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DATE: September 28, 1994 PPM-94-028

TO: J. Lohr/311.1
FROM: K. Sahu/300.1 KS
SUBJECT: Radiation Report on CASSINI/CIRS
Part No. LM108
Control No. 11423

cc: A. Sharma/311
Library/300.1

A radiation evaluation was performed on LM108 (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 2.5, 5, 10, 15, 20, 30, 50, 75 and 100 krads*. The dose rate was between 0.06 and 1.25 krads/hour, depending on the total dose level (see Table II for radiation schedule). After the 100 krad irradiation, the 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 all initial electrical measurements. All irradiated parts passed all electrical measurements up to and including the 10 krad irradiation level.

At the 15 krad level, six parts (S/N 52, 53, 56, 57, 58 and 59) exceeded the maximum specification limit of 2.00 nA for various P_IIB and N_IIBtests, with readings in the range of 2.009 to 2.294 nA.

At the 20 krad level, all irradiated parts exceeded the specification limit of 2.00 nA for at least four P_IIB and N_IIB tests and 6 parts (S/N 52, 53, 56, 57, 58, and 59) exceeded the maximum specification limit for all 8 such tests, with readings ranging from 2.001 to 2.688 nA.

At the 30 krad level, all irradiated parts exceeded the specification limits for all P_IIB and N_IIB tests, with readings of 2.251 to 3.534 nA. In addition, S/N 52 fell below the minimum specification limit of -500.0 μV for VOS_5V, with a reading of -557.4 μV.

At the 50 krad level, all parts continued to exceed the specification limits for all P_IIB and N_IIB tests, with readings ranging from 3.245 to 11.971 nA. In addition, S/N 52 fell below the minimum specification limit of -500.0 μV for VOS_N20V, VOS_P20V, VOS_0V and VOS_5V, with readings ranging from -667.4 to -799.8 μV and S/N 56, 57 and 58 exceeded the maximum specification limit of 0.200 nA for IIOS_N15, IIOS_P15, IIOS_0V and IIOS_5V, with readings ranging from 0.764 to 1.132 nA.

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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 75 krad level, all parts continued to exceed the specification limits for all P_IIB and N_IIB tests, with readings ranging from 4.857 to 9.385 nA. S/N 52 fell below the minimum specification limit of -500.0 μV for all 4 VOS tests, with readings ranging from -882.9 to -1101.0 μV and also exceeded the maximum specification limit of 16.00 μV/V for Minus_PSRR, with a reading of 17.74 μV/V. S/N 54 fell below the minimum specification limit of -16.00 μV/V for Minus_PSRR, with a reading of -19.28 μV/V and fell below the minimum specification limit of 80.00 V/mV for P_AOL, with a reading of 78.51 V/mV.

At the 100 krad level, the same failures in all P_IIB and N_IIB tests occurred in all irradiated parts, with readings ranging from 6.734 to 13.242 nA. In addition, S/N 52 fell below the minimum specification limit of -500.0 μV for all 4 VOS tests, with readings ranging from -1109.2 μV to -1368.3 μV. S/N 54 recovered to within specification limits for Minus_PSRR and P_AOL, but S/N 52 fell below the minimum specification limit of 80.00 V/mV for P_AOL and N_AOL, with readings of 59.74 and 79.35 V/mV.

After annealing for 168 hours at 25°C, some recovery was observed in the P_IIB and N_IIB tests, but readings were still outside the specification limits.

After annealing for 168 hours at 100°C, no rebound effects were observed.

Table IV provides a summary of the failures 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:	LM108
CASSINI/CIRS Part Number:	LM108*
EOS/AM Control Number:	8439
Charge Number:	C44541
Manufacturer:	National Semiconductor
Lot Date Code:	9409
Quantity Tested:	10
Serial Number of Control Samples:	50, 51
Serial Numbers of Radiation Sample:	52, 53, 54, 55, 56, 57, 58, 59
Part Function:	Op Amp
Part Technology:	CMOS
Package Style:	8-pin TO can
Test Equipment:	A540
Test Engineer:	T. Mondy

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

TABLE II. Radiation Schedule for LM108

EVENTS	DATE
1) INITIAL ELECTRICAL MEASUREMENTS	08/31/94
2) 2.5 KRAD IRRADIATION (0.15 KRADS/HOUR)	08/31/94
POST-2.5 KRAD ELECTRICAL MEASUREMENT	09/01/94
3) 5 KRAD IRRADIATION (0.13 KRADS/HOUR)	09/01/94
POST-5 KRAD ELECTRICAL MEASUREMENT	09/02/94
4) 10 KRAD IRRADIATION (0.06 KRADS/HOUR)*	09/02/94
POST-10 KRAD ELECTRICAL MEASUREMENT	09/06/94
5) 15 KRAD IRRADIATION (0.29 KRADS/HOUR)	09/06/94
POST-15 KRAD ELECTRICAL MEASUREMENT	09/07/94
6) 20 KRAD IRRADIATION (0.29 KRADS/HOUR)	09/07/94
POST-10 KRAD ELECTRICAL MEASUREMENT	09/08/94
7) 30 KRAD IRRADIATION (0.59 KRADS/HOUR)	09/08/94
POST-30 KRAD ELECTRICAL MEASUREMENT	09/09/94
8) 50 KRAD IRRADIATION (0.31 KRADS/HOUR)	09/09/94
POST-50KRAD ELECTRICAL MEASUREMENT	09/12/94
9) 75 KRAD IRRADIATION (0.06 KRADS/HOUR)	09/12/94
POST-75 KRAD ELECTRICAL MEASUREMENT	09/13/94
10) 100 KRAD IRRADIATION (1.25 KRADS/HOUR)	09/13/94
POST-100 KRAD ELECTRICAL MEASUREMENT	09/14/94
11) 168-HOUR ANNEALING @25°C	09/14/94
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	09/21/94
12) 168-HOUR ANNEALING @100°C**	09/21/94
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	09/28/94

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

*The parts were stored at room temperature under bias for nine days while the Co-60 irradiator was undergoing maintenance.

**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 LM108

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

TABLE IV: Summary of Electrical Measurements after Total Dose Exposures and Annealing for LM108 /1

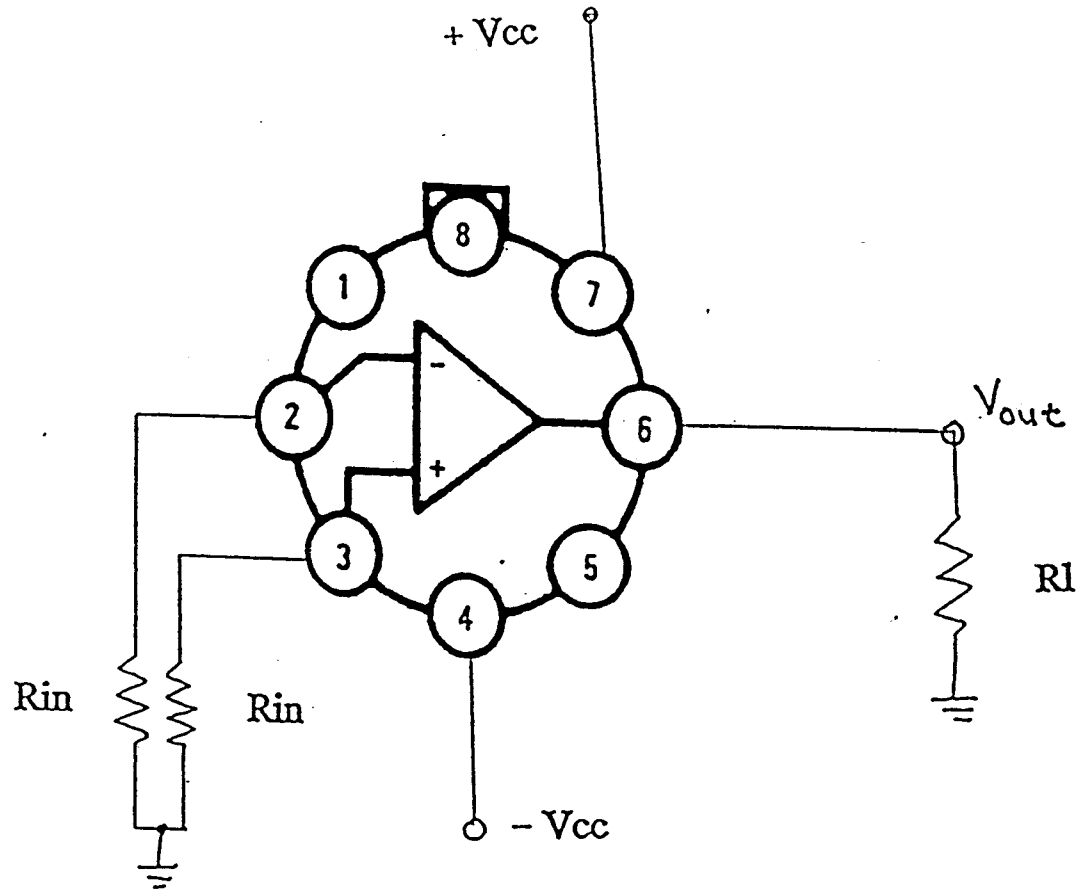
Test #	Parameter	Units	Spec. Lim./2 min	Spec. Lim./2 max	Total Dose Exposure (krads): Initials mean	Initials sd	2.5 mean	2.5 sd	5 mean	5 sd	10 mean	10 sd	15 mean	15 sd	20 mean	20 sd	30 mean	30 sd	50 mean	50 sd	75 mean	75 sd	100 mean	100 sd	Annealing 168 hrs @25°C mean	168 hrs @25°C sd	168 hrs @100°C mean	168 hrs @100°C sd
1	Plus_Icc	mA	0	6	.371	0	.370	0	.369	0	.362	0	.358	0	.357	0	.348	0	.337	.01	.338	0	.331	.01	.335	0	.357	0
2	Minus_Icc	mA	-6	0	-.374	.01	-.372	.01	-.371	0	-.368	0	-.365	0	-.362	0	-.351	.01	-.342	.01	-.341	0	-.333	0	-.338	0	-.361	0
3	VOS_N20V	µV	-500	500	-28.8	143	-29.1	.42	-30.6	144	-52.5	150	-80.7	154	-101	159	-189	141	-269	109	-262	289	-329	343	-247	301	-66.9	161
4	P_IIB_N15	nA	-0.1	2	1.34	.06	1.41	.08	1.54	.08	1.69	.10	1.86	.12	2.15	.18	4.21	2.2	6.50	3.5	6.97	1.4	9.93	2.0	7.95	1.3	2.92	.18
5	N_IIB_N15	nA	-0.1	2	1.49	.07	1.57	.08	1.69	.09	1.91	.11	2.01	.12	2.29	.19	4.18	2.5	6.19	2.9	7.05	1.4	9.97	2.0	8.02	1.2	3.04	.18
6	IIOS_N15	nA	-0.2	0.2	-.155	.01	-.153	.01	-.151	.01	-.150	.01	-.152	.01	-.144	.01	-.221	.07	316	.61	-.086	.03	-.017	.06	-.065	.03	-.126	.01
7	VOS_P20V	µV	-500	500	-24.6	142	-24.9	143	-25.4	144	-22.2	153	21.5	170	-89.8	157	-131	168	-224	188	-212	285	-261	335	-201	291	-54.6	161
8	P_IIB_P15	nA	-0.1	2	1.03	1.0	1.25	.09	1.62	.08	1.83	.10	1.97	.13	2.28	.20	4.33	1.9	7.11	4.0	7.51	1.5	10.7	2.2	8.56	1.4	3.10	.18
9	N_IIB_P15	nA	-0.1	2	1.54	.11	1.63	.11	1.77	.09	1.90	.11	2.11	.13	2.41	.20	4.29	2.2	6.81	3.4	7.58	1.5	10.7	2.2	8.60	1.3	3.21	.18
10	IIOS_P15	nA	-0.2	0.2	-.148	.01	-.144	.01	-.143	.01	-.143	.01	-.143	.01	-.136	.01	-.141	2.7	1.52	3.8	-.067	.03	-.016	.04	-.045	.03	-.117	.01
11	VOS_0V	µV	-500	500	-26.0	143	-27.0	142	-27.0	144	-51.3	151	-74.7	154	-93.7	158	-190	167	-242	188	-232	288	-288	340	-220	295	-58.6	161
12	P_IIB_0V	nA	-0.1	2	2.24	2.3	1.99	.10	1.62	.08	1.75	.11	1.96	.13	2.26	.19	4.59	3.0	7.00	3.9	7.31	1.4	10.4	2.1	8.33	1.3	3.05	.18
13	N_IIB_0V	nA	-0.1	2	1.59	.07	1.65	.08	1.79	.09	1.90	.12	2.14	.13	2.43	.19	4.61	2.9	6.80	3.5	7.41	1.4	10.5	2.0	8.41	1.3	3.20	.19
14	IIOS_0V	nA	-0.2	0.2	-.176	.01	-.171	.01	-.170	.02	-.173	.02	-.175	.02	-.168	.02	-.181	3.0	-.208	.49	-.101	.03	-.054	.04	-.078	.03	-.146	.02
15	VOS_5V	µV	-500	500	-45.4	142	-46.0	144	-47.6	144	-70.9	149	-102	154	-125	161	-269	189	-331	212	-300	364	-401	404	-313	346	-95.5	171
16	P_IIB_5V	nA	-0.1	2	1.30	.06	1.42	.07	1.51	.08	1.66	.10	1.84	.12	2.13	.18	4.23	2.8	6.55	3.6	7.02	1.4	10.0	2.0	8.04	1.3	2.88	.17
17	N_IIB_5V	nA	-0.1	2	1.46	.06	1.56	.07	1.66	.08	1.80	.09	1.99	.12	2.27	.18	4.25	2.2	6.21	2.9	7.12	1.4	10.1	2.0	8.10	1.3	3.01	.17
18	IIOS_5V	nA	-0.2	0.2	-.154	.01	-.152	.01	-.149	.01	-.150	.01	-.151	.01	-.146	.01	-.251	.45	.335	.64	-.086	.03	-.045	.04	-.041	.06	-.127	.01
19	CMR_15V	dB	96		138	4.1	136	4.0	136	3.8	133	3.7	132	3.5	130	3.7	127	4.1	118	5.3	116	2.4	113	2.0	117	2.3	128	1.3
20	Plus_PSRR	µV/V	-16	16	1.63	.17	1.69	.18	1.72	.17	1.81	.20	2.00	.22	2.30	.31	4.09	.98	5.78	1.9	4.98	5.1	7.65	3.6	6.02	2.7	2.56	.51
21	Minus_PSRR	µV/V	-16	16	.769	.17	.801	.18	.848	.16	1.02	.29	1.38	.35	1.88	.66	4.21	2.2	7.12	3.0	4.86	11	9.04	7.3	7.41	5.1	2.24	1.1
22	P_VOUT	V	16		18.6	.01	18.6	.01	18.6	.01	18.6	.01	18.6	.01	18.6	.01	18.6	.01	18.6	.01	18.6	.01	15.1	4.8	18.6	.01	18.6	.01
23	N_VOUT	V		-16	-18.3	.01	-18.3	.01	-18.3	.01	-18.3	.01	-18.3	.01	-18.3	.01	-18.3	.01	-18.3	.01	-18.3	.01	-18.3	.01	-18.3	.01	-18.3	.01
24	P_AOL	V/mV	80		1207	139	1153	140	1081	152	907	151	765	152	640	187	471	121	215	117	168	79	280	403	196	82	522	148
25	N_AOL	V/mV	80		3650	1516	3210	1170	2591	845	1685	571	948	305	708	237	485	185	242	131	251	183	181	102	208	57	660	181
26	AOL_5	V/mV	20		255	12	240	12	232	12	202	22	185	27	156	31	99.9	29	54.3	27	43.3	13	36.0	16	45.1	12	119	17
27	PLUS_SLEW	V/µs	0.05		.305	0	.300	0	.288	0	.281	0	.272	0	.265	0	.220	0	.234	.01	.228	.01	.222	0	.227	0	.265	0
28	MINUS_SLEW	V/µs		-0.05	-.406	0	-.401	0	-.395	0	-.388	0	-.378	0	-.368	.01	-.341	.01	-.327	.02	-.318	.01	-.310	.01	-.318	.01	-.367	0

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 are 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.

The radiation sensitive parameters were N_IIB, P_IIB, IIOS, VOS, Minus_PSRR, P_AOL and N_AOL.

Figure 1. Radiation Bias Circuit for LM108



+ Vcc = + 15 + / - 0.5 V
- Vcc = - 15 + / - 0.5 V
Rin = 2 Kohm + / - 5 % , 1/4 W .
Rl = 10 Kohm + / - 5 % , 1/4 W .