Government Systems Group

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DATE: February 2, 1995 PPM-95-124

TO: B. Fafaul/311
FROM: K. Sahu/300.1 KS
SUBJECT: Radiation Report on HST/BASE
Part No. AD677
Control No. 10984

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A radiation evaluation was performed on AD677 (A/D Converter) 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 ^{60}Co 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 0.31 krads/hour, depending on the total dose level (see Table II for radiation schedule). After the 20 krad irradiation, 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 and including the 2.5 krad level.

At the 5 krad irradiation level, S/N 132, 133, 134 and 135 exceeded the maximum specification limit of 640 mW for Po_Consum, with readings ranging from 650 mW to 775 mV. In addition, S/N 134 exceeded the maximum specification limit of 24 mA for I_{CC}, with a reading of 25.3 mA, and fell below the minimum specification limits of -24 mA for I_{EE} and 90 dB for S/N-D, with readings of -25.7 mA and 89.5 dB, respectively.

At the 7.5 krad irradiation level, S/N 132, 133, 134 and 135 continued to exceed the maximum specification limit for Po_Consum, with readings ranging from 868 mW to 1123 mV. S/N 134 continued to exceed the maximum specification limit for I_{CC}, with a reading of 37mA, and continued to fall below the minimum specification limits for I_{EE} and S/N-D, with readings of -37.5 mA and 87.8 dB, respectively. In addition S/N 132, 133 and 135 exceeded the maximum specification limit for I_{CC}, with readings ranging from 28.6 mA to 34.2 mA, and fell below the minimum specification limit for I_{EE}, with readings ranging from -29.1 mA to -34.6 mA.Also, S/N 139 exceeded the maximum specification limit for Po_Consum, with a reading of 673 mW.

At the 10 krad irradiation level, readings for I_{CC}, I_{EE}, Po_Consum and S/N-D were approximately 20% higher than at the 7.5 krad level. All other parameters continued to read within specification limits.

At the 15 krad level, the signal-to-noise ratio for S/N 132, 134, 135, 138, 139 and 140 could not be measured, due to the low signal value. This is equivalent to functional failure of the parts.

*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.

Also, at the 15 krad level, S/N 132, 135, 138, 139 and 140 exceeded the specification limits for max_DNL, min_DNL, max_INL, and min_INL, and S/N 134 exceeded specification limits for max_DNL and max_INL. This indicates missing codes, which is equivalent to functional failure of the parts. S/N 133 and 137 remained within specification limits for these parameters.

After the 15 krad irradiation, readings for I_{CC}, I_{EE}, Po_Consum and S/N-D ranged from 20% to 50% higher than at the 10 krad level.

After the 20 krad irradiation, readings for I_{CC}, I_{EE}, Po_Consum and S/N-D remained approximately the same as at the 15 krad level. All other irradiated parts exceeded the specification limits for max_DNL, min_DNL, max_INL, and min_INL, indicating functional failure.

In summary, the parts experienced functional failure between the 10 krad and 15 krad irradiation levels.

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

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

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:	AD677
HST/ADD Part Number:	AD677BD
HST/AD Control Number:	10984
Charge Number:	ES56052
Manufacturer:	Analog Devices
Lot Date Code:	9436, 9412
Quantity Tested:	10
Serial Number of Control Samples:	131, 136
Serial Numbers of Radiation Samples:	132, 133, 134, 135, 137, 138, 139, 140
Part Function:	A/D Converter
Part Technology:	BiCMOS
Package Style:	16-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 AD677

EVENTS	DATE
1) INITIAL ELECTRICAL MEASUREMENTS	12/15/94
2) 2.5 KRAD IRRADIATION (0.04 KRADS/HOUR)	12/16/94
POST-2.5 KRAD ELECTRICAL MEASUREMENT	12/19/94
3) 5 KRAD IRRADIATION (0.147 KRADS/HOUR)	12/19/94
POST-5 KRAD ELECTRICAL MEASUREMENT	12/20/94
4) 7.5 KRAD IRRADIATION (0.147 KRADS/HOUR)	12/20/94
POST-7.5 KRAD ELECTRICAL MEASUREMENT	12/21/94
5) 10 KRAD IRRADIATION (0.152 KRADS/HOUR)	12/21/94
POST-10 KRAD ELECTRICAL MEASUREMENT	12/22/94
6) 15 KRAD IRRADIATION (0.313 KRADS/HOUR)	12/22/94
POST-15 KRAD ELECTRICAL MEASUREMENT	12/23/94
7) 20 KRAD IRRADIATION (0.06 KRADS/HOUR)	12/23/94
POST-20 KRAD ELECTRICAL MEASUREMENT	12/27/94
8) 168-HOUR ANNEALING @25°C	12/27/94
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	01/10/95
9) 168-HOUR ANNEALING @100°C*	01/11/95
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	01/18/94

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

*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 AD677

TEST CONDITIONS: VCC = 12V, VEE = -12V VDD = 5V VREF =10V
100kSPS unless otherwise noted;

Test temperature : 25oC

tst	Test name	Min	Max
10	ICC		24.0 ma
11	IEE	-24.0 ma	
12	IDD		5.0 ma
13	Po_Consump		640.0 mW
20	cal iih	-10.00 ua	10.00 ua
21	clk iih	-10.00 ua	10.00 ua
22	sample iih	-10.00 ua	10.00 ua
23	cal iil	-10.00 ua	10.00 ua
24	clk iil	-10.00 ua	10.00 ua
25	sample iil	-10.00 ua	10.00 ua
40	S/N-D	90.0 dB	
41	thd		-95.0 dB
50	actual hits	16	
51	max_DNL	-1.000 lsb	< 1.000 lsb
52	min_DNL	-1.000 lsb	< 1.000 lsb
53	max_INL	-1.500 lsb	< 1.500 lsb
54	min_INL	-1.500 lsb	< 1.500 lsb

TABLE IV: Summary of Electrical Measurements after Total Dose Exposures and Annealing for AD677BD /1

Test #	Parameters	Units	Spec. Lim./2 min	Spec. Lim./2 max	Initial mean	Initial 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	-	24	12	0.44	13.3	0.99	18.7	4.23	26.3	7.75	31.7	9.38	43.2	11.2	44.9	11.7	35.0	4.93	15.4	1.32
2	IEE	mA	-24	-	-12.3	0.42	-13.7	0.98	-19.2	4.22	-26.8	7.73	-32.2	0.35	-43.7	11.2	-45.5	11.6	-35.3	5.0	-15.7	1.26
3	IDD	mA	-	5.0	1.65	1.65	1.86	0.95	1.45	1.18	0.58	0.22	0.60	0.27	1.03	1.15	0.98	1.11	0.96	1.12	1.08	1.24
4	Po_Consum	mW	-	640	375	18.3	416	32.5	576	130	799	232	963	282	1309	335	1362	349	1061	148	473	36.9
5	Caliih	nA	-10000	10000	67.6	6.87	59.7	7.73	73.8	8.34	75.4	9.06	73.0	7.27	68.3	8.26	67.2	7.09	57.0	5.21	66.4	7.79
6	Clkiih	nA	-10000	10000	67.2	9.59	62.9	9.51	69.9	6.87	73.8	9.87	73.4	6.87	66.8	7.64	69.1	4.85	57.4	9.14	65.2	9.21
7	Sampleiih	nA	-10000	10000	67.6	6.67	70.3	5.79	69.5	9.12	72.6	5.48	67.9	5.48	69.9	9.73	64.1	6.68	6.68	5.52	63.3	6.41
8	Caliil	nA	-10000	10000	111	4.39	115	5.89	117	6.01	116	8.96	113	8.48	118	9.71	115	8.14	116	7.17	112	7.42
9	Clkiil	nA	-10000	10000	92.2	6.68	91.4	8.96	97.6	5.96	92.9	4.34	88.3	8.31	91.4	5.48	95.3	11.3	87.9	3.89	89.8	5.96
10	Sampleiil	nA	-10000	10000	91.8	10.9	83.9	7.36	92.9	6.41	89.8	4.65	90.6	8.52	88.2	5.21	95.7	8.67	83.2	6.01	89.1	6.02
11	S/N-D	dB	90	-	97.9	3.62	97.3	4.73	96.7	5.16	96.5	5.82	95.2	6.93	3/	3/	3/	3/	3/	3/	96.9	9.66
12	THD	dB	-	-95	-107	1.72	-106	1.10	-106	1.35	-106	0.57	-107	1.16	-11.5	58.3	19.9	0.0	-43.4	67.7	-106	2.04
13	Actualbits		16	-	58.8	0.36	58.7	0.36	58.7	0.32	58.8	0.29	58.8	0.28	26.5	28.5	0	0.0	29.5	31.5	58.9	0.32
14	Max_DNL/	lsb	-1	1	0.52	0.13	0.50	0.02	0.50	0.06	0.49	0.07	0.58	0.18	2P6F		F		3P5F		6P2F	
15	Min_DNL/	lsb	-1	1	-0.42	0.04	-0.41	0.04	-0.40	0.02	-0.47	0.06	-0.47	0.09	3P5F		F		3P5F		7P1F	
16	Max_INL/4	lsb	-1	1	0.62	0.14	0.63	0.12	0.63	0.10	0.67	0.13	0.79	0.25	2P6F		F		3P5F		7P1F	
17	Min_INL/4	lsb	-1	1	-0.50	0.06	-0.53	0.07	-0.52	0.08	-0.63	0.09	-0.67	0.12	3P5F		F		3P5F		6P2F	

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 pre-irradiation data sheet specification limits. No post-irradiation limits were provided by the manufacturer at the time the tests were performed.

3/ The parts are not responding to the input signal and the value for signal-to-noise plus distortion ratio cannot be calculated. This indicates functional failure due to low signal response.

4/ A failure of these tests indicates functional failure of the part, therefore, when one or more parts failed these tests, results are shown as "nPmF", where n parts passed and m parts failed the test. "F" indicates that all parts failed the test. **Radiation-sensitive parameters were: Po_Consum, Icc, Iee, S/N-D, max_DNL, min_DNL, max_INL and min_INL.**

Figure 1. Radiation Bias Circuit for AD677