Unisys

DATE: June 24, 1999 PPM-99-022
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SUBJECT: Radiation Report on **AD7545AUQ/883B (Analog Devices) (LDC 9807)**
PROJECT: IRAC

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A radiation evaluation was performed on **AD7545AUQ/883B CMOS 12-Bit Buffered Multiplying DAC (Analog Devices)** to determine the total dose tolerance of these parts. The total dose testing was performed using a Co^{60} gamma ray source. During the radiation testing, five parts were irradiated under bias (see Figure 1 for bias configuration) and one part was used as a control sample. The total dose radiation levels were 2.5, 5.0, 10.0, 15.0, 20.0, and 30.0kRads.[1] The effective dose rate was 0.07 kRads/hour (0.02 Rads/s). See Table II for the radiation schedule and effective dose rate calculation. After the 10.0kRad irradiation, the parts were annealed under bias at 25°C for 96 hours and for 264 hours. After the 30.0kRad irradiation, the parts were annealed under bias at 25°C for 168 hours and 100°C for 168 hours.[2] After each radiation exposure and annealing treatment, parts were electrically tested according to the test conditions and the specification limits[3] listed in Table III. An executive summary of the test results is provided below in bold, followed by a detailed summary of the test results after each radiation level and annealing step.

All parts passed all tests up to 5kRads. After 10kRads some parts showed marginal degradation in DNL and Iout Leakage at V_{DD} = 5V and all parts showed degradation in Iout Leakage, and Icc_Vil at V_{DD} = 15V. After annealing the parts for 264 hours at 25°C, the parts showed significant recovery in all sensitive parameters and passed all tests.

After the 15 to 30kRad irradiations, the parts showed significant degradation DNL, INL, Iout Leakage, Icc_0V, and Icc_5V at V_{DD} = 5V and all parts showed significant degradation in DNL, INL, Iout Leakage, Icc_Vil, Icc_0V, and Icc_5V at V_{DD} = 15V. After annealing the parts for 168 hours at 25°C, the parts showed no significant recovery in any parameter. After annealing the parts for 168 hours at 100°C, the parts showed no rebound effects. See Figures 2 through 5 for more information on radiation sensitive parameters. Please note that the degradation in INL and DNL was more than 100 times greater at V_{DD} = 5V than at V_{DD} = 15V.

Initial electrical measurements were made on 6 samples. Five samples (SN's 227, 228, 229, 230, and 231) were used as radiation samples while SN 226 was used as a control sample. All parts passed all tests during initial electrical measurements.

All parts passed all tests up to 5.0kRads.

After the 10kRad irradiation, for V_{DD} = 5V, all parts fell below the specification limit of -10nA for Iout Leakage with readings in the range of -1143 to -1287nA. For V_{DD} = 15V, one part exceeded the specification limit of 1.00lsb for DNL with a reading of 1.25lsb. All parts fell below the specification limit of -10nA for Iout Leakage with readings in the range of -474 to -544nA. All parts exceeded the specification limit of 2000μA for Icc_Vil with readings in the range of 2422 to 2734nA. **All parts passed all other tests.**

After annealing the parts for 96 and 264 hours at 25°C, all parts showed some recovery in all radiation sensitive parameters.

[1] The term Rads, as used in this document, means Rads (silicon). All radiation levels cited are cumulative.
[2] The temperature 25°C as used in this document implies room temperature.
[3] These are manufacturer's pre-irradiation data specification limits. The manufacturer provided no post-irradiation limits at the time these tests were performed.

After the 15kRad irradiation, for V_{DD} = 5V, all parts exceeded the specification limit of 0.50lsb for INL with readings in the range of 0.89 to 1.26lsb. One part exceeded the specification limit of 1.00lsb for DNL with a reading of 1.24lsb. All parts fell below the specification limit for Iout Leakage with readings in the range of -1592 to -1656nA. For V_{DD} = 15V, all parts exceeded the specification limit of 0.50lsb for INL with readings in the range of 0.66 to 0.86lsb. One part exceeded the specification limit of 1.00lsb for DNL with a reading of 1.25lsb. All parts fell below the specification limit for Iout Leakage with readings in the range of -675 to -695nA. All parts exceeded the specification limit for Icc_Vil with readings in the range of 2911 to 3355nA. **All parts passed all other tests.**

After the 20kRad irradiation, for V_{DD} = 5V, all parts showed significant degradation in INL and DNL with readings in the range of 24 to 7761lsb for both. All parts fell below the specification limit for Iout Leakage with readings in the range of -1669 to -1765nA. All parts exceeded the specification limit of 100µA for Icc_0V with readings in the range of 330 to 510µA. For V_{DD} = 15V, all parts exceeded the specification limit for INL with readings in the range of 1.59 to 2.08lsb. Four parts exceeded the specification limit for DNL with readings in the range of 1.07 to 1.22lsb. All parts fell below the specification limit for Iout Leakage with readings in the range of -708 to -744nA. All parts exceeded the specification limit for Icc_Vil with readings in the range of 4366 to 4996nA. All parts exceeded the specification limit of 100µA for Icc_0V with readings in the range of 474 to 740µA. All parts exceeded the specification limit of 100µA for Icc_5V with readings in the range of 324 to 510µA. **All parts passed all other tests.**

After the 30kRad irradiation, for V_{DD} = 5V, all parts showed significant degradation in INL and DNL with readings in the range of 3963 to 6397lsb for both. All parts fell below the specification limit for Iout Leakage with readings in the range of -1844 to -1949nA. All parts exceeded the specification limit for Icc_0V with readings in the range of 1889 to 2740µA. All parts exceeded the specification limit of 100µA for Icc_5V with readings in the range of 137 to 165µA. For V_{DD} = 15V, all parts exceeded the specification limit for INL with readings in the range of 3.49 to 4.37lsb. All parts exceeded the specification limit for DNL with readings in the range of 1.29 to 2.12lsb. All parts fell below the specification limit for Iout Leakage with readings in the range of -726 to -766nA. All parts exceeded the specification limit for Icc_Vil with readings in the range of 4994 to 4996nA. All parts exceeded the specification limit for Icc_0V with readings in the range of 2807 to 4000µA. All parts exceeded the specification limit for Icc_5V with readings in the range of 207 to 437µA. **All parts passed all other tests.**

After annealing the parts for 168 hours at 25°C, the parts showed no significant recovery in any parameter.

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

Table IV provides a summary of the test results with the mean and standard deviation values for each parameter after each irradiation exposure and annealing step.

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

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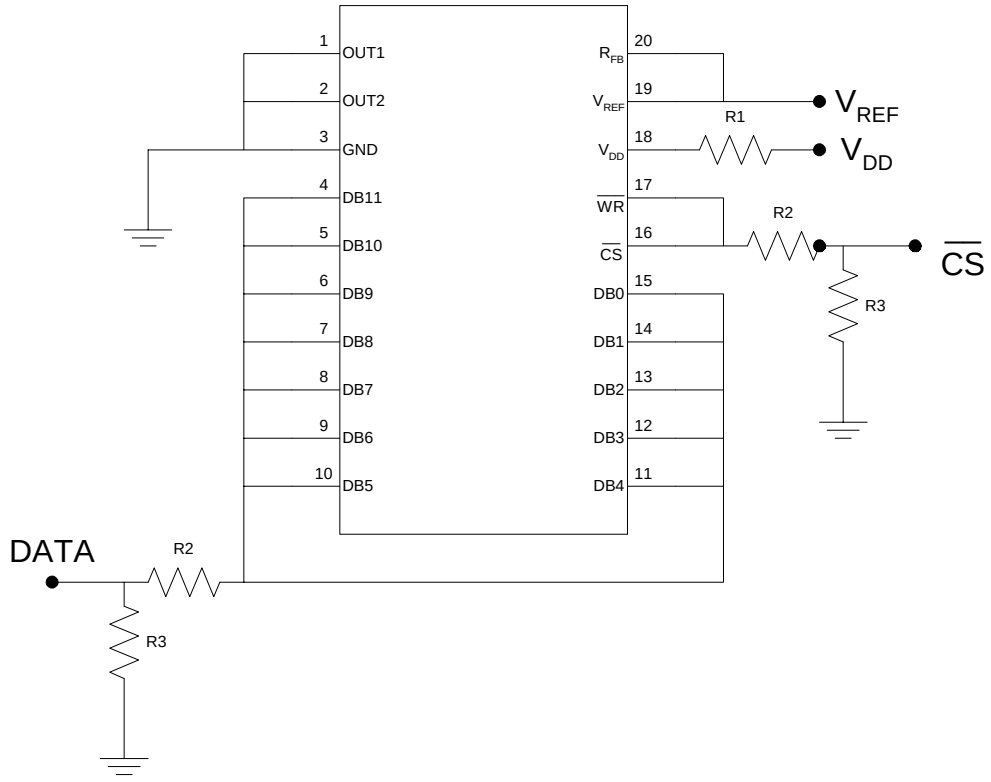
Figure 1. Radiation Bias Circuit for AD7545AUQ/883



Notes:
1. R_1 = 1kΩ ±5%, ¼W.
2. R_2 = 2kΩ ±5%, ¼W.
3. R_3 = 100kΩ ±5%, ¼W. Each R_3 is used only once per board for noise suppression.
4. V_{REF} = +10V.
5. V_{DD} = +15V.
6. DATA = V_{DD}.

TABLE I. Part Information

Generic Part Number:	AD7545AUQ/883B
IRAC Part Number	5962-8770204RA
IRAC TID Requirement	10kRads (RDM ≥ 2)
Charge Number:	M99762
Manufacturer:	Analog Devices
Lot Date Code (LDC):	9807
Quantity Tested:	6
Serial Number of Control Samples:	226
Serial Numbers of Radiation Samples:	227, 228, 229, 230, 231
Part Function:	CMOS 12-Bit Buffered Multiplying DAC
Part Technology:	CMOS
Package Style:	20-Pin DIP
Test Equipment:	A540
Test Engineer:	S. Archer-Davies

- The manufacturer for this part guaranteed no radiation tolerance/hardness.

TABLE II. Radiation Schedule for AD7545AUQ/883B

EVENT	DATE
1) INITIAL ELECTRICAL MEASUREMENTS	05/03/99
2) 2.5 KRAD IRRADIATION (0.147 KRADS/HOUR)	05/03/99
POST-2.5 KRAD ELECTRICAL MEASUREMENT	05/04/99
3) 5.0 KRAD IRRADIATION (0.147 KRADS/HOUR)	05/04/99
POST-5.0 KRAD ELECTRICAL MEASUREMENT	05/05/99
4) 10.0 KRAD IRRADIATION (0.294 KRADS/HOUR)	05/05/99
POST-10.0 KRAD ELECTRICAL MEASUREMENT	05/06/99
5) 96 HOUR ANNEALING @25°C	05/06/99
POST-96 HOUR ANNEAL ELECTRICAL MEASUREMENT	05/10/99
6) 264 HOUR ANNEALING @25°C	05/06/99
POST-264 HOUR ANNEAL ELECTRICAL MEASUREMENT	05/17/99
7) 15.0 KRAD IRRADIATION (0.294 KRADS/HOUR)	05/18/99
POST-15.0 KRAD ELECTRICAL MEASUREMENT	05/19/99
8) 20.0 KRAD IRRADIATION (0.294 KRADS/HOUR)	05/19/99
POST-20.0 KRAD ELECTRICAL MEASUREMENT	05/20/99
9) 30.0 KRAD IRRADIATION (0.588 KRADS/HOUR)	05/20/99
POST-30.0 KRAD ELECTRICAL MEASUREMENT	05/21/99
10) 168 HOUR ANNEALING @25°C	05/21/99
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	05/28/99
11) 168 HOUR ANNEALING @100°C	05/28/99
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	06/04/99

Effective Dose Rate = 30,000 RADS/18 DAYS=69.4 RADS/HOUR=0.019 RADS/SEC

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

Table III. Electrical Characteristics of AD7545AUQ/883B (1)

Test #	Parameter	Units	Spec. min	Lim. max	Test Conditions (2)
V_{DD} = 5V					
110	INL	lsb	0.00	1.00	
120	DNL	lsb	0.00	1.00	
200-213	Iil	nA	-1000	1000	
214-227	Iih	nA	-1000	1000	
300	Iout Leakage	nA	-10.0	10.0	
400	Icc_Vil	µA	0	2000	Inputs = 0.8V
401	Icc_Vih	µA	0	2000	Inputs = 2.4V
402	Icc_0V	µA	0	100	Inputs = 0.0V
403	Icc_5V	µA	0	100	Inputs = 5.0V
500	PSRR	µV	-20.0	20.0	V_{DD} = ±5%
501	Gain_error	mV	-7.326	7.326	
V_{DD} = 15V					
510	INL	lsb	0.00	1.00	
511	DNL	lsb	0.00	1.00	
600-613	Iil	nA	-1000	1000	
614-627	Iih	nA	-1000	1000	
700	Iout Leakage	nA	-10.0	10.0	
800	Icc_Vil	µA	0	2000	Inputs = 1.5V
801	Icc_Vih	µA	0	2000	Inputs = 13.5V
802	Icc_0V	µA	0	100	Inputs = 0.0V
803	Icc_5V	µA	0	100	Inputs = 15.0V
900	PSRR	µV	-20.0	20.0	V_{DD} = ±5%
901	Gain_error	mV	-7.326	7.326	

Notes:

(1) These are the manufacturer's non-irradiated data sheet specification limits. The manufacturer provided no post-irradiation limits at the time the tests were performed.

(2) V_{REF} = -10V unless otherwise noted.

TABLE IV: Summary of Electrical Measurements after Total Dose Exposures and Annealing for AD7545A (1)

							Total Dose Exposure (kRads Si)						Annealing (3)				Total Dose Exposure (kRads Si)						Annealing			
Test			Spec. Lim. (2)		Initial		2.5		5.0		10.0		96 hours @25°C		264 hours @25°C		15.0		20.0		30.0		168 hours @25°C		168 hours @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	mean	sd
VDD = 5V																										
110	INL	lsb	0.00	1.00	0.33	0.06	0.43	0.05	0.42	0.06	0.64	0.09	0.45	0.04	0.39	0.03	1.13	0.28	4924	2928	5245	775	4773	978	11.03	14.33
120	DNL	lsb	0.00	1.00	0.25	0	0.25	0	0.25	0	0.75	0.17	0.50	0	0.35	0.14	0.98	0.15	4070	2611	4230	337	3772	730	12.67	18.92
200-213	Iil	nA	-1000	1000	134	35	150	14	156	17	116	30	106	42	150	14	144	17	138	17	144	28	113	17	25	3
214-227	Iih	nA	-1000	1000	100	28	84	9	75	17	52	37	34	35	75	17	66	20	72	24	75	17	59	17	31	0
300	Iout Leakage	nA	-10.0	10.0	0.0	0.0	0.0	0.0	-4.3	1.6	-1203	55	-905	110	-336	103	-1629	24	-1731	38	-1889	46	-1853	39	-1168	545
400	Icc_Vil	mA	0	2000	0	0	7	1	48	6	330	32	251	29	156	21	597	59	1175	144	978	134	974	130	68	73
401	Icc_Vih	mA	0	2000	361	5	286	9	223	14	143	20	138	21	140	19	89	22	76	21	167	15	91	14	44	23
402	Icc_0V	mA	0	100	0	0	0	0	0	0	5	2	2	1	0	0	47	13	404	74	2163	373	1240	304	29	41
403	Icc_5V	mA	0	100	0	0	0	0	0	0	1	0	0	0	0	0	3	0	27	3	148	13	73	9	18	24
500	PSRR	mV	-20.0	20.0	-1.6	0.5	-1.5	0.2	-1.3	0.7	0.1	0.5	-2.0	0.5	0.6	0.5	2.3	0.8	5.1	0.7	15.5	2.0	15.7	1.3	(5)	
501	Gain_error	mV	-7.326	7.326	2.025	0.178	2.125	0.151	2.145	0.148	2.187	0.140	2.163	0.145	2.227	0.151	2.330	0.148	2.484	0.133	3.360	0.102	3.053	0.078	5.243	0.726
VDD = 15V																										
510	INL (4)	lsb	0.00	1.00	0.35	0	0.35	0	0.35	0	0.60	0.08	0.99	0	0.34	0.04	0.76	0.09	1.93	0.20	4.13	0.37	4.61	0.88	3.01	2.89
511	DNL (4)	lsb	0.00	1.00	0.31	0.01	0.30	0.11	0.30	0.11	0.65	0.11	1.00	0	0.52	0.05	0.92	0.05	1.06	0.11	1.86	0.33	2.50	0.55	2.07	2.11
600-613	Iil	nA	-1000	1000	129	33	144	17	156	14	103	65	131	41	131	14	144	17	138	17	125	44	112	17	25	2
614-627	Iih	nA	-1000	1000	121	33	91	7	94	13	75	23	59	17	78	31	75	7	84	9	88	9	59	17	31	0
700	Iout Leakage	nA	-10.0	10.0	0.1	0.0	0.0	0.0	-1.6	0.6	-503	27	-359	49	-131	41	-687	8	-731	14	-752	16	-761	16	-461	222
800	Icc_Vil	mA	0	2000	432	14	832	36	1262	60	2534	124	2208	126	1692	101	3090	177	4668	255	4995	1	4995	1	491	247
801	Icc_Vih	mA	0	2000	71	3	37	4	16	4	7	2	4	2	2	2	49	14	397	77	268	95	607	190	43	59
802	Icc_0V	mA	0	100	0	0	0	0	0	0	7	3	3	1	0	0	70	20	582	109	3212	509	1790	501	39	55
803	Icc_5V	mA	0	100	0	0	0	0	0	0	5	2	2	1	0	0	49	14	397	77	269	95	595	183	43	59
900	PSRR	mV	-20.0	20.0	4.1	0.4	3.4	0.3	2.8	0.4	2.1	0.5	2.1	0.2	2.2	0.4	2.3	0.3	2.3	0.3	6.0	1.0	5.0	0.8	(5)	
901	Gain_error	mV	-7.326	7.326	2.072	0.176	2.168	0.145	2.183	0.145	2.193	0.137	2.210	0.141	2.216	0.146	2.267	0.142	2.301	0.140	2.696	0.080	2.492	0.101	2.741	0.189

Notes:

(1) The mean and standard deviation values were calculated over the five parts irradiated in this testing. The control samples remained constant throughout 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) This annealing step was performed because the parts showed degradation at 10kRads which is the IRAC Project Radiaiton Requirement.
The room temperature annealing was performed to determine if the parts would recover in the low dose rate envirnment of space and thus qualify the parts for IRAC.

(4) The INL nad DNL measurements initially and after irradiation up to 10kRads were made using a technique called # of hits/code.
This technique gave values for INL and DNL at 15V about 0.4lsb higher than the transfer technique which was used for all steps after 10kRads.
The initial to 10kRad values for INL and DNL at 15V have been corected by 0.4lsb.

(5) No reliable measurement could be made for this parameter at this step.

Radiation sensitive parameters: At Vdd = 5V: INL, DNL, Iout Leakage, Icc_0V, Icc_5V; At Vdd = 15V: INL, DNL, Iout Leakage, Icc_Vil, Icc_0V, Icc_5V.