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TO: S. Pszczolka/311.1

FROM: K. Sahu/300.1 KS

SUBJECT: Radiation Report on ISTP/SOHO/CELIAS
Part No. M38510/10104BGA (LM108A)
Control No. 8707

cc: A. Sharma/311
Library/300.1

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, two 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, 10, 15, 20 and 50 krads*. The dose rate was between 0.07 and 1.54 krads/hour, depending on the total dose level (see Table II for radiation schedule). After the 50 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. Both irradiated parts passed all parametric tests up to and including the 2 krad irradiation level. At the 5 krad level, both irradiated parts marginally exceeded the maximum specification limit of 2.0 nA for N_IIB_P15, with maximum readings of 2.005 and 2.092 nA, respectively. In addition, S/N 3 exceeded the maximum specification limits of 2.0 nA for M_IIB_N15 and N_IIB_0V, with readings of 2.045 and 2.130 nA, respectively. At the 10 krad level, both irradiated parts exceeded the maximum specification limits for VOS_N20V, P_IIB_N15, N_IIB_N15, IIOS_N15, VOS_P20V, P_IIB_P15, N_IIB_P15, IIOS_P15, VOS_0V, P_IIB_0V, N_IIB_0V, IIOS_0V, VOS_5V, P_IIB_5V, N_IIB_5V, IIOS_5V, P_AOL and AOL_5. In addition, S/N 3 exceeded the maximum specification limit for N_AOL. At the 15 krad level, S/N 2 also exceeded the maximum specification limit for N_AOL. At this level, both parts also exceeded the maximum specification limit for PLUS_SLEW. These failures continued up to the 50 krad level. At this level, failures for IIOS_N15, IIOS_P15, IIOS_0V and IIOS_5Vremained marginal, while readings for the other parameters had increased greatly out of specs. After annealing for 168 hours at 25°C and annealing for 168 hours at 100°C, virtually no recovery was observed.

Table IV provides 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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*The term rads, as used in this document, means rads(silicon). All radiation levels cited are cumulative.
**These are manufacturers' non-irradiated data specification limits. No post-irradiation limits were provided by the manufacturer at the time these tests were performed.

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TABLE I. Part Information

Generic Part Number:	LM108A
ISTP/SOHO/CELIAS Part Number:	M38501/10104BGA*
ISTP/SOHO/CELIAS Control Number:	8707
Charge Number:	C33659
Manufacturer:	National Semiconductor
Lot Date Code:	8739A
Quantity Tested:	3
Serial Number of Control Sample:	1
Serial Numbers of Radiation Samples:	2, 3
Part Function:	Op Amp
Part Technology:	CMOS
Package Style:	8-pin TOx can
Test Equipment:	Teradyne 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	11/23/93
2) 2 KRAD IRRADIATION (0.11 KRADS/HOUR)	11/23/93
POST-2 KRAD ELECTRICAL MEASUREMENT	11/24/93
3) 5 KRAD IRRADIATION (0.07 KRADS/HOUR)	11/24/93
POST-5 KRAD ELECTRICAL MEASUREMENT	11/26/93
4) 10 KRAD IRRADIATION (1.26 KRADS/HOUR)	11/26/93
POST-10 KRAD ELECTRICAL MEASUREMENT	11/29/93
5) 15 KRAD IRRADIATION (0.29 KRADS/HOUR)	11/29/93
POST-15 KRAD ELECTRICAL MEASUREMENT	11/30/93
6) 20 KRAD IRRADIATION (0.29 KRADS/HOUR)	12/01/93
POST-20 KRAD ELECTRICAL MEASUREMENT	12/02/93
7) 50 KRAD IRRADIATION (1.54 KRADS/HOUR)	12/02/93
POST-50 KRAD ELECTRICAL MEASUREMENT	12/03/93
8) 168-HOUR ANNEALING @25°C	12/03/93
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	12/10/93
9) 168-HOUR ANNEALING @100°C**	12/10/93
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	12/27/93

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

*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

Unless Otherwise Specified: T_A =25°C, VCC = +/- 20Vdc

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
		OUTPUT TESTS		
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

Parameters		Spec. Lim. /2 min	max	Initials mean	sd	Total Dose Exposure (krads) 2 mean	sd	5 mean	sd	10 mean	sd	15 mean	sd	20 mean	sd	50 mean	sd	Annealing 168 hrs @25°C mean	sd	168 hrs @100°C mean	sd
Plus_Icc	mA	0	0.6	-.279	.02	-.281	.02	-.282	.02	-.267	.02	-.270	.02	-.266	.02	-.256	.02	-.259	.01	-.278	.02
Minus_Icc	mA	-0.6	0	-.293	.02	-.284	.03	-.288	.02	-.281	.02	-.270	.02	-.271	.02	-.251	.02	-.261	.02	-.284	.01
VOS_N20V	µV	-500	500	-170	270	-183	264	-299	260	-1229	82	-1281	0	-3976	560	-8522	2149	-5123	0	-3144	349
P_IIB_N15	nA	-0.1	2	.668	.11	1.06	.06	1.89	0	3.84	.18	6.29	.49	8.30	.65	19.6	0.2	19.7	.51	3.01	0.1
N_IIB_N15	nA	-0.1	2	.736	.18	1.13	.14	1.99	.08	4.23	0.1	6.96	.49	8.29	0.6	19.8	0.1	20.5	.49	3.26	.07
IIOS_N15	nA	-0.2	0.2	-.068	.08	-.071	.08	-.098	.08	-.390	.08	-.672	0	-.290	.05	-296	.13	-.597	.02	-.248	.02
VOS_P20V	µV	-500	500	-161	267	-173	251	-286	256	-1209	102	-1281	0	-3554	555	-7775	1936	-5123	0	-3101	344
P_IIB_P15	nA	-0.1	2	.688	0.1	1.10	.06	1.97	.01	4.03	.17	6.64	.53	8.50	0.7	19.3	.54	20.1	.08	3.17	.11
N_IIB_P15	nA	-0.1	2	.751	.18	1.16	.14	2.06	.07	4.41	.07	7.12	.52	8.75	.65	19.6	.45	20.7	.06	3.40	.09
IIOS_P15	nA	-0.2	0.2	-.062	.08	-.061	.08	-.090	.08	-.388	.09	-.685	0	-.215	.05	-.100	.09	-.595	.02	-.236	.02
VOS_0V	µV	-500	500	-165	268	-175	252	-291	259	-1216	92	-1281	0	-3706	558	-8094	2028	-5123	0	-3124	346
P_IIB_0V	nA	-0.1	2	.691	.12	1.09	.08	1.95	.01	4.02	.16	6.61	.49	8.33	.67	19.6	.35	20.3	.34	3.15	.09
N_IIB_0V	nA	-0.1	2	.764	.21	1.17	.17	2.06	0.1	4.46	.08	7.38	.47	8.65	.62	20.0	.24	21.0	0.3	3.42	.06
IIOS_0V	nA	-0.2	0.2	-.073	.09	-.075	.09	-.108	.08	-.444	.09	-.765	.02	-.322	.05	-.139	0.1	-.500	.04	-.278	.03
VOS_5V	µV	-500	500	-168	269	-183	265	-311	256	-1281	0	-1281	0	-4306	630	-8643	1252	-5123	0	-3787	356
P_IIB_5V	nA	-0.1	2	.638	0.1	1.02	.06	1.84	.01	3.80	.22	6.16	.46	7.99	.64	19.7	.02	19.5	.38	2.98	.09
N_IIB_5V	nA	-0.1	2	.701	.17	1.09	.14	1.92	.07	4.40	.19	6.84	.45	8.22	.59	20.0	.12	20.1	.56	3.27	.07
IIOS_5V	nA	-0.2	0.2	-.064	.08	-.068	.08	-.101	.07	-.502	.04	-.679	.02	-.329	.05	-.139	.14	-.580	.03	-.291	.03
CMR_15V	dB	96	-	114	2.3	110	2.8	108	2.3	*	*	*	*	107.2	.28	92.3	2.5	*	*	116.9	1.1
Plus_PSRR	µV/V	-16	16	1.93	.23	1.98	.25	2.59	.01	1.11	1.6	0	0	32.2	2.5	58.0	41	0	0	10.2	/05
Minus_PSRR	µV/V	-16	16	-1.06	.01	-.165	.02	-.305	.28	6.14	8.7	0	0	59.4	7.5	73.6	31	0	0	65.4	.79
P_VOUT	V	16	-	16.7	.02	16.7	.02	16.7	.01	16.7	.01	16.7	.02	16.7	.01	16.6	.01	16.5	0.7	16.7	.02
N_VOUT	V	-	-16	-16.5	.19	-16.6	.01	-16.6	.01	-16.5	0	-16.5	0	-16.5	.01	-16.6	.01	-16.5	.01	-16.5	.01
P_AOL	V/mV	50	-	1890	526	212	65	2474	880	66.3	2.7	*	*	26.8	4.1	22.1	.52	*	*	22.5	.08
N_AOL	V/mV	50	-	609	165	970	413	3252	2970	90.7	12	*	*	31.2	1.8	26.1	.96	*	*	33.1	.72
AOL_5	V/mV	20	-	222	11	172	11	105	11	*	*	*	*	9.87	.24	8.13	6.8	*	*	11.9	.03
PLUS_SLEW	V/µs	.05	-	0.291	.01	.285	.01	.276	.01	.257	.01	.237	.01	.222	.01	.162	.02	.165	.02	.259	.01
MINUS_SLEW	V/µs	-	-.05	-.389	.02	-.384	.02	-.374	.02	-.341	.02	-.351	.02	-.341	.02	-.290	.01	-.330	.01	-.371	.01

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

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

* No reliable readings could be obtained at this level.

Figure 1. Radiation Bias Circuit for LM108A