Unisys Corporation
4700 Boston Way
Lanham, MD 20706

Unisys

DATE: March 19, 1998 PPM-98-001
TO: S. Hull/562
FROM: K. Sahu/S. Kniffin/300.1
SUBJECT: **Radiation Report on: AD976 (Analog Devices) (LDC 9723)**
Project: IRAC
Job #: M78281
Project part #: AD976

cc: R. Williams/562
M. Delmont/303
A. Reyes/OSC
A. Sharma/562
OFA Library/300.1

A radiation evaluation was performed on **AD976 16-bit, BiCMOS A/D Converter (Analog Devices)** 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 Co^{60} gamma ray source. During the radiation testing, ten 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 5.0, 10.0, 15.0, 20.0, 30.0, 50.0, and 100.0 kRads.* The dose rate was between 0.125 and 0.625 kRads/hour (0.035 to 0.174 Rads/s) depending upon the dose step. After the 5.0 kRad exposure the parts were annealed for 96 hours at 25°C under bias and for 336 hours at 25°C without bias. See Table II for the radiation schedule and effective dose rate calculation. The effective dose rate over all testing was 0.033 Rads/sec. After each radiation exposure and annealing treatment, parts were electrically tested according to the test conditions and the specification limits** listed in Table III.

Initial electrical measurements were made on 12 samples. Eight samples (SN's 54, 55, 56, 57, 58, 59, 60, and 61) were used as radiation samples, two were held as spares (SN's 62 and 63) and SN's 52 and 53 were used as a control samples. All parts passed all tests during initial electrical measurements.

SN's 54 through 61
After the 5.0 kRad irradiation, all eight parts had missing codes with numbers in the range of 18 to 35. Although a significant increase in INL and DNL was noted, SN 61 was the only part to marginally exceed the specification limit of 3.00lsb for DNL with a reading of 3.07 lsb. **All parts passed all other tests.**

After annealing the parts for 96 hours at 25°C, parts showed an increased number of missing codes with numbers in the range of 26 to 61. Additional degradation occurred in both DNL and INL with SN's 54, 60 and 61 exceeding the specification limit for DNL with readings in the range of 3.32 to 3.45 lsb. SN's 54 and 60 also exceeded the specification limit of 3.00 lsb for INL with readings of 3.20 and 3.14 lsb. These results indicate that the radiation induced degradation may be higher at lower dose rates than used in this testing. **All parts passed all other tests.**

After annealing the parts for 336 hours at 25°C without bias, parts showed very modest recovery with number of missing codes in the range of 21 to 54. A very marginal improvement in DNL and INL was noted with four parts exceeding the specification limit for DNL with readings in the range of 3.07 to 3.45 lsb and SN 60 and 61 exceeding the specification limit for INL with readings of 3.38 and 3.00 lsb respectively. **All parts passed all other tests.**

* 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. The manufacturer provided no post-irradiation limits at the time these tests were performed.

After the 10.0 to 30.0 kRad irradiations, all parts had missing codes ranging in number from a minimum of 99 at 10kRads to a maximum of 971 at 30kRads. All parts exceeded the specification limit for DNL with readings ranging from 4.85 lsb at 10kRads to 15.43 lsb at 30kRads. All parts exceeded the specification limit for INL with readings ranging from 4.97 lsb at 10kRads to 15.19 lsb at 30kRads. **All parts passed all other tests.**

After the 50.0 kRad irradiation, all parts had missing codes in the range of 1394 to 1722, exceeded the specification limit for DNL with readings in the range of 18.15 to 25.56lsb and exceeded the specification limit for INL with readings in the range of 16.96 to 24.17lsb. Three parts failed voh with readings of 0V against the specification limit of 4.0V and five parts failed vol with readings of 5V against the specification limit of 400mV. These readings indicate functional failure of the parts. Four and six parts exceeded the specification limit of 8lsb for psrr_+5% and psrr_-5% respectively with readings greater than 35lsb for both.

After the 100.0 kRad irradiation, all parts had more than 15,000 missing codes, exceeded the specification limit for DNL with readings greater than 33lsb and exceeded the specification limit for INL with readings greater than 35lsb. All parts fell below the specification limit of 2.48V for vref with readings of 2.47V. Three parts fell below the specification limit of 4V for voh all with readings of 0V and four parts exceeded the specification limit of 400mV for vol all with readings of 5V. Seven parts exceeded the specification limit of 8lsb for psrr_+5% and psrr_-5% each with readings greater than 30lsb for both.

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

Since these first eight parts showed significant degradation at 5.0 kRads, the remaining two parts (SN's 62 and 63) were irradiated in 1.0kRad increments to better determine the point of deviation from the manufacturer's specifications. It is interesting to note that at the much lower total dose rate of 0.006Rads/s for the two parts, the number of missing codes was higher after the 5kRad step than were the number of missing codes from the main group that was tested at 0.033Rads/s. The results for the two parts are presented below and in Table IVa. A brief summary of the test results is provided below. The radiation schedule is provided in Table IIa.

SN's 62 and 63
All parts passed al tests up to 1.0 kRad.

After the 2.0 kRad irradiation, both parts had missing codes, 5 and 4 respectively. **All parts passed all other tests.**

After annealing the parts for 96 hours at 25°C, parts showed an increase in the number of missing codes, 7 and 11 respectively. **This again indicates that the parts may show more radiation damage at lower dose rates. All parts passed all other tests.**

After the 3.0 kRad irradiation, the number of missing codes continued to increase with readings of 13 and 32 respectively. There was also a significant increase in DNL and INL but parts were still within the specification limits for INL and DNL. **All parts passed all other tests.**

After the 4.0 kRad irradiation, the number of missing codes continued to increase with readings of 25 and 59 respectively. SN 63 exceeded the specification limit of 3.00 lsb for both DNL and INL with readings of 3.45 and 3.15 respectively. **All parts passed all other tests.**

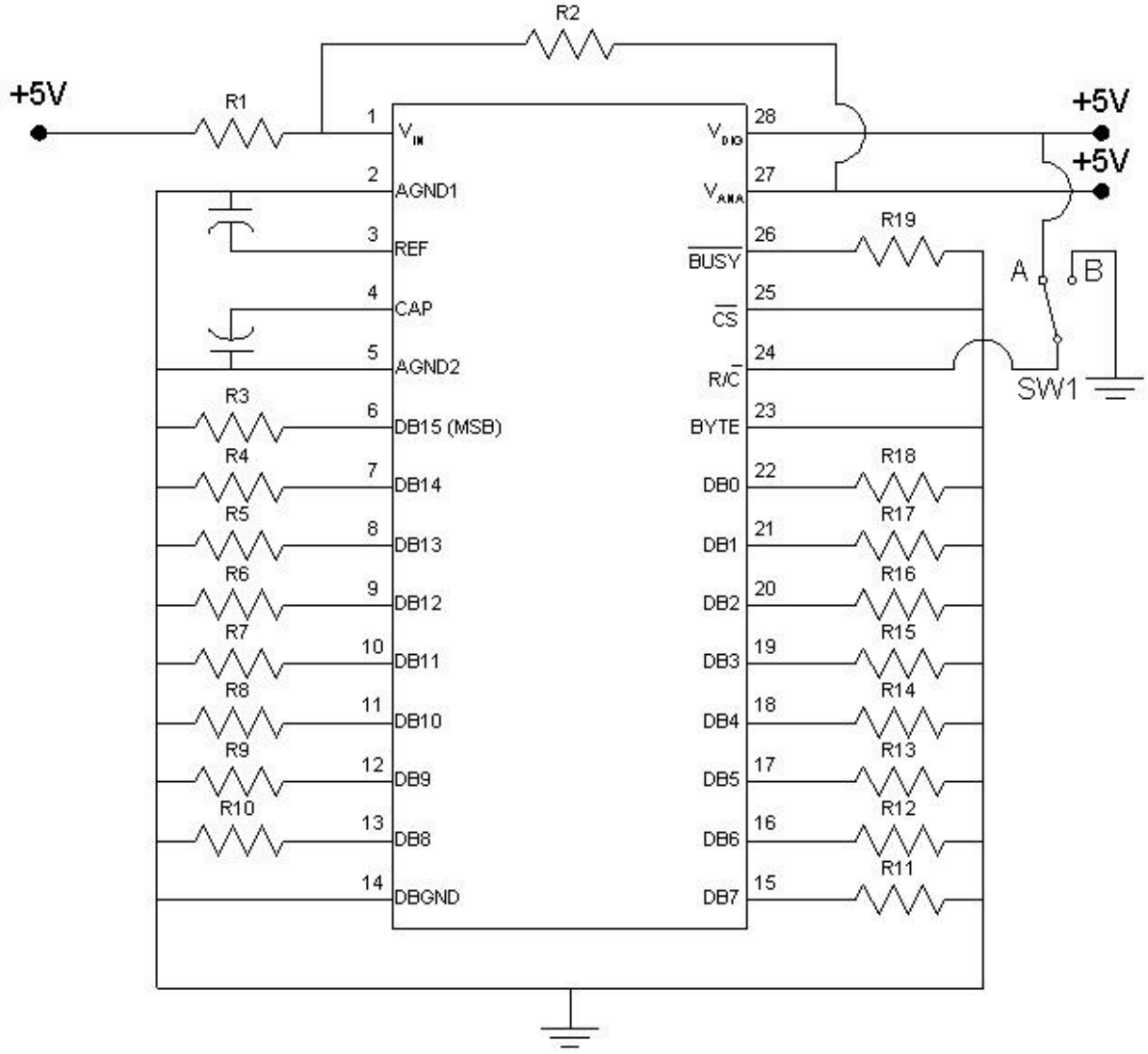
After the 5.0 kRad irradiation, both parts continued to degrade. Missing codes were 30 and 72 respectively and SN 63 continued to exceed the specification limits for DNL and INL with readings of 3.32 and 3.52 lsb. **All parts passed all other tests.**

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.

In summary, the AD 976 parts showed significant degradation after 2.0kRads. Figures 1 through 4 show the degradation in the most sensitive radiation parameters upon exposure from 5 to 100 kRads.

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

Figure 1. Radiation Bias Circuit for AD976



Notes:
1. R1 = 200Ω ±5% ¼W.
2. R2 = 66.4KΩ ±5% ¼W.
3. R3 – R19 = 10Ω ±5% ¼W.
4. Capacitors are 2.2µf, 25V, Tantalum
5. To start radiation bias, momentarily switch SW1 to position B and then return to position A.

TABLE I. Part Information

Generic Part Number:	AD976
IRAC Part Number	AD976
Charge Number:	M78281
Manufacturer:	Analog Devices
Lot Date Code (LDC):	9723
Quantity Tested:	12
Serial Number of Control Samples:	52, 53
Serial Numbers of Radiation Samples:	54, 55, 56, 57, 58, 59, 60, and 61 (62 & 63)
Part Function:	16-bit, 200kSPS, BiCMOS A/D Converter
Part Technology:	CMOS
Package Style:	28 Pin DIP
Test Equipment:	A540
Test Engineer:	S. Archer-Davies

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

TABLE II. Radiation Schedule for AD976 First Eight Parts

EVENT	DATE
1) INITIAL ELECTRICAL MEASUREMENTS	01/28/98
2) 5.0 KRAD IRRADIATION (0.125 KRADS/HOUR)	01/30/98
POST-5.0 KRAD ELECTRICAL MEASUREMENT	02/02/98
3) 96 HOUR ANNEALING @25°C	02/02/98
POST-96 HOUR ANNEAL ELECTRICAL MEASUREMENT	02/06/98
4) 336 HOUR ANNEALING @25°C (unbiased)	02/06/98
POST-336 HOUR ANNEAL ELECTRICAL MEASUREMENT	02/20/98
5) 10.0 KRAD IRRADIATION (0.125 KRADS/HOUR)	02/20/98
POST-10.0 KRAD ELECTRICAL MEASUREMENT	02/23/98
6) 15.0 KRAD IRRADIATION (0.125 KRADS/HOUR)	02/23/98
POST-15.0 KRAD ELECTRICAL MEASUREMENT	02/25/98
7) 20.0 KRAD IRRADIATION (0.125 KRADS/HOUR)	02/25/98
POST-20.0 KRAD ELECTRICAL MEASUREMENT	02/27/98
8) 30.0 KRAD IRRADIATION (0.250 KRADS/HOUR)	02/27/98
POST-30.0 KRAD ELECTRICAL MEASUREMENT	03/02/98
9) 50.0 KRAD IRRADIATION (0.500 KRADS/HOUR)	03/02/98
POST-50.0 KRAD ELECTRICAL MEASUREMENT	03/04/98
10) 100.0 KRAD IRRADIATION (0.625 KRADS/HOUR)	03/04/98
POST-100.0 KRAD ELECTRICAL MEASUREMENT	03/06/98
11) 168 HOUR ANNEALING @25°C	03/06/98
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	03/12/98

Effective Dose Rate = 100,000 RADS/35 DAYS=119.0 RADS/HOUR=0.033 RADS/SEC
The effective dose rate is lower than that of the individual radiation steps as it takes into account the interim-annealing step.

The interim annealing following the 5.0 kRad step was added due to degradation in the parts. The addition of an interim annealing step better simulates the space environment's lower dose rate for very sensitive devices. This may allow the parts to show satisfactory performance at higher doses or indicate that the part can not be used beyond the previous dose level.

PARTS WERE IRRADIATED AND ANNEALED UNDER BIAS, EXCEPT FOR STEP #4 IN TABLE II. SEE FIGURE 1.

Table IIa. Radiation Schedule for AD976 SN's 62 and 63

EVENT	DATE
1) INITIAL ELECTRICAL MEASUREMENTS	01/27/98
2) 1.0 KRAD IRRADIATION (0.059 KRADS/HOUR)	02/11/98
POST-1.0 KRAD ELECTRICAL MEASUREMENT	02/12/98
3) 2.0 KRAD IRRADIATION (0.059 KRADS/HOUR)	02/12/98
POST-2.0 KRAD ELECTRICAL MEASUREMENT	02/13/98
4) 96 HOUR ANNEALING @25°C	02/13/98
POST-96 HOUR ANNEAL ELECTRICAL MEASUREMENT	02/17/98
5) 3.0 KRAD IRRADIATION (0.059 KRADS/HOUR)	02/17/98
POST-3.0 KRAD ELECTRICAL MEASUREMENT	02/18/98
6) 4.0 KRAD IRRADIATION (0.059 KRADS/HOUR)	02/18/98
POST-4.0 KRAD ELECTRICAL MEASUREMENT	02/19/98
7) 5.0 KRAD IRRADIATION (0.059 KRADS/HOUR)	02/19/98
POST-5.0 KRAD ELECTRICAL MEASUREMENT	02/20/98

Effective Dose Rate = 5,000 RADS/10 DAYS=20.8 RADS/HOUR=0.006 RADS/SEC
The effective dose rate is lower than that of the individual radiation steps as it takes into account the interim-annealing step.

The interim annealing following the 2.0 kRad step was added due to degradation in the parts. The addition of an interim annealing step better simulates the space environment's lower dose rate for very sensitive devices. This may allow the parts to show satisfactory performance at higher doses or indicate that the part can not be used beyond the previous dose level.

PARTS WERE IRRADIATED AND ANNEALED UNDER BIAS, EXCEPT FOR STEP #4 IN TABLE II. SEE FIGURE 1.

Table III. Electrical Characteristics of AD976 /1

Test #	Parameter	Units	Test Conditions	Spec. min	Lim. max
100	Missing/Min. Code /2		V_{dig}=5V, V_{ana}=5V, AIN=ramp –10V to 10V		0
101	No. of Missing Codes		V_{dig}=5V, V_{ana}=5V, AIN=ramp –10V to 10V		0
102	DNL /3	lsb	V_{dig}=5V, V_{ana}=5V, AIN=ramp –10V to 10V	0	3.00
103	INL	lsb	V_{dig}=5V, V_{ana}=5V, AIN=ramp –10V to 10V	0	3.00
200	Vref	V	V_{dig}=5V, V_{ana}=5V	2.48	2.52
300	Idig	mA	V_{dig}=5V, V_{ana}=5V	0	
301	Iana	mA	V_{dig}=5V, V_{ana}=5V	0	
302	Pd	mW	Pd = (I_{ana} + I_{dig})*5V	0	100
400	byte_iil	mA	V_{dig}=5V, V_{ana}=5V, Vin=0V	-10.0	10.0
401	rc_iil	mA	V_{dig}=5V, V_{ana}=5V, Vin=0V	-10.0	10.0
402	cs_iil	mA	V_{dig}=5V, V_{ana}=5V, Vin=0V	-10.0	10.0
403	byte_iih	mA	V_{dig}=5V, V_{ana}=5V, Vin=5V	-10.0	10.0
404	rc_iih	mA	V_{dig}=5V, V_{ana}=5V, Vin=5V	-10.0	10.0
405	cs_iih	mA	V_{dig}=5V, V_{ana}=5V, Vin=5V	-10.0	10.0
500-515	DB*_voh	V	VD=5V, VDD=5V, Ioh=-500mA, DB15-DB0	4.00	
600-615	DB*_vol	mV	VD=5V, VDD=5V, Ioh=1.6mA, DB15-DB0		400
700	psrr_+5%	lsb	VD=5.25-5.00V, Vin=5V		8
701	psrr_-5%	lsb	VD=5.00-4.75V, Vin=5V		8
800-815	DB*_iozh	mA	V_{dig}=5V, V_{ana}=5V, Vin=5V, DB15-DB0	-5.0	5.0
900-915	DB*_iozl	mA	V_{dig}=5V, V_{ana}=5V, Vin=0V, DB15-DB0	-5.0	5.0

Notes:

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

2/ Missing Codes is a go/no-go test and an "F" appears after the code number displayed when it fails. Since the device is an AD976, it is tested as 16 bits as per the spec's. There are 32,768 codes (2^{16}) for inputs from –10V to 10V. A triangular wave pulse is applied to the analog input. 256k digital samples are captured at the output rate of 100kSPS. The samples are statistically analyzed for "code hits", INL and DNL. For a passing part, the code that is hit the least is displayed. For a failing part, the first code that is missing is displayed.

3/ The limit used for DNL is the same as for INL (3lsb). The data sheet does not include a DNL test.

TABLE IV: Summary of Electrical Measurements after Total Dose Exposures and Annealing for AD976 /1

						TDE (kRads)		Annealing				Total Dose Exposure (kRads (Si))												Annealing	
					Initial		5.0		48 hours @25°C biased		336 hours @25°C unbiased		10.0		15.0		20.0		30.0		50.0		100.0		168 hours @25°C	
Test #	Parameters	Units	Spec. Lim. /2 min	max	mean	sd	mean	sd	mean			sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
100	Missing/Min. Code /3 /5			0	P		F		F		F		F		F		F		F		F		F		F	
101	No. of Missing Codes			0	0		28	4.5	47	11.2	35	10.3	162	29.3	364	58.8	579	87.6	777	115	1615	102	21133	5238	15963	3087
102	DNL	lsb	0	3.00	1.02	0.04	2.48	0.34	3.05	0.25	2.86	0.38	5.85	0.53	8.99	1.12	11.74	1.28	14.25	1.26	22.87	2.19	37.9	3.2	36.9	1.9
103	INL	lsb	0	3.00	1.29	0.15	2.25	0.26	2.72	0.32	2.65	0.36	5.29	0.47	8.51	0.95	11.24	0.88	13.65	1.35	21.89	2.11	38.5	7.1	35.6	3.0
200	Vref	V	2.48	2.52	2.50	0	2.50	0	2.50	0	2.50	0	2.50	0	2.50	0	2.50	0	2.49	0.005	2.49	0	2.47	0	2.48	0
300	Idig	mA	0		2.7	0.2	2.8	0.2	2.8	0.2	2.8	0.2	5.8	0.8	3.2	0.7	2.1	0.5	1.9	0.3	1.9	0.1	1.9	0.1	1.8	0.1
301	Iana	mA	0		9.6	0.1	9.6	0.1	9.6	0.2	9.6	0.2	9.6	0.2	9.6	0.2	9.2	0.1	9.2	0.1	8.8	0.1	8.6	0.1	8.6	0.2
302	Pd	mW	0	100	62	1.2	62	1.2	62	1.2	62	1.2	77	4.1	63	3.6	56	2.7	55	1.5	54	0.6	53	0.6	53	0.6
400	byte_iil	mA	-10.0	10.0	0.04	0.01	0.04	0.01	0.03	0.01	0.04	0.01	0.03	0.01	0.03	0.01	0.03	0.01	0.03	0.01	0.03	0.01	0.03	0.01	0.03	0.01
401	rc_iil	mA	-10.0	10.0	0.04	0.01	0.04	0.01	0.03	0.01	0.04	0.01	0.03	0.01	0.03	0.01	0.03	0.01	0.03	0.01	0.03	0.01	0.03	0.01	0.03	0.01
402	cs_iil	mA	-10.0	10.0	0.04	0.01	0.04	0.01	0.04	0.01	0.04	0.01	0.03	0.01	0.03	0.01	0.03	0.01	0.03	0.01	0.03	0.01	0.03	0.01	0.03	0.01
403	byte_iih	mA	-10.0	10.0	0.03	0.01	0.04	0.01	0.03	0.01	0.04	0.01	0.03	0.01	0.03	0.01	0.03	0.01	0.03	0.01	0.03	0.01	0.03	0.01	0.03	0.01
404	rc_iih	mA	-10.0	10.0	0.03	0.01	0.04	0.01	0.04	0.01	0.04	0.01	0.03	0.01	0.03	0.01	0.03	0.01	0.03	0.01	0.03	0.01	0.03	0.01	0.03	0.01
405	cs_iih	mA	-10.0	10.0	0.03	0.01	0.04	0.01	0.04	0.01	0.04	0.01	0.03	0.01	0.03	0.01	0.03	0.01	0.03	0.01	0.03	0.01	0.03	0.01	0.03	0.01
500-515	DB*_voh /4 /5	V	4.00		4.9	0	4.9	0	4.9	0	4.9	0	4.9	0	4.9	0	4.9	0	4.9	0	5P/3F		5P/3F		5P/3F	
600-615	DB*_vol /4 /5	mV		400	111	2.8	111	4.4	111	3.4	112	2.8	113	3.1	112	2.4	114	3.5	115	3.3	3P/5F		4P/4F		F	
700	psrr_+5% /5	lsb		8	4	1.9	4	1.6	4	1.7	4	1.6	5	2.0	4	1.0	5	2.3	5	1.5	4P/4F		1P/7F		1P/7F	
701	psrr_-5% /5	lsb		8	4	1.6	4	1.7	3	1.7	5	1.4	4	1.5	5	2.1	5	1.4	4	1.7	2P/6F		1P/7F		4P/4F	
800-815	DB*_iozh /4	mA	-5.0	5.0	0.1	0	0.1	0	0.1	0	0.1	0	0.1	0	0.1	0	0.1	0	0.1	0	0.1	0	0.3	0.1	0.2	0.1
900-915	DB*_iozl /4	mA	-5.0	5.0	0.1	0	0.1	0	0.1	0	0.1	0	0.1	0	0.1	0	0.1	0	0.1	0	0.1	0	0.3	0.1	0.2	0.1

Notes:

1/ The mean and standard deviation values were calculated over the eight parts irradiated in this testing. The control samples remained constant throughout 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/ Missing Codes is a go/no-go test and an "F" appears when there is even one missing code out of the 2^16 bits.

4/ The * repersents that this test was performed on all pins from DB0 to DB15. The mean and sd are calculated based on the value of the pin closest to or farthest out of spec for each part.

5/ "P" ("F") implies all parts passed (failed) this test at this level. nPmF implies that "n" parts passed and "m" parts failed this test at this level.

Radiation sensitive parameters: Missing Codes (# of Missing Codes), DNL, INL, Vref, DB*_voh, DB*_vol, psrr_+5%, psrr_-5%.

TABLE IVa: Summary of Electrical Measurements after Total Dose Exposures and Annealing for AD976 /1

							TDE (kRads (Si))				Annealing		Total Dose Exposure (kRads (Si))					
			Spec. Lim. /2		Initial		1.0		2.0		96 hours @25°C		3.0		4.0		5.0	
Test #	Parameters	Units	min	max	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
100	Missing/Min. Code /3 /5			0	P		P		F		F		F		F		F	
101	No. of Missing Codes /4			0	0		0		5	1	9	2	23	10	42	17	51	21
102	DNL	lsb	0	3.00	1.03	0	1.10	0.07	1.35	0.19	1.67	0.38	1.93	0.26	2.63	0.83	2.88	0.45
103	INL	lsb	0	3.00	1.41	0.12	1.48	0.16	1.55	0.24	1.85	0.05	1.82	0.21	2.59	0.57	2.92	0.60
200	Vref	V	2.48	2.52	2.50	0	2.50	0	2.50	0	2.50	0	2.50	0	2.50	0	2.50	0
300	Idig	mA	0		2.9	0.2	2.9	0.2	2.9	0.2	2.9	0.2	2.8	0.2	2.9	0.2	2.9	0.2
301	Iana	mA	0		9.9	0.3	9.9	0.3	9.9	0.3	9.9	0.3	9.9	0.3	9.9	0.3	9.9	0.3
302	Pd	mW	0		64	2.5	64	2.5	64	2.5	64	2.5	64	2.5	64	2.5	64	2.5
400	byte_iil	mA	-10.0	10.0	0.04	0	0.04	0	0.04	0.01	0.02	0	0.03	0.01	0.03	0	0.04	0
401	rc_iil	mA	-10.0	10.0	0.04	0	0.04	0	0.04	0	0.04	0	0.04	0	0.04	0	0.04	0
402	cs_iil	mA	-10.0	10.0	0.04	0	0.04	0	0.04	0	0.04	0	0.035	0.005	0.04	0	0.04	0
403	byte_iih	mA	-10.0	10.0	0.02	0	0.03	0	0.035	0.005	0.03	0	0.03	0.01	0.03	0	0.03	0
404	rc_iih	mA	-10.0	10.0	0.04	0.01	0.03	0	0.03	0	0.03	0	0.04	0	0.035	0.005	0.03	0
405	cs_iih	mA	-10.0	10.0	0.04	0	0.03	0	0.03	0	0.03	0	0.03	0	0.025	0.005	0.03	0
500-515	DB*_voh	V	4.00		4.9	0	4.9	0	4.9	0	4.9	0	4.9	0	4.9	0	4.9	0
600-615	DB*_vol	mV		400	105.5	5.5	152.5	52.5	106	7	107	7	106	4	104	6	107	7
700	psrr_+5%	lsb		8	4	0	4.5	1.5	3	2	5	1	4	1	2	1	4.5	0.5
701	psrr_-5%	lsb		8	5	1	5.5	1.5	3.5	2.5	2.5	0.5	3	1	3	2	4	0
800-815	DB*_iozh	mA	-5.0	5.0	0.1	0	0.1	0	0.1	0	0.1	0	0.1	0	0.1	0	0.1	0
900-915	DB*_iozl	mA	-5.0	5.0	0.1	0	0.1	0	0.1	0	0.1	0	0.1	0	0.1	0	0.1	0

Notes:

1/ The mean and standard deviation values were calculated over the two parts irradiated in this testing. The control samples remained constant throughout testing and are not included in this ta

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/ Missing Codes is a go/no-go test and an “F” appears when there is even one missing code out of the 2^16 bits.

4/ The * repersents that this test was performed on all pins from DB0 to DB15. The mean and sd are calculated based on the value of the pin closest to or farthest out of spec for each part.

5/ "P" ("F") implies all parts passed (failed) this test at this level. nPmF implies that "n" parts passed and "m" parts failed this test at this level.

Radiation sensitive parameters: Missing Codes (# of Missing Codes), DNL, INL.

Fig. 2: Missing Codes vs Total Dose