

Unisys

DATE: September 03, 1999
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SUBJECT: Radiation Report on **AD7535 (Analog Devices) (LDC 9812)**
PROJECT: GLAS

PPM-99-027

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A radiation evaluation was performed on **AD7535 14Bit CMOS Current Out Multiplying DAC with Byte/Parallel Input Structure (Analog Devices)** to determine the total dose tolerance of these parts. The total dose testing was performed using a Co⁶⁰ gamma ray source. During the radiation testing, one part was irradiated under bias to determine the initial degradation level. Five parts were then irradiated under bias (see Figure 1 for bias configuration) and one part was used as a control sample. The total dose radiation levels for the five parts were 10.0, 17.5 and 25.0kRads.¹ The average dose rate was 0.16kRads/hour (0.05 Rads/s). See Table II for the radiation schedule and average dose rate calculation. After the 25.0kRad irradiation, the parts were annealed under bias at 25°C for 168 hours.² After each radiation exposure and annealing treatment, parts were electrically tested according to the test conditions and the specification limits³ listed in Table III. These tests included the measurement of Integral Non-Linearity (RA) and Differential Non-Linearity (DNL) at different Vil of 0.8V, 0.4V and 0V. The reason for doing different Vil was that the test on the one sample showed that with increasing radiation, these parameters were sensitive to the logic level input voltage on Vil. 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 10kRads. After the 17.5 and 25kRad irradiations, All parts showed significant degradation in RA and DNL with Vil = 0.8 or 0.4V; the parts performed reasonably well with Vil = 0V. Some parts showed modest degradation in full_scale_error, IDD3 and IDD4. After annealing the parts at 25°C for 168 hours, the parts showed no significant recovery in any radiation sensitive parameter. See Figures 2-5 for further details.

Initial electrical measurements were made on 8 samples. One part was used to determine the initial degradation level (SN 81). Five samples (SN's 83, 84, 85, 86, and 87) were used as radiation samples while SN 82 was used as a control sample. All parts passed all tests during initial electrical measurements.

All parts passed all tests up to 10.0kRads with Vil = 0V, 0.4V and 0.8V.

After the 17.5kRad irradiation, all parts except one passed all RA and DNL tests with Vil = 0V and 0.4V. One part exceeded the specification limit of 1.00lsb for RA_vil_0.4V and RA_5V_0V with a reading of 1.20lsb for both. All parts exceeded the specification limit of 1.00lsb for RA_vil_0.8V with readings in the range of 5889 to 7885lsb. All parts exceeded the specification limit of 1.00lsb for DNL_vil_0.8V with readings in the range of 2479 to 3108lsb. All parts exceeded the specification limit of 0.50mA for IDD3 with readings in the range of 0.56 to 0.66mA. **All parts passed all other tests.**

After the 25kRad irradiation, three parts marginally exceeded the specification limit for RA_5V_0V with readings in the range of 1.65 to 2.27lsb. However, one other part had readings of >2000lsb for RA_5V_0V and DNL_5V_0V. Based on further testing, these two readings on this part can not be considered reliable and thus were not included in the mean and standard deviation calculations in Table 4 for these two tests. All parts exceeded the specification

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.

limit of 1.00lsb for RA_vil_0.4V with readings in the range of 3887 to 7818lsb. All parts exceeded the specification limit of 1.00lsb for DNL_vil_0.4V with readings in the range of 2061 to 3557lsb. All parts exceeded the specification limit for RA_vil_0.8V with readings in the range of 6144 to 9166lsb. All parts exceeded the specification limit for DNL_vil_0.8V with readings in the range of 2615 to 6500lsb. Three parts fell marginally below the specification limit of -4.00lsb for full_scale_error with readings in the range of -4.18 to -4.35lsb. All parts exceeded the specification limit for IDD3 with readings in the range of 1.94 to 2.74mA. All parts exceeded the specification limit of 0.50mA for IDD4 with readings in the range of 0.91 to 1.05mA. **All parts passed all other tests.**

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

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.

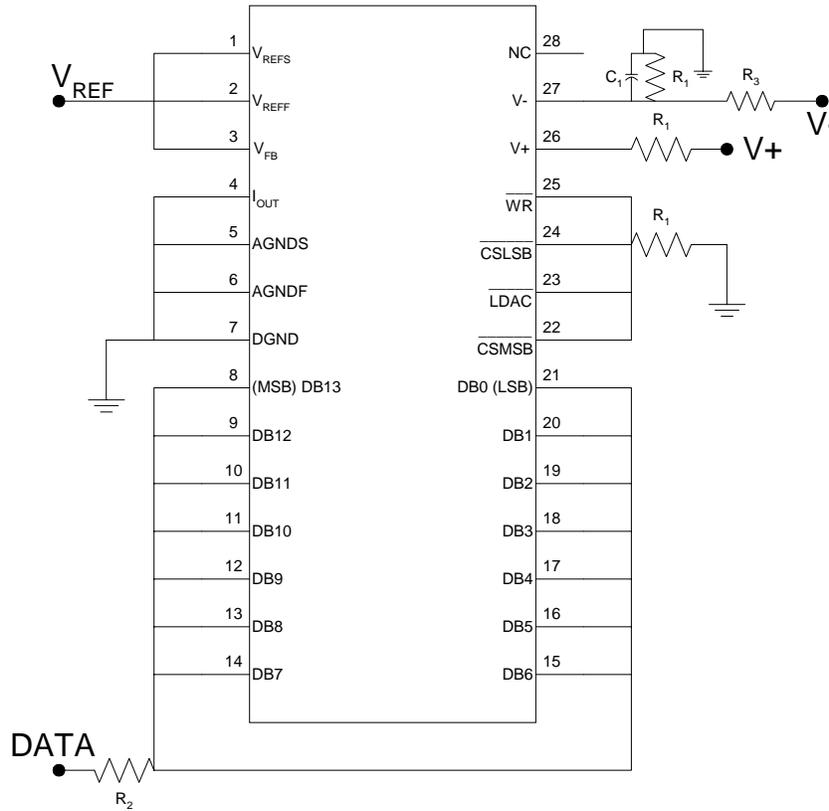
Any further details about this evaluation can be obtained upon request. If you have any questions, please call us at (301) 731-8954.

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Figure 1. Radiation Bias Circuit for AD7535



Notes:

1. $V+ = +15.0V \pm 0.5V$ DC.
2. $V- = -15.0V \pm 0.5V$ DC.
3. $DATA = +15.0V \pm 0.5V$ DC.
4. $V_{REF} = +10.0V \pm 0.5V$ DC.
5. $R_1 = 1k\Omega \pm 5\%$, $\frac{1}{4}W$.
6. $R_2 = 2k\Omega \pm 5\%$, $\frac{1}{4}W$.
7. $R_3 = 47k\Omega \pm 5\%$, $\frac{1}{4}W$.
8. $C_1 = 4.7\mu F$, 50V.

TABLE I. Part Information

Generic Part Number:	AD7535
GLAS Part Number	AD7535
GLAS TID Requirement	25kRads (RDM = 5)
Charge Number:	M90421
Manufacturer:	Analog Devices
Lot Date Code (LDC):	9812
Quantity Tested:	7
Serial Numbers of Control Samples:	82
Serial Number of Initial Degradation Sample:	81
Serial Numbers of Radiation Samples:	83, 84, 85, 86, 87
Part Function:	14Bit CMOS Current Out Multiplying DAC
Part Technology:	CMOS
Package Style:	28 Pin DIP
Test Equipment:	A-540
Test Engineer:	S. Archer-Davies

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

TABLE II. Radiation Schedule for AD7535

EVENT	DATE
1) INITIAL ELECTRICAL MEASUREMENTS	07/29/99
One Part Test Runs	
2) 12 KRAD IRRADIATION (0.180 KRADS/HOUR).....	07/30/99
POST-12 KRAD ELECTRICAL MEASUREMENT	08/02/99
3) 18.0 KRAD IRRADIATION (0.125 KRADS/HOUR).....	08/02/99
POST-18.0 KRAD ELECTRICAL MEASUREMENT	08/06/99
4) 25.0 KRAD IRRADIATION (0.099 KRADS/HOUR).....	08/06/99
POST-25.0 KRAD ELECTRICAL MEASUREMENT	08/10/99
All Remaining Parts	
5) 10.0 KRAD IRRADIATION (0.155 KRADS/HOUR).....	08/13/99
POST-10.0 KRAD ELECTRICAL MEASUREMENT	08/16/99
6) 17.5 KRAD IRRADIATION (0.170 KRADS/HOUR).....	08/16/99
POST-17.5 KRAD ELECTRICAL MEASUREMENT	08/18/99
7) 25.0 KRAD IRRADIATION (0.170 KRADS/HOUR).....	08/18/99
POST-25.0 KRAD ELECTRICAL MEASUREMENT	08/20/99
8) 168 HOUR ANNEALING @25°C.....	08/20/99
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	08/27/99

Average Dose Rate = 25,000 RADS/153 HOURS=163.4 RADS/HOUR=0.05 RADS/SEC

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

Table III. Electrical Characteristics AD7535 (1)

Test #	Parameter	Units	Spec. Limit		Test Conditions (2)
			min	max	
100	RA_vil_0.8V	lsb	-1.00	1.00	
101	DNL_vil_0.8V	lsb	-1.00	1.00	Guaranteed Monotonic to 14 Bits
102	RA_vil_0.4V	lsb	-1.00	1.00	
103	DNL_vil_0.4V	lsb	-1.00	1.00	Guaranteed Monotonic to 14 Bits
104	RA_5V_0V	lsb	-1.00	1.00	
105	DNL_5V_0V	lsb	-1.00	1.00	Guaranteed Monotonic to 14 Bits
200	full scale error	lsb	-4.00	4.00	
400-418	Iih	nA	-1000	1000	V _{IN} = 0V or V _{DD}
419-435	Iil	nA	-1000	1000	V _{IN} = 0V or V _{DD}
500	IDD1	mA	0	4.00	All digital inputs = V _{IL} (0.8V)
501	IDD2	mA	0	4.00	All digital inputs = V _{IH} (2.4V)
502	IDD3	mA	0	0.50	All digital inputs = 0V
503	IDD4	mA	0	0.50	All digital inputs = V _{DD} (15V)
600	PSRR	%/%	-20.0	20.0	V _{DD} = 15.75V to 14.25V

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_{DD} = +15V, V_{REF} = +10V, V_{PIN3} = V_{PIN4} = 0V, V_{SS} = -300mV unless otherwise specified.

ABLE IV: Summary of Electrical Measurements after Total Dose Exposures and Annealing for AD7535 (

Test #	Parameters	Units	Spec. Lim. (2)		Total Dose Exposure (kRads Si)								Annealing	
					Initial		10.0		17.5		25.0		168 hours @25°C	
					min	max	mean	sd	mean	sd	mean	sd	mean	sd
100	RA_vil_0.8V	lsb	-1.00	1.00	0.29	0.02	0.32	0.01	6477	718	7026	1086	6569	549
101	DNL_vil_0.8V	lsb	-1.00	1.00	0.10	0.01	0.11	0.01	2673	246	3492	1505	2764	317
102	RA_vil_0.4V	lsb	-1.00	1.00	0.30	0.03	0.30	0.02	0.90	0.20	5641	1478	6404	300
103	DNL_vil_0.4V	lsb	-1.00	1.00	0.10	0.01	0.10	0.01	0.78	0.21	3013	563	2727	293
104	RA_5V_0V	lsb	-1.00	1.00	0.29	0.03	0.32	0.01	0.90	0.19	1.67	0.47	1.68	0.44
105	DNL_5V_0V	lsb	-1.00	1.00	0.08	0.01	0.10	0.01	0.77	0.22	0.92	0.09	1.08	0.37
200	full scale error	lsb	-4.00	4.00	-2.66	0.29	-2.81	0.31	-3.17	0.30	-4.06	0.24	-3.87	0.28
400-418	Iih	nA	-1000	1000	50	2.4	26	3.3	38	2.2	26	3.3	30	3.1
419-435	Iil	nA	-1000	1000	25	3.3	26	1.5	31	3.3	27	2.8	30	3.2
500	IDD1	mA	0	4.00	0.19	0	0.67	0.03	0.69	0.03	0.49	0.03	0.47	0.02
501	IDD2	mA	0	4.00	0.32	0.02	0.22	0.01	0.33	0.01	0.82	0.06	0.46	0.04
502	IDD3	mA	0	0.50	0.20	0.01	0.21	0.01	0.60	0.04	2.29	0.27	0.97	0.15
503	IDD4	mA	0	0.50	0.20	0.01	0.20	0.01	0.42	0.02	0.97	0.05	0.64	0.07
600	PSRR	%/%	-20.0	20.0	0.004	0.003	0.015	0.005	0.033	0.006	0.067	0.008	0.069	0.011

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) After the 25kRad irradiation, the mean and standard deviation for RA_5V_0V and DNL_5V_0V are based on four parts only. One part's readings were considered.

Radiation sensitive parameters: RA, DNL, full scale error, IDD.