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DATE: August 23, 1994

PPM-94-020

TO: V. Patel/406.0
FROM: K. Sahu/300.1 KS
SUBJECT: Radiation Report on EOS/AM
Part No. OP 07A
Control No. 8543

cc: A. Sharma/311
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A radiation evaluation was performed on OP 07A (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. All irradiated parts passed all electrical tests up to and including the 5 krad irradiation level. At the 10 krad irradiation level, 7 parts (S/N 3, 4, 5, 7, 8, 9 and 10) exceeded the maximum specification limit of 2.00 nA for +Ibias, with readings in the range of 2.40-5.16 nA, 7 parts (S/N 4, 5, 6, 7, 8, 9 and 10) exceeded the maximum specification limit of 2.00 nA for -Ibias, with readings in the range of 2.02-5.74 nA and 1 part (S/N 5) exceeded the minimum specification limit of -25.0 μV for Vio, with a reading of -30.8 μV.

At the 15 krad level, all irradiated parts failed both +Ibias and -Ibias, with readings approximately twice the previous values and S/N 5 continued to fail the Vio test, with a reading of -35.8 μV.

After the 20 krad irradiation, the same failures continued for +Ibias and -Ibias, with readings in the range of 9 to 23 nA and 6 to 17 nA, respectively and S/N 3, 5, 6, 8 and 9 failed the Vio test, with readings in the range of -44 to +28 μV.

At the 30 krad level, all irradiated parts continued to fail +Ibias and -Ibias, with slightly higher readings. All parts except S/N 4 failed Vio, with readings ranging from -71 to +34 μV, and one part (S/N 5) exceeded the minimum specification limit of -2.00 nA for Iio, with a reading of -3.08 nA.

At the 50 krad level, all irradiated parts continued to fail +Ibias and -Ibias, with readings ranging from 36 to 73 nA and 35 to 77 nA, respectively. S/N 3, 5, 8 and 9 failed Vio, with readings ranging from -51 to +97 μV and S/N 3, 5 and 8 fell below the minimum specification limit of 300 V/mV for Avs_2K, with readings ranging from 230 to 290 V/mV. No reliable readings could be obtained for -SR at this level.

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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.

In addition, at the 50 krad level, S/N 8 and 9 fell below the minimum specification limit of 100.0 dB for +PSRR, with readings of 98.9 and 97.3 dB, respectively and S/N 9 fell below the minimum specification limit of 100.0 dB for -PSRR, with a reading of 98.4 dB.

At the 75 krad level, all irradiated parts except S/N 7 and 10 failed Vio, +Ibias, -Ibias, Iio and Avs_2K with increasing readings. S/N 7 and 10 passed the Iio test. All parts except S/N 6 read 0.00 V for -Sr. S/N 3, 4, 6, 7 and 8 marginally failed -PSRR with readings ranging from 93.1 to 98.8 dB and S/N 9 marginally failed +PSRR, with a reading of 96.1 dB.

From the 75 krad level, through the 168-hour room-temperature anneal, no reliable readings could be obtained for +SR and -SR.

At the 100 krad level, all irradiated parts except S/N 6, which read 0.95 nA, passed Iio. S/N 4 and 5 passed Vio at this level and S/N 3, 4, 5, 7, 8, 9 and 10 passed Iio. All other parts continued to fail Vio, +Ibias, -Ibias and Avs_2K, with readings two to three times higher than at the 75 krad level. Marginal +PSRR and -PSRR failures continued. In addition, S/N 8 and 9 marginally fell below the minimum specification limit of 110.0 dB for CMRR, with readings of 107.9 and 106.5 dB, respectively.

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.

TABLE I. Part Information

Generic Part Number:	OP 07A
FUSE Part Number:	OP177A
FUSE Control Number:	8543
Charge Number:	C44406
Manufacturer:	Linear Technology
Lot Date Code:	9410
Quantity Tested:	10
Serial Number of Control Samples:	1, 2
Serial Numbers of Radiation Sample:	3, 4, 5, 6, 7, 8, 9, 10
Part Function:	Op Amp
Part Technology:	Linear
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 OP 07A

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	06/22/94
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.

*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 OP 07A

Test Name	Min.	Max.
Idd_15	0 mA	4 mA
Iss_15	-4 mA	0 mA
+Vo_600	10 V	-
-Vo_2K	12 mA	-
-Vo_600	-	-10
-V0_2K	-	-12
Vio	-25 μV	25 μV
+Ibias	-2 nA	2 nA
-Ibias	-2 nA	2 nA
Iio	-2 nA	2 nA
Avs_2K	300 V/mV	-
CMRR	110 dB	-
+PSRR	100 dB	-
-PSRR	100 dB	-
+Ios	-65	0
-Ios	0	65
+SR	0.08V	-
-SR	0.08V	-

TABLE IV: Summary of Electrical Measurements after Total Dose Exposures and Annealing for OP 07A /1

Parameters		Spec. Lim./2 min	Spec. Lim./2 max	Initials mean	Initials sd	Total Dose Exposure (krads) 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
Idd_15v	mA	0	4	1.44	.03	1.44	.03	1.43	.03	1.44	.03	1.44	.03	1.44	.03	1.49	.03	1.50	.03	1.55	.04	1.51	.03	1.46	.03
Iss_15v	mA	-4	0	-1.43	.03	-1.43	.03	-1.43	.02	-1.42	.02	-1.43	.03	-1.44	.03	-1.49	.03	-1.51	.03	-1.55	.04	-1.51	.03	-1.47	.02
+Vo_600	V	10		14.0	0	14.0	0	14.0	0	14.0	0	14.0	0	14.0	0	14.0	0	14.0	.01	13.9	.05	13.9	.04	14.0	.07
+Vo_2k	V	12		14.2	0	14.2	0	14.2	0	14.2	0	14.2	0	14.2	0	14.2	0	14.2	0	14.2	0	14.2	.05	14.2	.04
-Vo_600	V		-10	-14.0	0	-14.0	0	-14.0	0	-14.0	0	-14.0	0	-13.9	.05	-13.9	0	-13.9	.01	-13.9	0	-14	.04	-13.9	0
-Vo_2k	V		-12	-14.2	.05	-14.2	.01	-14.2	0	-14.2	0	-14.2	0	-14.2	0	-14.2	0	-14.2	.01	-14.2	.05	-14.2	.04	-14.2	0
Vio	uV	-25	25	2.56	9.3	-2.46	12	-5.80	16	-8.29	19	-16.1	22	-30.9	32	-8.39	63	233	91	-7.13	126	-99.6	160	-34.5	32
+Ibias	nA	-2	2	-0.75	.37	0.21	.46	3.42	1.1	6.14	1.8	13.1	4.7	24.2	5.5	61.8	14	193	44	209	10	180	18	46.6	44
-Ibias	nA	-2	2	-0.83	.26	-.098	.43	5.68	6.0	8.37	1.9	11.4	3.3	23.0	6.4	60.2	15	145	44	209	7.4	182	22	61.4	7.2
Iio	nA	-2	2	.075	.34	.211	.23	.010	.31	-.063	.58	1.71	5.4	1.12	4.7	1.56	4.8	2.60	5.5	-.039	2.8	26.8	79	0.15	1.9
Avs_2k	V/mv	300		1003	35	938	33	838	34	761	41	701	55	581	65	405	44	112	23	155	30	239	41	476	30
CMRR	dB	110		140	7.0	139	6.9	134	6.2	131	7.1	129	8.0	126	9.3	121	4.8	118	6.1	114	5.5	115	5.7	123	7.0
-PSRR	dB	100		114	3.0	113	3.1	111	3.6	111	4.1	109	5.5	108	9.9	107	9.0	101	8.6	93.9	6.7	101	11	105	3.1
-PSRR	dB	100		125	8.1	123	8.0	119	7.8	117	7.7	111	5.6	110	4.2	109	7.5	107	8.1	105	9.7	101	7.1	112	7.6
+Ios	mA	-65	0	-29.8	.51	-29.9	.41	-29.9	.32	-29.9	.30	-29.8	.31	-29.7	.31	-29.5	.30	-29.3	.29	-29.3	.27	-29.3	.27	-29.6	.29
-Ios	mA	0	65	35.2	.72	35.7	.68	36.0	.46	35.1	.41	28.8	.30	27.4	.26	36.0	.25	36.1	.28	35.7	.27	35.7	.29	36.4	.36
+SR	V	0.08		0.19	0.01	0.19	0.01	0.17	.01	0.17	.01	0.17	.01	0.15	.01	0.14	0	*	*	*	*	*	*	0.16	.02
-SR	V	0.08		0.19	0.01	0.19	0.01	0.18	.01	0.18	0.01	0.16	.01	0.16	.01	*	*	*	*	*	*	*	*	0.15	0

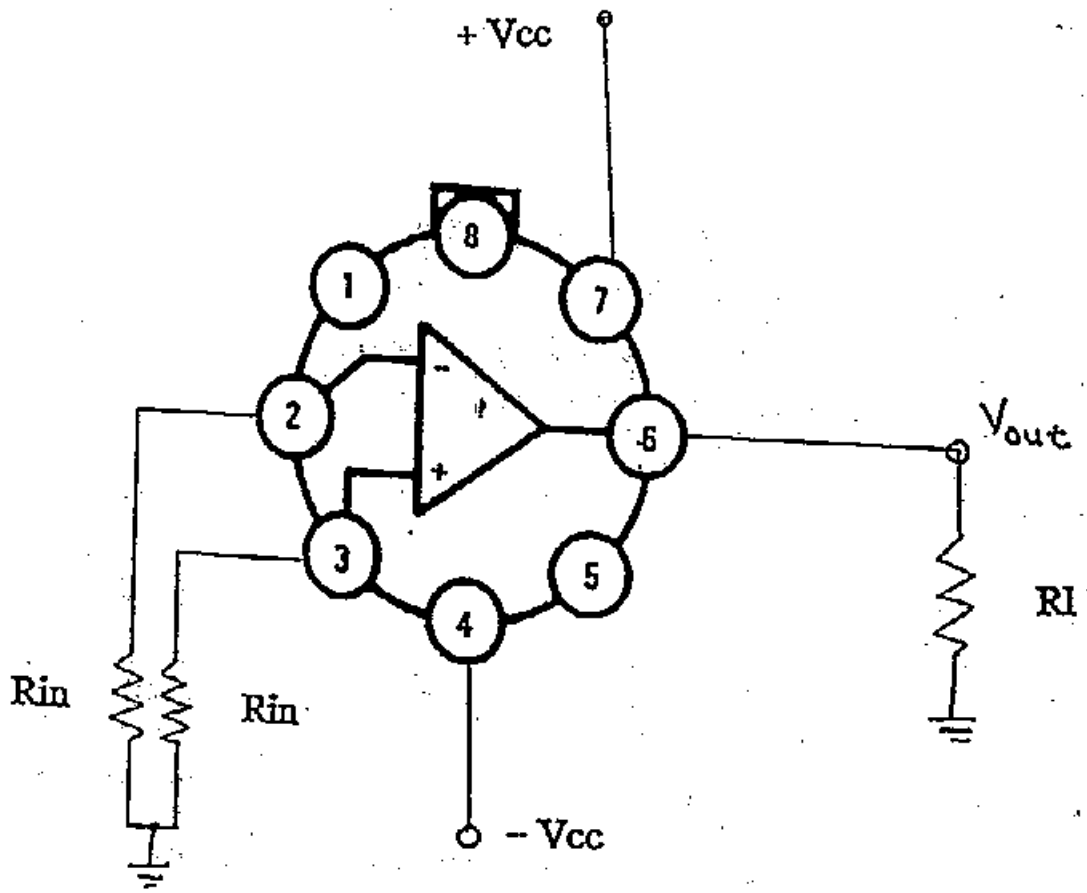
* Reliable readings could not be obtained at these levels.

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 +Ibias, -Ibias, Vio, Iio, Avs_2K, +PSRR, -PSRR and CMRR.

Figure 1. Radiation Bias Circuit for OP 07A



+ Vcc = + 15 + / - 0.5 V

- Vcc = - 15 + / - 0.5 V

Rin = 2 Kohm + / - 5 %, 1/4 W.

Rl = 10 Kohm + / - 5 %, 1/4 W.