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TO: V. Patel/406.0
FROM: K. Sahu/300.1 KSahu
SUBJECT: Radiation Report on EOS/AM
Part No. LM108A
Control No. 8538

cc: A. Sharma/311
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A radiation evaluation was performed on LM108A (Op Amp) 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 cobalt-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 total dose radiation levels were 5, 10, 15, 20, 30, 50, 75 and 100 krads*. The dose rate was between 0.08 and 1.32 krads/hour, depending on the total dose level (see Table II for radiation schedule). After the 100 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. At the 5 krad radiation level, all irradiated parts marginally exceeded the maximum specification limit of 2 nA for P_IIB_N15, N_IIB_N15, P_IIB_P15, N_IIB_P15, P_IIB_0V, N_IIB_0V, P_IIB_5V and N_IIB_5V, with readings ranging from 2.02 nA to 2.99 nA.

At the 10 krad radiation level, the same failures continued, with readings in the range of 3.90 nA to 8.96 nA. In addition, one part (S/N 52) fell below the minimum specification limit of -0.200 nA for IIOS_N15, IIOS_P15, IIOS_0V and IIOS_5V, with readings ranging from -0.30 nA to -0.32 nA.

At the 15 krad level, the same failures continued, with increasing values.

At the 20 krad level, The same failures for P_IIB and N_IIB continued, with readings ranging from 12.7 to 17 nA, S/N 51 failed all four IIOS tests and 52 failed three of four IIOS tests, with readings ranging from -.21 to -.33 nA, and S/N 51, 52, 54, 55 and 57 fell below the minimum specification limit of -500 μV for all four VOS tests, with readings ranging from -567 to -764 μV.

At the 30 krad level, the same failures for P_IIB and N_IIB continued, with increasing values. All irradiated parts failed at least one IIOS test, with readings ranging from -.315 nA to -.663 nA and all irradiated parts failed all four VOS tests, with readings ranging from -772 μV to -2777 μV. In addition, S/N 51, 52, 55, 57 and 59 fell below the minimum specification limit of 80.00 V/mV for P_AOL and N_AOL and the minimum specification limit of 20.00 V/mV for AOL_5, with readings ranging from 33 to 745, 33 to 67 and 112 to 20 V/mV, respectively, while S/N 53 failed N_AOL and AOL_5, with readings of 55 and 19 V/mV and S/N 54 failed P_AOL and N_AOL, with readings of 745 and 67 V/mV.

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*The term rads, as used in this document, means rads(silicon). All radiation levels cited are cumulative.

**These are manufacturer's non-irradiation data specification limits. No post-irradiation limits were provided by the manufacturer at the time these tests were performed. No radiation tolerance/hardness was guaranteed by the manufacturer for this part.

At the 50 krad level, S/N 51 failed all parametric tests except Plus_Icc, Minus_Icc, P_VOUT and N_VOUT, with readings in the range of 5 to 10 times the maximum specification limits. All other irradiated parts failed all parametric tests except Plus_Icc, Minus_Icc, P_VOUT, N_VOUT, PLUS_SLEW and MINUS_SLEW and in addition, S/N 52 passed Minus PSRR. Readings were in the range of 5 to 10 times the maximum specification limits.

At the 75 krad level, the same failures continued, with slightly increasing readings, along with a few marginal failures in P_VOUT.

At the 100 krad level, the same failures continued.

After annealing for 168 hours at 25°C, the same failures continued, with no appreciable recovery observed.

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.

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

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TABLE I. Part Information

Generic Part Number:	LM108A
EOS/AM Part Number:	LM108A
EOS/AM Control Number:	8538
Charge Number:	C44406
Manufacturer:	Linear Technology
Lot Date Code:	9347
Quantity Tested:	10
Serial Number of Control Samples:	50, 56
Serial Numbers of Radiation Sample:	51, 52, 53, 54, 55, 57, 58, 59
Part Function:	Op Amp
Part Technology:	Bipolar
Package Style:	TO-8 can
Test Equipment:	A540
Test Engineer:	C. Nguyen

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

TABLE II. Radiation Schedule for LM108A

EVENTS	DATE
1) INITIAL ELECTRICAL MEASUREMENTS	07/20/94
2) 5 KRAD IRRADIATION (0.26 KRADS/HOUR)	07/21/94
POST-5 KRAD ELECTRICAL MEASUREMENT	07/22/94
3) 10 KRAD IRRADIATION (0.08 KRADS/HOUR)	07/22/94
POST-10 KRAD ELECTRICAL MEASUREMENT	07/25/94
4) 15 KRAD IRRADIATION (0.26 KRADS/HOUR)	07/25/94
POST-15 KRAD ELECTRICAL MEASUREMENT	07/27/94
5) 20 KRAD IRRADIATION (0.29 KRADS/HOUR)	07/27/94
POST-20 KRAD ELECTRICAL MEASUREMENT	07/28/94
6) 30 KRAD IRRADIATION (0.50 KRADS/HOUR)	07/28/94
POST-30 KRAD ELECTRICAL MEASUREMENT	07/29/94
7) 50 KRAD IRRADIATION (0.31 KRADS/HOUR)	07/29/94
POST-50 KRAD ELECTRICAL MEASUREMENT	08/01/94
8) 75 KRAD IRRADIATION (1.25 KRADS/HOUR)	08/01/94
POST-75 KRAD ELECTRICAL MEASUREMENT	08/02/94
9) 100 KRAD IRRADIATION (1.32 KRADS/HOUR)	08/02/94
POST-100 KRAD ELECTRICAL MEASUREMENT	08/03/94
10) 168-HOUR ANNEALING @25°C	08/03/94
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	08/10/94
11) 168-HOUR ANNEALING @100°C*	08/10/94
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	08/17/94

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

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*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 LM108A

TEST NAME	SYMBOL	CONDITIONS	LIMITS	
			MIN	MAX
		SUPPLY CURRENT		
Plus_Icc	Icc	+Vcc = 15V, -Vcc=-15V, V_{OUT} = 0V		600uA
Minus_Icc	Icc	+Vcc = 15V, -Vcc=-15V, V_{OUT} = 0V	-600uA	
		INPUT OFFSET TESTS		
VOS_N20V	V_{IO}	(Vcm=-15V) +Vcc = 35V, -Vcc=-5V, V_{OUT} = 15V	-500uV	500uV
P_IIB_N15	$+I_{IB}$	(Vcm=-15V) +Vcc = 35V, -Vcc=-5V, V_{OUT} = 15V	-100pA	2nA
N_IIB_N15	$-I_{IB}$	(Vcm=-15V) +Vcc = 35V, -Vcc=-5V, V_{OUT} = 15V	-100pA	2nA
IIOS_N15	I_{IO}	(Vcm=-15V) +Vcc = 35V, -Vcc=-5V, V_{OUT} = 15V	-200pA	200pA
VOS_P20V	V_{IO}	(Vcm=15V) +Vcc = 5V, -Vcc=-35V, V_{OUT} = -15V	-500uV	500uV
P_IIB_P15	$+I_{IB}$	(Vcm=15V) +Vcc = 5V, -Vcc=-35V, V_{OUT} = -15V	-100pA	2nA
N_IIB_P15	$-I_{IB}$	(Vcm=15V) +Vcc = 5V, -Vcc=-35V, V_{OUT} = -15V	-100pA	2nA
IIOS_P15	I_{IO}	(Vcm=15V) +Vcc = 5V, -Vcc=-35V, V_{OUT} = -15V	-200pA	200pA
VOS_0V	V_{IO}	V_{CM} =0V	-500uV	500uV
P_IIB_0V	$+I_{IB}$	V_{CM} =0V	-100pA	2nA
N_IIB_0V	$-I_{IB}$	V_{CM} =0V	-100pA	2nA
IIOS_0V	I_{IO}	V_{CM} =0V	-200pA	200pA
VOS_5V	V_{IO}	V_{CM} =0V, Vcc = +/- 5V	-500uV	500uV
P_IIB_5V	$+I_{IB}$	V_{CM} =0V, Vcc = +/- 5V	-100pA	2nA
N_IIB_5V	$-I_{IB}$	V_{CM} =0V, Vcc = +/- 5V	-100pA	2nA
IIOS_5V	I_{IO}	V_{CM} =0V, Vcc = +/- 5V	-200pA	200pA
CMR_15	CMR	V_{CM} = +/- 15V	96dB	
Plus_PSRR	+PSRR	+Vcc = 10V, -Vcc = -20V	-16uV/V	16uV/V
Minus_PSRR	-PSRR	+Vcc = 20V, -Vcc = -10V	-16uV/V	16uV/V
P_VOUT	$+V_{OP}$	R_L = 10KΩ	16V	
N_VOUT	$-V_{OP}$	R_L = 10KΩ		-16V
		OPEN LOOP GAIN TESTS		
P_AOL	$+A_{VS}$	R_L = 10KΩ, V_{OUT} = -15V	80V/mV	
N_AOL	$-A_{VS}$	R_L = 10KΩ, V_{OUT} = 15V	80V/mV	
P_AOL_5	$+A_{VS}$	Vcc=+/-5V, R_L = 2KΩ, V_{OUT} = +/-2V	20V/mV	
PLUS_SLEW	+SR	A_V=1, V_{IN} = -5V to +5V, R_F=10KΩ, Cs=30pF, R_L=10KΩ	0.05V/uS	
MINUS_SLEW	-SR	A_V=1, V_{IN} = +5V to -5V, R_F=10KΩ, Cs=30pF, R_L=10KΩ	0.05V/uS	

TABLE IV: Summary of Electrical Measurements after Total Dose Exposures and Annealing for LM108A /1

Test			Spec. Lim. /2		Initials		Total Dose Exposure (krads)																		Annealing			
							5		10		15		20		30		50		75		100				168 hrs @25°C		168 hrs** @100°C	
#	Parameter	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
1	Plus_Icc	mA	0	6	0.38	.01	0.38	.01	0.38	.01	0.38	.01	0.38	.01	0.38	.01	0.38	.01	0.38	.01	0.34	.02			0.37	.03	0.38	.01
2	Minus_Icc	mA	-6	0	-0.39	.01	-0.38	.01	-0.38	.01	-0.38	.01	-0.38	.01	-0.38	.01	-0.38	.01	-0.22	.02	0.35	.02			-0.37	.03	-0.39	.01
3	VOS_N20V	uV	-500	500	-22.3	16	-32.0	17	-194	33	-353	64	-1433	202	-1805	542	*	*	*	*	*	*			*	*	-3382	763
4	P_IIB_N15	nA	-0.1	2	0.73	.13	2.26	.20	3.35	.98	8.85	1.5	9.77	1.9	11.2	3.8	16.4	2.5	-4.52	3.4	-8.65	9.8			2.02	13	14.0	1.5
5	N_IIB_N15	nA	-0.1	2	0.87	.13	2.38	.19	5.08	2.1	8.91	1.5	10.1	3.0	12.1	3.5	17.3	2.3	-4.55	3.3	-7.57	11			7.93	11	15.0	1.5
6	IIOS_N15	nA	-0.2	0.2	-0.15	0	-0.12	.01	-0.13	.01	8.91	1.5	-0.21	.20	-0.27	.21	-0.92	.27	0.07	.21	-1.02	1.2			-1.53	.66	-0.95	.08
7	VOS_P20V	uV	-500	500	20.7	16	-30.5	17	-178	35	-0.15	.01	-977	141	-1334	435	-2877	561	*	*	*	*			*	*	-2591	1096
8	P_IIB_P15	nA	-0.1	2	0.77	.14	2.43	.23	2.71	.31	-313	60	12.2	1.1	19.0	1.3	12.2	1.4	16.1	3.5	9.23	3.1			8.42	.96	11.5	2.9
9	N_IIB_P15	nA	-0.1	2	0.91	.13	2.54	.22	8.01	.72	10.4	1.6	13.0	1.1	19.3	1.4	13.3	1.3	17.1	3.1	10.7	2.8			9.98	.91	12.5	3.0
10	IIOS_P15	nA	-0.2	0.2	-0.14	0	-0.11	.01	-0.12	.01	-0.17	.01	-0.20	.01	-0.22	.09	-1	0.1	-2.02	.39	-1.48	.31			-1.56	.09	-0.77	.72
11	VOS_0V	uV	-500	500	21.9	16	-30.2	16	-182	36	-325	60	-768	237	-1511	469	-3580	773	*	*	*	*			*	*	-2260	2149
12	P_IIB_0V	nA	-0.1	2	0.79	.13	2.39	.22	5.51	.39	9.76	1.6	12.1	1.9	16.6	2.6	14.9	1.7	-12	11	10.3	8.5			11.5	2.3	13.3	3.3
13	N_IIB_0V	nA	-0.1	2	0.96	.13	2.53	.21	4.49	.55	9.83	1.6	10.9	2.0	16.9	2.5	15.9	1.6	-10.3	11	11.5	8.5			13.1	2.1	14.3	3.3
14	IIOS_0V	nA	-0.2	0.2	-0.17	0	-0.14	.01	-0.15	.01	-0.21	.02	-0.23	.10	-0.24	.14	-1.00	.09	-1.26	.94	-1.20	.51			-1.49	.25	-1.04	.05
15	VOS_5V	uV	-500	500	20.4	16	-35	19	-201	41	-361	73	-978	200	-1745	565	*	*	*	*	*	*			*	*	-3478	731
16	P_IIB_5V	nA	-0.1	2	0.75	.12	2.34	.20	5.07	.78	9.61	1.5	12.1	1.9	15.6	2.9	15.7	1.4	-17.6	2.6	8.31	14			12.4	2.8	13.1	3.0
17	N_IIB_5V	nA	-0.1	2	0.83	.12	2.45	.19	6.00	.33	9.66	1.6	11.8	2.1	15.9	2.8	16.2	1.5	-17.1	2.3	9.69	14			13.6	2.5	14.1	2.9
18	IIOS_5V	nA	-0.2	0.2	-0.14	.01	-0.12	.01	-0.13	.02	-0.19	.10	-0.21	0.11	-0.24	.16	-0.37	.25	-0.53	.37	-0.83	.45			-1.22	.23	-0.99	.08
19	CMR_15V	dB	56		146	3.8	145	2.6	133	2.6	121	2.8	103	3.0	96.7	3.6	65.7	2.0	*	*	*	*			*	*	90.4	.83
20	Plus_PSRR	uV/V	-16	16	-0.09	.09	0.03	.14	0.65	.24	1.68	.60	7.91	3.3	18.1	6.9	59.3	14	*	*	*	*			*	*	44.3	3.5
21	Minus_PSRR	uV/V	-16	16	0.35	.19	0.63	.26	1.80	.48	3.16	1.3	43.3	13	66.3	24	41.7	15	*	*	*	*			*	*	51.1	5.0
22	P_VOUT	V	16		19.0	.01	19.0	.01	19.0	.01	19.0	.01	27.8	11	53.6	19	19.0	.01	-16.8	4.4	-7.93	9.9			10.4	13	19.0	.01
23	N_VOUT	V		-16	-18.9	.35	-19.0	.01	-19.0	.01	-19.0	.01	18.7	1.1	17.5	6.3	-18.9	.01	-18.9	.01	-18.9	.01			-18.9	.01	-18.9	.01
24	P_AOL	V/mV	80		2839	981	1436	332	546	127	317	83	11.8	3.4	0.24	.01	23.3	2.7	*	*	*	*			*	*	22.5	1.8
25	N_AOL	V/mV	80		4100	1614	1654	527	401	101	270	73	75.1	22	-0.33	.01	25.0	.84	*	*	*	*			*	*	25.0	2.7
26	AOL_5	V/mV	20		2197	927	719	174	521	67	96.6	25	56.2	10	17.5	6.3	5.7	1.6	*	*	*	*			*	*	7.20	.50
27	PLUS_SLEW	V/us	0.05		0.29	.01	0.26	.01	0.28	.01	0.26	.01	0.24	.02	0.24	.01	0.19	.02	0.14	.02	0.15	.03			0.17	.03	0.24	.01
28	MINUS_SLEW	V/us		-0.05	-0.38	.01	-0.33	.01	-0.38	.01	-0.35	.01	-0.34	.01	-0.33	.01	-0.30	.02	-0.26	.02	-0.27	.01			-0.29	.03	-0.35	.03

* No reliable readings could be obtained at this level.

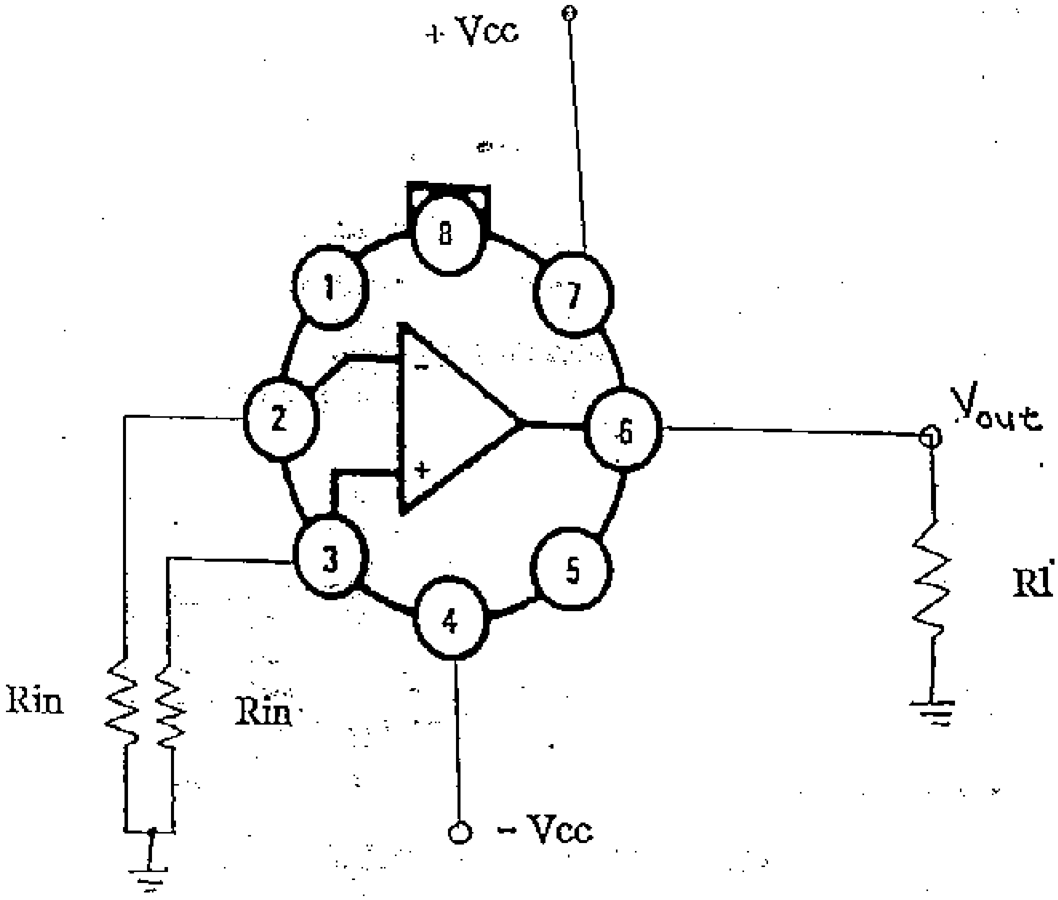
** At this level, readings for CMR_15V, Plus_PSRR, Minus_PSRR, P_AOL, N_AOL and AOL_5 are for seven samples.

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 is not included in this table.

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

3/ The radiation sensitive parameters were P_IIB, N_IIB, IIOS, VOS, AOL and PSRR.

Figure 1: Radiation Bias Circuit for LM108A



+ Vcc = + 15 +/ − 0.5 V

− Vcc = − 15 + / − 0.5 V

Rin = 2 Kohm +/ − 5 % , 1/4 W .

Rl = 10 Kohm + / − 5 % , 1/4 W .