Government Systems Group

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DATE: October 25, 1994

PPM-94-037

TO: B Fafaul/311.1
FROM: K. Sahu/300.1 KS
SUBJECT: Radiation Report on HST/ADD
Part No. OP400AY
Control No. 11001

cc: A. Sharma/311
Library/300.1

A radiation evaluation was performed on OP400AY (Low Offset Quad 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 and 50 krads*. The dose rate was between 0.04 and 1.18 krads/hour, depending on the total dose level (see Table II for radiation schedule). After the 50 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.

At initial electrical measurements, S/N 36 fell below the minimum specification limit of -1.00 nA for Iio 2, with a reading of -1.32 nA. All other parts passed all initial electrical measurements.

At the 2.5 krad irradiation level, S/N 34, 36, 37 and 39 fell below the minimum specification limit of -1.00 nA for Iio 4, with readings of -1.92, -1.71, -1.36 and -1.08 nA, respectively. In addition, S/N 34 and 36 exceeded the maximum specification limit of 3.00 nA for +Ibias 4, with readings of 3.5 and 3.1 nA, respectively.

At the 5 krad irradiation level, All irradiated parts recovered to within specification limits for Iio 4. S/N 34, 37 and 38 exceeded the maximum specification limit of 3.00 nA for +Ibias 4, with readings of 3.3, 3.4 and 3.5 nA, respectively, and S/N 34 also exceeded the maximum specification limit of 3.00 nA for -Ibias 4, with a reading of 3.3 nA. S/N 36 recovered to within specification limits for +Ibias 4. In addition, S/N 33 also fell below the minimum specification limit of 2000V/mV for Avs_2k 1, with a reading of 1958.6 V/mV and S/N 37 fell below the minimum specification limit of 5000 V/mV for Avs_10k 2 and Avs_10k 4, with readings of 4965.3 and 4768.6 V/mV, respectively. S/N 39 exceeded the maximum specification limit of 3.00 nA for +Ibias 2, +Ibias 4, -Ibias 3 and -Ibias 4, with readings of 3.0, 3.4, 3.0 and 3.3 nA, respectively.

At the 10 krad irradiation level, all irradiated parts exceeded the maximum specification limit of 3.00 nA for all Ibias tests, with readings ranging from 3.7 to 6.3 nA. All irradiated parts also fell below the minimum specification limit of 5000 V/mV for all Avs_10k tests, with readings ranging from 2518 to 4959 V/mV, and all irradiated parts fell below the minimum specification limit of 2000 V/mV for at least one Avs_2k test, with readings ranging from 1722 to 1999 V/mV. In addition S/N 37 and 40 exceeded the maximum specification limit

*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.

of 1.00 nA for Iio 2, with readings of 1.39 and 1.26 nA, respectively.

At the 15 krad level, all irradiated parts failed all Ibias tests and all Avs tests, with readings ranging from 6.3 to 8.7 nA for Ibias, and 1146 to 1945 V/mV and 1649 to 3573 V/mV for Avs_2k and Avs_10k, respectively. In addition, all irradiated parts except s/N 33 fell below the minimum specification limit of 0.10 V for at least two SR tests, with readings of 0.00 V. This reading indicates that the output did not reach the minimum value within the time specified in the test and constitutes a functional failure of the part.

At the 20 krad level, the same failures in Ibias, Avs and SR continued, with readings for Ibias approximately 20% higher and about the same for Avs. All irradiated parts read 0.00 V for at least four SR tests. S/N 36 fell below the minimum specification limit of -150.0 μV for Vio 3, with a reading of -147.3 μV and exceeded the maximum specification limit of 1.00 nA for Iio 3, with a reading of 1.10 nA.

At the 30 krad level, three parts read 0.00 for only one SR test, four parts read 0.00 V for two SR tests and one part read 0.00 for four SR tests. All parts continued to fail all Ibias tests and all Avs tests, with readings approximately 20% higher for Ibias and approximately 20 % lower for Avs. S/N 36 continued to fail Vio 3 and Iio 3, with readings of -218.0 μA and 1.82 nA, respectively.

At the 50 krad level, only one part (S/N 33) read 0.00 V for one SR test. All others passed all SR tests. the same failures seen at the 30 krad level continued, again with readings approximately 20% worse. In addition, S/N 36 also exceeded the maximum specification limit of 1.00 nA for Iio 2, with a reading of 1.17 nA.

After annealing for 168 hours at 25°C, no recovery was seen in the Ibias and Avs failures and a slight increase in the rate of SR failures was seen (3 parts with one failure, 3 parts with 2 failures and 2 parts with 3 failures). No other recovery was seen, and S/N 33 exceeded the maximum specification limit of 1.00 nA for Iio 2, with a reading of 1.15 nA.

After annealing for 168 hours at 100°C, no rebound effects were observed, except for a slight increase in the rate of SR failures.

All parts passed all other electrical tests throughout all irradiation and annealing steps.

Table IV provides a summary of the results 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:	OP400AY
HST/ADD Part Number:	5962-8777101MCA*
HST/ADD Control Number:	11001
Charge Number:	C44625
Manufacturer:	Analog Devices (PMI)
Lot Date Code:	9415
Quantity Tested:	10
Serial Number of Control Samples:	31, 32
Serial Numbers of Radiation Samples:	33, 34, 35, 36, 37, 38, 39, 40
Part Function:	Low Offset Quad Op Amp
Part Technology:	CMOS
Package Style:	14-pin DIP
Test Equipment:	A540
Test Engineer:	C. Nguyen

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

TABLE II. Radiation Schedule for OP400AY

EVENTS	DATE
1) INITIAL ELECTRICAL MEASUREMENTS	09/13/94
2) 2.5 KRAD IRRADIATION (0.04 KRADS/HOUR)	09/16/94
POST-2.5 KRAD ELECTRICAL MEASUREMENT	09/19/94
3) 5 KRAD IRRADIATION (0.15 KRADS/HOUR)	09/19/94
POST-5 KRAD ELECTRICAL MEASUREMENT	09/20/94
4) 10 KRAD IRRADIATION (0.26 KRADS/HOUR)	09/20/94
POST-10 KRAD ELECTRICAL MEASUREMENT	09/21/94
5) 15 KRAD IRRADIATION (0.26 KRADS/HOUR)	09/21/94
POST-15 KRAD ELECTRICAL MEASUREMENT	09/22/94
6) 20 KRAD IRRADIATION (0.08 KRADS/HOUR)	09/22/94
POST-20 KRAD ELECTRICAL MEASUREMENT	09/26/94
7) 30 KRAD IRRADIATION (0.59 KRADS/HOUR)	09/26/94
POST-30 KRAD ELECTRICAL MEASUREMENT	09/27/94
8) 50 KRAD IRRADIATION (1.18 KRADS/HOUR)	09/27/94
POST-30 KRAD ELECTRICAL MEASUREMENT	09/28/94
9) 168-HOUR ANNEALING @25°C	09/28/94
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	10/05/94
10) 168-HOUR ANNEALING @100°C*	10/05/94
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	10/12/94

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 OP400AY

TEST CONDITIONS: VDD= +/- 15V unless otherwise noted;

Test temperature : 25oC

tst #	Test name	Min	Max	Conditions
1	+Idd	0.0 ma	2.9 ma	
2	-Idd	-2.90 ma	0.00 ma	
3	Voh1_2k	11.0 v		R1 = 2K
4	Voh2_2k	11.0 v		R1 = 2K
5	Voh3_2k	11.0 v		R1 = 2K
6	Voh4_2k	11.0 v		R1 = 2K
7	Vol1_2k		-11.0 v	R1 = 2K
8	Vol2_2k		-11.0 v	R1 = 2K
9	Vol3_2k		-11.0 v	R1 = 2K
10	Vol4_2k		-11.0 v	R1 = 2K
11	Voh1_10k	12.0 v		R1 = 10K
12	Voh2_10k	12.0 v		R1 = 10K
13	Voh3_10k	12.0 v		R1 = 10K
14	Voh4_10k	12.0 v		R1 = 10K
15	Vol1_10k		-12.0 v	R1 = 10K
16	Vol2_10k		-12.0 v	R1 = 10K
17	Vol3_10k		-12.0 v	R1 = 10K
18	Vol4_10k		-12.0 v	R1 = 10K
19	vio 1	-150.0 uv	150.0 uv	
20	vio 2	-150.0 uv	150.0 uv	
21	vio 3	-150.0 uv	150.0 uv	
22	vio 4	-150.0 uv	150.0 uv	
23	+ibias 1	-3.0 na	3.0 na	
24	+ibias 2	-3.0 na	3.0 na	
25	+ibias 3	-3.0 na	3.0 na	
26	+ibias 4	-3.0 na	3.0 na	
27	-ibias 1	-3.0 na	3.0 na	
28	-ibias 2	-3.0 na	3.0 na	
29	-ibias 3	-3.0 na	3.0 na	
30	-ibias 4	-3.0 na	3.0 na	
31	iio 1	-1.0 na	1.0 na	
32	iio 2	-1.0 na	1.0 na	
33	iio 3	-1.0 na	1.0 na	
34	iio 4	-1.0 na	1.0 na	
35	Avs_2k 1(V/mv)	2000.0		R1 = 2K
36	Avs_2k 2(V/mv)	2000.0		R1 = 2K
37	Avs_2k 3(V/mv)	2000.0		R1 = 2K
38	Avs_2k 4(V/mv)	2000.0		R1 = 2K

Table III (Cont'd.). Electrical Characteristics of OP400AY

TEST CONDITIONS: VDD= +/- 15V unless otherwise noted;

Test temperature : 25oC

tst #	Test name	Min	Max	Conditions
39	Avs_10k 1(V/mv)	5000.0		Rl = 10K
40	Avs_10k 2(V/mv)	5000.0		Rl = 10K
41	Avs_10k 3(V/mv)	5000.0		Rl = 10K
42	Avs_10k 4(V/mv)	5000.0		Rl = 10K
43	psrr1 (uV/V)		1.80	VCC = +/-3v to +/-18v
44	psrr2 (uV/V)		1.80	VCC = +/-3v to +/-18v
45	psrr3 (uV/V)		1.80	VCC = +/-3v to +/-18v
46	psrr4 (uV/V)		1.80	VCC = +/-3v to +/-18v
47	cmrr 1	120.0 db		VCM = +/- 12v
48	cmrr 2	120.0 db		VCM = +/- 12v
49	cmrr 3	120.0 db		VCM = +/- 12v
50	cmrr 4	120.0 db		VCM = +/- 12v
51	+SR 1 *	0.10 v/μs		Vout = +/- 0.25v
52	+SR 2	0.10 v/μs		Vout = +/- 0.25v
53	+SR 3	0.10 v/μs		Vout = +/- 0.25v
54	+SR 4	0.10 v/μs		Vout = +/- 0.25v
55	-SR 1	0.10 v/μs		Vout = +/- 0.25v
56	-SR 2	0.10 v/μs		Vout = +/- 0.25v
57	-SR 3	0.10 v/μs		Vout = +/- 0.25v
58	-SR 4	0.10 v/μs		Vout = +/- 0.25v

* A reading of 0.00 in this parameter indicates that the device output failed to reach the minimum value within the time specified in the test, and therefore constitutes a functional failure of the part.

TABLE IV: Summary of Electrical Measurements after Total Dose Exposures and Annealing for OP400AY /1

Test #	Parameter	Units	Spec. Lim./2 min	Spec. Lim./2 max	Initials mean	Initials sd	Total Dose Exposure (krads) 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	Annealing 168 hrs @25°C mean	168 hrs @25°C sd	168 hrs @100°C mean	168 hrs @100°C sd
1	+Idd	mA	0.0	2.9	2.39	.04	2.29	.04	2.19	.04	2.01	.04	1.86	.05	1.75	.05	1.44	.09	1.15	.09	1.44	.07	1.90	0
2	-Idd	mA	-2.9	0.0	-2.38	.02	-2.28	.03	-2.19	.03	-2.02	.05	-1.86	.06	-1.74	.06	-1.43	.08	-1.15	.08	-1.43	.06	-1.93	.03
3	Voh3_2k	V	11.0	-	12.8	.05	12.8	.04	12.8	.04	12.8	.04	12.8	.04	12.8	0	12.6	.05	12.7	0	12.7	0	12.8	0
4	Vol3_2k	V	-	-11.0	-13.5	0	-13.5	0	-13.5	0	-13.5	0	-13.5	0	-13.5	0	-13.5	.05	-13.5	.05	-13.5	.04	-13.5	0
5	Voh3_10k	V	12.0	0	12.9	0	12.9	0	12.9	0	12.9	0	12.9	0	12.9	0	12.7	.05	12.9	.04	12.9	.05	12.9	0
6	Vol3_10k	V	-	-12.0	-13.7	0	-13.7	0	-13.7	0	-13.7	0	-13.7	0	-13.7	0	-13.7	0	-13.7	0	-13.7	0	-13.7	0
7	Vio3	µV	-150.0	150.0	-12.5	27	-11.6	27	-8.91	0.29	-8.70	27	-12.5	30	-35.5	57	-56.0	69	-118	117	-87.3	130	-17.1	33
8	+Ibias 3	nA	-3.0	3.0	0.46	.17	1.60	.18	2.44	.23	5.11	.49	7.86	.67	10.4	.79	19.0	.99	31.5	1.7	27.2	1.6	8.26	.66
9	-Ibias 3	nA	-3.0	3.0	0.60	.05	1.74	.13	2.73	.18	5.10	.35	7.86	.54	10.4	.57	18.6	.93	30.9	1.3	27.0	1.4	8.24	.60
10	Iio 3	nA	-1.0	1.0	0	.09	-0.06	.10	0.05	.07	0.10	.11	0.08	.20	0.07	.43	0.20	.66	1.20	3.3	1.49	4.2	0.07	.08
11	Avs_2k 3	V/mV	2000	-	2495	227	2579	189	2342	296	1871	112	1467	204	1193	212	636	65	420	36	547	97	1594	156
12	Avs_10k 3	V/mV	5000	-	4.3E4	9.3E4	8404	1579	8189	2986	3749	707	2229	512	1529	365	769	78	478	19	638	75	2937	762
13	PSRR3	µV/V	-	1.80	0.24	.14	-.23	.14	0.24	.14	0.24	.14	0.25	.16	0.26	.26	0.33	.26	0.69	.64	0.47	.61	0.25	.15
14	CMRR3	dB	120.0	-	144	4.7	141	5.4	143	7.2	144	7.7	144	8.6	146	8.0	145	10	140	4.0	143	8.8	143	6.3
15	+SR 3/3	V/µs	0.10	-	0.28	.01	0.27	.01	0.26	.01	0.23	.01	1P7F		F		F		F		2P5F		F	
16	-SR 3/3	V/µs	0.10	-	0.28	.01	0.27	.01	0.26	0	0.23	.01	1P7F		F		F		F		2P6F		F	

Notes:

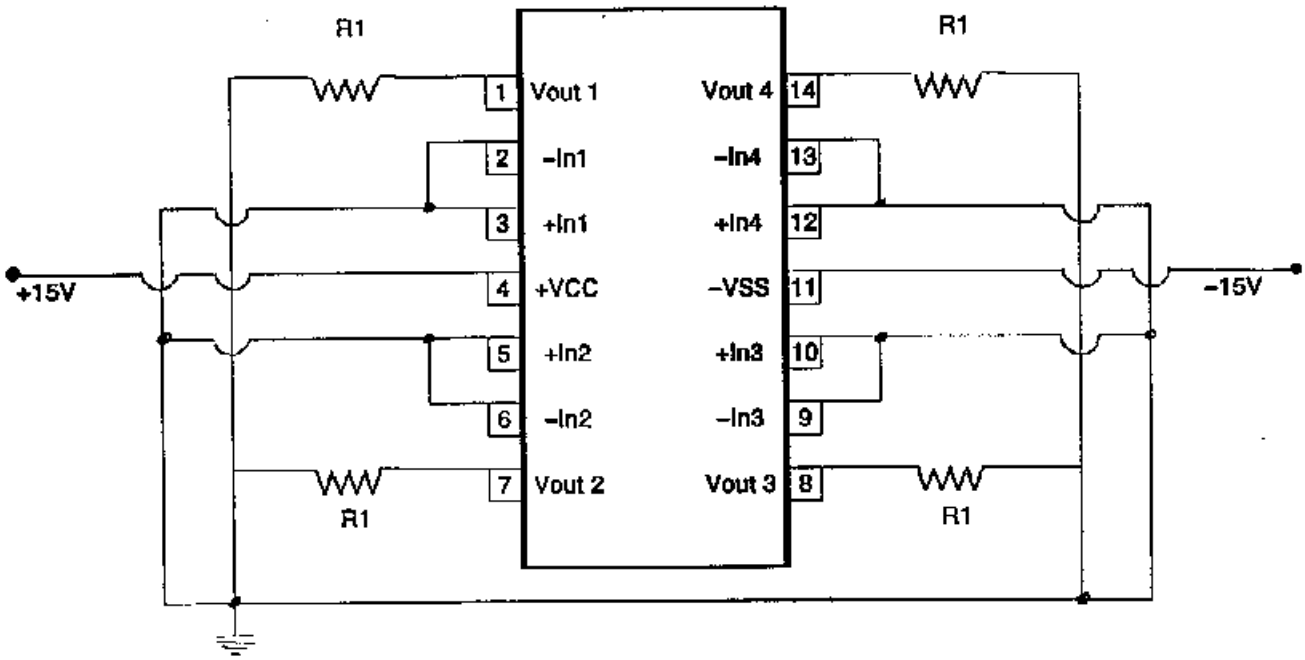
1/ The mean and standard deviation values were calculated over the eight parts irradiated in this testing. The control samples remained constant throughout the testing and are not included in this table. Values are given only for Section 3, which was the worst case. Data for other sections are available on request.

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/ Values of mean and standard deviation for this parameter, where shown, are for section 3, as in /1. A failure in this parameter, however, constitutes a functional failure of the part. Therefore, failures in this parameter are given as "nPmF", where all four sections of n parts passed the test at this level and at least one section of m parts failed. "F" in this column means that at least one section of all irradiated parts failed this test.

The radiation-sensitive parameters were Ibias, Avs, Iio, SR and Vio.

Figure 1. Radiation Bias Circuit for OP400AY



R1 = 15 Kohms ; +/– 10% ; 1/2 w