicative of an incorrect output state, which constitutes functional failure.

4/ Tests #22-29, 30-37, 38-45 and 46-53 from Table III are shown as t1H, tH1, tH0 and t0H, respectively. Tests #54-89 from Table III are shown as Iin_leak and tests 90-105 from Table III are shown as Iout_leak. These tests are shown as "Pass/Fail", where "nPmF" means the same as in 3/, "P" means that all parts passed and "F" means that all parts fail.

* No data could be obtained for this parameter for most parts at this radiation or annealing level.

The radiation sensitive parameters were voh, vol, TUE, t1H, tH1, tH0 and t0H.

Figure 1. Radiation Bias Circuit for ADC0816



NOTE :

ALL Rs = 10kohms 5% 1/4W