Unisys

DATE: January 10, 1999 PPM-99-014
TO: S Hull/562
FROM: K. Sahu/S. Kniffin/300.1
SUBJECT: Radiation Report on **AD588 (Analog Devices) (LDC 9814)**
PROJECT: IRAC

cc: R. Williams/722.0, R. Reed/562, A. Sharma/562, OFA Library/300.1

A radiation evaluation was performed on **AD588 (5962-8972802EA) High Precision Voltage Reference (Analog Devices)** to determine the total ionizing dose (TID) tolerance of these parts. The TID testing was performed using a Co^{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 TID radiation levels were 2.5, 5.0, 10.0, 15.0, 20.0, 30.0, 50.0, 75, and 100.0kRads.[1] The dose rate was 0.181kRads/hour (0.05Rads/s). See Table II for the radiation schedule and effective dose rate calculation. After the 100.0kRad irradiation, the parts were annealed under bias at 25°C and tested after 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. For detailed information, refer to Tables I through IV and Figure 1.

All parts passed all tests initially and upon irradiation to 15kRads. The parts showed marginal degradation in Vo_10V and Vo_-10V and some degradation in Vo_10V_error and Vo_-10V_error from 20 to 50kRads. At 50kRads, one part showed marginal degradation in Vo_5V and Vo_5V_error. After annealing the parts for 120 hours at 25°C, significant recovery was noted in all sensitive parameters with all parts passing all tests. After the 75 and 100kRad irradiations, the parts again showed very marginal degradation in all four Vo_10V measurements. After annealing the parts for 168 hours at 25°C, significant recovery was noted in all sensitive parameters with all but one part passing all tests. For all Vo_10V and Vo_-10V measurements, no parts fell below the specification limit by more than 1%. For the Vo_10V_err and Vo_-10V_err measurements, no parts were ever more than a factor of 2 above or below the specification limits.

Initial electrical measurements were made on 10 samples. Eight samples (SN's 159, 160, 161, 162, 163, 164, 165, and 166) were used as radiation samples while SN's 157 and 158 were used as control samples. All parts passed all tests during initial electrical measurements.

All parts passed all tests up to 15kRads.

After the 20kRad irradiation, SN 165 fell marginally below the specification limit of 9.9950V for Vo_10V with a reading of 9.9946V, marginally exceeded the specification limit of 5.0000mV for V0_10V_err with a reading of 5.4083mV, marginally exceeded the specification limit of -4.9950V for V0_-10V with a reading of -9.9948V, and fell marginally below the specification limit of -5.0000mV for V0_-10V_err with a reading of -5.2288mV. **All parts passed all other tests.**

After the 30kRad irradiation, four parts fell marginally below the specification limit for Vo_10V with readings in the range of 9.9934 to 9.9939V. Four parts exceeded the specification limit V0_10V_err with readings in the range of 6.0665 to 6.5575mV. Four parts marginally exceeded the specification limit for V0_-10V with readings in the

[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.

range of -9.9937 to -9.9943V. Four parts fell below the specification limit for V0_-10V_err with readings in the range of -5.6213 to -6.3393mV. **All parts passed all other tests.**

After the 50kRad irradiation, SN 165 fell marginally below the specification limit of 4.9950V for V0_5V with a reading of 4.9949V and marginally exceeded the specification limit of 5.0000mV for Vo_5V_err with a reading of 5.1231mV. All parts fell marginally below the specification limit for Vo_10V with readings in the range of 9.9903 to 9.9940V. All parts exceeded the specification limit V0_10V_err with readings in the range of 6.0612 to 9.6971mV. All parts marginally exceeded the specification limit for V0_-10V with readings in the range of -9.9902 to -9.9942V. All parts fell below the specification limit for V0_-10V_err with readings in the range of -5.9504 to -9.8308mV. **All parts passed all other tests.**

After annealing the parts for 120 hours at 25°C, the parts showed significant recovery in all sensitive parameters with all parts passing all tests.

After the 75kRad irradiation, three parts fell marginally below the specification limit for Vo_10V with readings in the range of 9.9902 to 9.9947V. Three parts exceeded the specification limit V0_10V_err with readings in the range of 5.2552 to 9.8080mV. Three parts marginally exceeded the specification limit for V0_-10V with readings in the range of -9.9903 to -9.9949V. Three parts fell below the specification limit for V0_-10V_err with readings in the range of -5.1109 to -9.7516mV. **All parts passed all other tests.**

After the 100kRad irradiation, three parts fell marginally below the specification limit for Vo_10V with readings in the range of 9.9932 to 9.9943V. Three parts exceeded the specification limit V0_10V_err with readings in the range of 5.7005 to 6.8268mV. Four parts marginally exceeded the specification limit for V0_-10V with readings in the range of -9.9930 to -9.9949V. Four parts fell below the specification limit for V0_-10V_err with readings in the range of -5.1250 to -6.9711mV. **All parts passed all other tests.**

After annealing the parts for 168 hours at 25°C, the parts showed significant recovery in all sensitive parameters with only SN 160 falling marginally below the specification limit for Vo_10V (9.9945V), Vo_10V_err (5.4893mV), Vo_-10V (9.9948V), and Vo_-10V_err (-5.2042mV).

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.

ADVISORY ON THE USE OF THIS DOCUMENT

The information contained in this document has been developed solely for the purpose of providing general guidance to employees of the Goddard Space Flight Center (GSFC). This document may be distributed outside GSFC only as a courtesy to other government agencies and contractors. Any distribution of this document, or application or use of the information contained herein, is expressly conditional upon, and is subject to, the following understandings and limitations:

(a) The information was developed for general guidance only and is subject to change at any time;

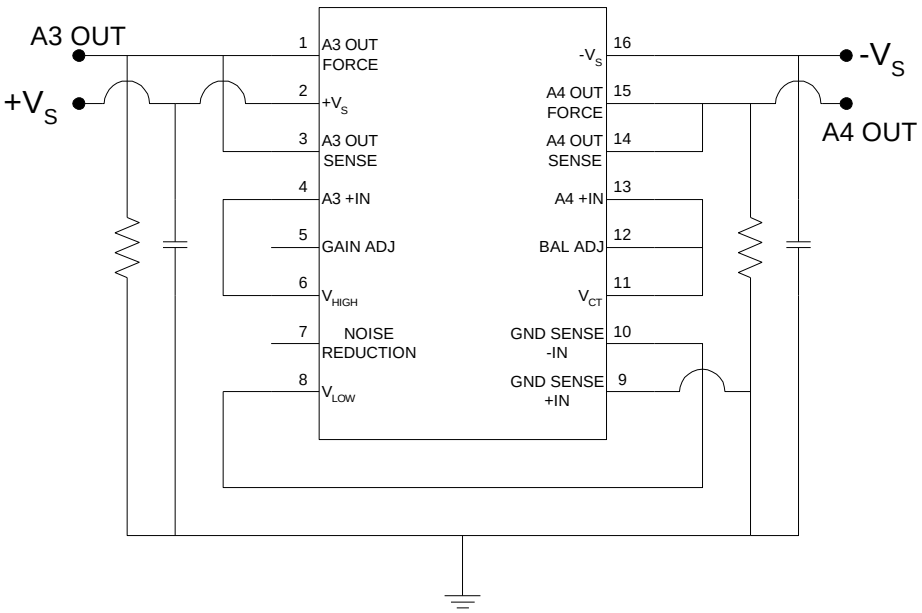
(b) The information was developed under unique GSFC laboratory conditions which may differ substantially from outside conditions;

(c) GSFC does not warrant the accuracy of the information when applied or used under other than unique GSFC laboratory conditions;

(d) The information should not be construed as a representation of product performance by either GSFC or the manufacturer;

(e) Neither the United States government nor any person acting on behalf of the United States government assumes any liability resulting from the application or use of the information.

Figure 1. Radiation Bias Circuit for AD588



Notes:
1. $+V_S$ = +15.0V ±0.5V, $-V_S$ = -15.0V ±0.5V.
2. Check V_{OUT3} = +10.0V ±0.5V, Check V_{OUT4} = +5V ±0.5V.
3. R = 1kΩ ±5%, ¼W.
4. C = 0.1µf (to prevent oscillation).

TABLE I. Part Information

Generic Part Number:	AD588
IRAC Part Number:	AD588 (5962-8972802EA)
Charge Number:	M99718
Manufacturer:	Analog Devices
Lot Date Code (LDC):	9814
Quantity Tested:	10
Serial Number of Control Samples:	157, 158
Serial Numbers of Radiation Samples:	159, 160, 161, 162, 163, 164, 165, and 166
Part Function:	High Precision Voltage Reference
Part Technology:	Bipolar
Package Style:	16 Pin DIP
Test Equipment:	A540
Test Engineer:	S. Norris

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

TABLE II. Radiation Schedule for AD588

EVENT	DATE
1) INITIAL ELECTRICAL MEASUREMENTS	12/01/98
2) 2.5 KRAD IRRADIATION (0.147 KRADS/HOUR)	12/07/98
POST-2.5 KRAD ELECTRICAL MEASUREMENT	12/08/98
3) 5.0 KRAD IRRADIATION (0.147 KRADS/HOUR)	12/08/98
POST-5.0 KRAD ELECTRICAL MEASUREMENT	12/09/98
4) 10.0 KRAD IRRADIATION (0.294 KRADS/HOUR)	12/09/98
POST-10.0 KRAD ELECTRICAL MEASUREMENT	12/10/98
5) 15.0 KRAD IRRADIATION (0.294 KRADS/HOUR)	12/10/98
POST-15.0 KRAD ELECTRICAL MEASUREMENT	12/11/98
6) 20.0 KRAD IRRADIATION (0.077 KRADS/HOUR)	12/11/98
POST-20.0 KRAD ELECTRICAL MEASUREMENT	12/14/98
7) 30.0 KRAD IRRADIATION (0.588 KRADS/HOUR)	12/14/98
POST-30.0 KRAD ELECTRICAL MEASUREMENT	12/15/98
8) 50.0 KRAD IRRADIATION (1.176 KRADS/HOUR)	12/15/98
POST-50.0 KRAD ELECTRICAL MEASUREMENT	12/16/98
9) 120 HOUR ANNEALING @25°C	12/16/98
POST-120 HOUR ANNEAL ELECTRICAL MEASUREMENT	12/21/98
10) 75.0 KRAD IRRADIATION (0.000 KRADS/HOUR)	12/23/98
POST-75.0 KRAD ELECTRICAL MEASUREMENT	12/28/98
11) 100.0 KRAD IRRADIATION (0.000 KRADS/HOUR)	12/28/98
POST-100.0 KRAD ELECTRICAL MEASUREMENT	12/30/98
12) 168 HOUR ANNEALING @25°C	12/30/98
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	01/08/98

Effective Dose Rate = 100,000 RADS/23 DAYS=181.2 RADS/HOUR=0.05 RADS/SEC

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

Table III. Electrical Characteristics of AD588 /1

Test #	Parameter	Units	Test Conditions /2 /3	Spec. Lim. min	Spec. Lim. max
1	Icc	mA	No Load		10.0
2	Iee	mA	No Load	-10.0	
3	Vo_10V	V	I_L = 0.0 to 10.0mA, Vo = ±10V	9.9950	10.0050
4	Vo_10V_err	mV	No Load	-5.000	5.000
5	Vo_5V	V	I_L = 0.0 to 10.0mA, Vo = ±5V	4.9950	5.0050
6	Vo_5V_err	mV	No Load	-5.000	5.000
7	Vo_-10V	V	I_L = 0.0 to 10.0mA, Vo = ±10V	-10.0050	-9.9950
8	Vo_-10V_err	mV	No Load	-5.000	5.000
9	Vo_-5V	V	I_L = 0.0 to 10.0mA, Vo = ±5V	-5.0050	-4.9950
10	Vo_-5V_err	mV	No Load	-5.000	5.000
11	Vline_10V	mV	Vo = +10V, Vcc = 13.5V to 18V		900
12	Vline_5V	mV	Vo = +5V, Vcc = 12V to 18V		1.2
13	Vline_-10V	mV	Vo = -10V, Vee = -13.5V to -18V		900
14	Vline_-5V	mV	Vo = -5V, Vee = -12V to -18V		1.2
15	Vline_10V	mV	Vo = +10V, Vcc = 13.5V to 18V		500
16	Vline_-10V	mV	Vo = -10V, Vee -13.5V to -18V		500

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_{CC} = +15V, V_{EE} = -15V, T_A = 25°C unless otherwise noted.

3/ Parts will not operate at Vcc, Vee = 10.58V as per spec. in the Vline test.

TABLE IV: Summary of Electrical Measurements after Total Dose Exposures and Annealing for AD588 /1

					Total Dose Exposure (kRads Si)																Annealing		Total Dose Exposure (kRads Si)				Annealing	
					Initial		2.5		5.0		10.0		15.0		20.0		30.0		50.0		120 hours @25°C		75.0		100.0		168 hours @25°C	
Test #	Parameters	Units	Spec. Lim. /2 min	Spec. Lim. /2 max	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
1	Icc	mA		10.0	7.2	0.5	7.2	0.5	7.2	0.5	7.2	0.5	7.2	0.5	7.1	0.5	7.1	0.5	7.1	0.5	7.1	0.5	7.1	0.5	7.1	0.5	7.1	0.4
2	Iee	mA	-10.0		-7.2	0.5	-7.2	0.5	-7.2	0.5	-7.2	0.5	-7.2	0.5	-7.1	0.5	-7.1	0.5	-7.1	0.5	-7.1	0.5	-7.1	0.5	-7.1	0.5	-7.1	0.4
3	Vo_10V	V	9.9950	10.0050	9.9995	0.0031	9.9993	0.0007	9.9989	0.0040	9.9981	0.0021	9.9972	0.0021	9.9959	0.0019	9.9945	0.0011	9.9925	0.0013	9.9963	0.0007	9.9948	0.0018	9.9950	0.0024	9.9965	0.0010
4	Vo_10V_err	mV	-5.0000	5.0000	0.5012	0.7849	0.7177	0.8006	1.0600	0.7144	1.9128	0.7437	2.7780	0.8696	4.1317	0.9892	5.5434	1.1471	7.4614	1.3408	3.7127	0.6985	5.2018	1.9643	5.0385	0.9762	3.8307	1.2988
5	Vo_5V	V	4.9950	5.0050	4.9996	0.0003	4.9995	0.0003	4.9993	0.0003	4.9988	0.0003	4.9984	0.0003	4.9978	0.0003	4.9971	0.0003	4.9961	0.0003	4.9979	0.0013	4.9971	0.0012	4.9971	0.0016	4.9980	0.0005
6	Vo_5V_err	mV	-5.0000	5.000	0.4180	0.3887	0.5286	0.3850	0.7056	0.3276	1.1592	0.3498	1.5774	0.3906	2.2401	0.5046	2.9026	0.5750	3.9160	0.6645	2.0627	0.3197	2.8945	0.9124	2.8650	0.4059	2.1783	0.5763
7	Vo_-10V	V	-10.0050	-9.9950	-10.0000	0.0037	-9.9998	0.0036	-9.9995	0.0007	-9.9986	0.0007	-9.9977	0.0008	-9.9962	0.0008	-9.9947	0.0033	-9.9926	0.0014	-9.9966	0.0006	-9.9949	0.0024	-9.9950	0.0009	-9.9967	0.0010
8	Vo_-10V_err	mV	-5.0000	5.0000	0.0294	0.7372	-0.2124	0.7243	-0.5459	0.7407	-1.4320	0.7382	-2.3255	0.8714	-3.8194	1.0707	-5.3426	1.1976	-7.3822	1.4512	-3.4265	0.7001	-5.0506	1.9599	-4.9726	0.9876	-3.5660	1.3135
9	Vo_-5V	V	-5.0050	-4.9950	-5.0003	0.0004	-5.0002	0.0004	-5.0000	0.0018	-4.9996	0.0004	-4.9992	0.0004	-4.9984	0.0004	-4.9977	0.0012	-4.9967	0.0007	-4.9986	0.0004	-4.9979	0.0024	-4.9980	0.0005	-4.9986	0.0019
10	Vo_-5V_err	mV	-5.0000	5.0000	0.2950	0.4145	0.1754	0.4063	0.0084	0.4130	-0.4179	0.4000	-0.8354	0.4650	-1.5602	0.5344	-2.3045	0.5671	-3.2631	0.6993	-1.3704	0.3877	-2.1320	1.0725	-2.0224	0.5248	-1.4012	0.7294
11	Vline_10V	?V		900	-72	74	-51	50	-105	45	-86	31	-90	37	-120	51	-129	64	-157	84	-101	56	-117	50	-153	56	-136	53
12	Vline_5V	mV		1.2	0.09	0.08	0.08	0.03	0.08	0.05	0.1	0.04	0.1	0.04	0.1	0.04	0.1	0.05	0.1	0.05	0.1	0.04	0.1	0.06	0.2	0.05	0.1	0.06
13	Vline_-10V	?V		900	155	93	192	117	217	100	268	110	215	74	388	110	519	122	638	163	348	142	630	151	611	162	184	114
14	Vline_-5V	mV		1.2	0.08	0.05	0.08	0.02	0.1	0.03	0.07	0.04	0.07	0.05	0.05	0.02	0.07	0.04	0.07	0.04	0.06	0.05	0.03	0.03	0.04	0.04	0.06	0.04
15	Vline_10V	?V		500	-28	39	18	47	-16	41	-27	40	-35	13	-13	33	-18	38	-38	30	-11	34	6	32	-1	39	-20	36
16	Vline_-10V	?V		500	4	30	8	41	12	28	12	27	3	50	19	27	-6	35	11	31	-10	24	4	32	-1	42	-13	30

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 t

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 perform

Radiation sensitive parameters: Vo_10V, Vo_10V_err, Vo_-10V, Vo_-10V_err.