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Memorandum

PPM-93-040

DATE: Mar. 8, 1993  
TO: C. Kellenbenz/711.3  
FROM: K. Sahu/300.1  
SUBJECT: Radiation Report on ISTD/HYDRA  
Part No. OP43AJ/883 (OP437AJ)  
Control No. 7481

cc: S. Jung/300.1  
A. Sharma/311  
Library/300.1

A radiation evaluation was performed on OP43AJ (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 steps were 5, 10, 20, 30, 50, 75 and 100 krad\*. After the 5-krad irradiation, the parts were annealed at 25°C for 48 hours and after the 10-krad irradiation, the parts were annealed at 25°C for 24 hours. After 100 krad, parts were annealed for 168 hours at 25°C. The dose rate was between 0.05 and 1.35 krad/hour, depending on the total dose level (see Table II for radiation schedule). After each radiation exposure and annealing treatment, parts were electrically tested at 25°C according to the test conditions and the specification limits\*\* listed in Table III.

All ten parts passed initial (pre-rad) electrical tests. After the 5-krad exposure, All eight irradiated parts exceeded the maximum specification limit of  $\pm 0.5$  mV for Vos, with readings ranging from -0.8 to -1.5 mV and exceeded the maximum specification limit of 3.5 pA for Ios, with readings ranging from 3.7 to 5.6 pA. All eight irradiated parts also exceeded the maximum specification limit of 5 pA for Ib+, Ib- and Ibias.

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\*The term rads, as used in this document, means rads(silicon).  
\*\*These are manufacturers' non-irradiated data sheet specification limits. No post-irradiation limits were provided by the manufacturer at the time these tests were performed.

Readings for  $I_{b+}$  ranged from 33 to 41 pA; readings for  $I_{b-}$  ranged from 29 to 36 pA, and readings for  $I_{bias}$  ranged from 31 to 38 pA.

After annealing for 48 hours at 25 °C, SN 225, 226, 228, 229, 230 and 232 continued to fail  $V_{os}$ , with readings ranging from -1.0 to -1.7 mV and SN 226 continued to fail  $I_{os}$ , with a reading of 3.8 pA. All other irradiated parts recovered to within specification limits for these parameters. All eight irradiated parts continued to exceed the maximum specification limit of 5 pA for  $I_{b+}$ ,  $I_{b-}$  and  $I_{bias}$ , with readings ranging from 10 to 62 pA for  $I_{b+}$ , 8.7 to 59 pA for  $I_{b-}$  and 9.4 to 61 pA for  $I_{bias}$ .

After the 10-krad irradiation, all eight irradiated parts exceeded the specification limit of  $\pm 0.5$  mV for  $V_{os}$ , with readings ranging from -0.6 to -2.5 mV. SN 225, 227, 229 and 231 exceeded the maximum specification limit of 3.5 pA for  $I_{os}$ , with readings ranging from 3.6 to 4.5 pA. All eight irradiated parts continued to exceed the maximum specification limit of 5 pA for  $I_{b+}$ ,  $I_{b-}$  and  $I_{bias}$ , with readings ranging from 58 to 69 pA for  $I_{b+}$ , 55 to 65 pA for  $I_{b-}$  and 57 to 67 pA for  $I_{bias}$ .

After annealing for 24 hours at 25°C, all eight irradiated parts exceeded the maximum specification limits for  $V_{os}$ ,  $I_{os}$ ,  $I_{b+}$ ,  $I_{b-}$  and  $I_{bias}$ . Readings ranged from -2.1 to -4.0 mV for  $V_{os}$ , 3.6 to 6.5 pA for  $I_{os}$ , 63 to 81 pA for  $I_{b+}$ , 59 to 76 pA for  $I_{b-}$  and 61 to 79 pA for  $I_{bias}$ .

All eight irradiated parts continued to exceed maximum specification limits, with progressively increasing values of the parameters for these five tests throughout all irradiation steps up to and including the 100-krad level. After the 75-krad irradiation, all but one (SN 231) part failed to meet the minimum specification limit of -12.3 V for  $-V_{o}$ , with readings ranging from -11.9 to -11.3 V, and SN 226 and 228 failed to meet the minimum specification limit of 1 MV/V for  $A_{ol}$ , with readings of 0.84 and 0.72 MV/V, respectively. After the 100-krad irradiation, SN 227 read within specification limits for  $-V_{o}$  with a reading of -12.5 V and SN 231 failed to meet the minimum specification limit for  $-V_{o}$ , with a reading of -12.28 V. In addition, one part (SN 229) marginally failed to meet the minimum specification limit of 12.3 volts for  $+V_{o}$ , with a reading of 12.29 V. SN 226 and 228 recovered to within specification limits for  $A_{ol}$ , while SN225 failed  $A_{ol}$ , with a reading of .66 MV/V.

After annealing for 168 hours at 25°C, all eight irradiated parts continued to fail  $V_{os}$ ,  $I_{os}$ ,  $I_{b+}$ ,  $I_{b-}$  and  $I_{bias}$ . All eight parts read within specification limits for  $+V_{o}$  and  $A_{ol}$ , but SN 226, 228, 229, 230 and 232 continued to fail  $-V_{o}$ , with readings ranging from -11.5 to -12.6 V.

No significant changes were observed in any other parameters throughout all irradiation and annealing steps.

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:	OP43AJ
Part Number:	OP43AJ/883
ISTP/HYDRA Control Number:	7481
Charge Number:	C33154
Manufacturer:	Analog Devices
Lot Date Code:	9212
Quantity Tested:	10
Serial Numbers of Radiation Samples:	224, 225, 226, 227, 228, 229, 230, 231, 232
Serial Numbers of Control Samples:	223, 224
Part Function:	Op Amp
Part Technology:	JFET
Package Style:	8-lead TOx Can
Test Equipment:	Genrad mod. 1731
Test Engineer:	K. Kim

TABLE II. Radiation Schedule for OP43AJ

EVENTS	DATE
1) INITIAL ELECTRICAL MEASUREMENTS	02/01/93
2) 5 KRAD IRRADIATION (0.25 KRADS/HOUR)	02/02/93
POST-5 KRAD ELECTRICAL MEASUREMENT	02/03/93
3) 48 HOUR ANNEALING @ 25°C	02/03/93
POST-48 HOUR ANNEAL ELECTRICAL MEASUREMENTS	02/05/93
4) 10 KRAD IRRADIATION (0.05 KRADS/HOUR)	02/05/93
POST-10 KRAD ELECTRICAL MEASUREMENTS	02/09/93
5) 24 HOUR ANNEALING @25°C	02/09/93
POST-24 HOUR ANNEAL ELECTRICAL MEASUREMENTS	02/10/93
6) 20 KRAD IRRADIATION (0.45 KRADS/HOUR)	02/10/93
POST-20 KRAD ELECTRICAL MEASUREMENTS	02/11/93
7) 30 KRAD IRRADIATION (0.50 KRADS/HOUR)	02/11/93
POST-30 KRAD ELECTRICAL MEASUREMENTS	02/12/93
8) 50 KRAD IRRADIATION (0.22 KRADS/HOUR)	02/12/93
POST-50 KRAD ELECTRICAL MEASUREMENTS	02/16/93
9) 75 KRAD IRRADIATION (1.35 KRADS/HOUR)	02/16/93
POST-75 KRAD ELECTRICAL MEASUREMENTS	02/17/93
10) 100 KRAD IRRADIATION (1.25 KRADS/HOUR)	02/17/93
POST-100 KRAD ELECTRICAL MEASUREMENTS	02/18/93
11) 168 HOUR ANNEALING @25°C	02/18/93
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENTS	02/25/93

ALL ELECTRICAL MEASUREMENTS WERE PERFORMED AT 25°C.

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

Table III. Electrical Characteristics of OP43AJ

Test	Units	Specification Limits		Conditions
		Min	Max	
+I <sub>CC</sub>	mA	0	1.0	R <sub>s</sub> = 50 Kohms
-I <sub>CC</sub>	mA	-1.0	0	"
V <sub>OS</sub>	mV	-0.5	0.5	+V <sub>s</sub> = +15V, -V <sub>s</sub> = -15V
I <sub>OS</sub>	nA	-3.5	3.5	V <sub>CM</sub> = 0 V
I <sub>b+</sub>	nA	-5	5	T <sub>a</sub> = 25°C
I <sub>b-</sub>	nA	-5	5	"
I <sub>bias</sub>	nA	-5	5	"
A <sub>ol</sub>	MV/V	1.0	-	R <sub>l</sub> = 2 Kohms, V <sub>o</sub> = ± 10 VDC
CMRR	dB	100	-	V <sub>CM</sub> = ± 11 VDC
+PSRR	dB	92	-	V <sub>s</sub> = ± 18 VDC
-PSRR	dB	92	-	"
+V <sub>o</sub>	V	12.3	-	R <sub>l</sub> = 2 Kohms
-V <sub>o</sub>	V	-12.3	-	"

TABLE IV: Summary of Electrical Measurements After Total Dose Exposures and Annealing Steps for OP43AJ 1/

Parameters		Spec. Lim./2		TDE*		TDE		Anneal		TDE		Anneal	
		min	max	0 Pre-Rad mean	sd	5 krad	sd	48 hrs. @25°C mean	sd	10 krad	sd	24 hrs. @25°C mean	sd
+Icc	mA	0	1.0	0.73	.02	0.74	.02	0.75	.01	0.75	.01	0.74	.01
-Icc	mA	-1.0	0	-0.73	.02	-0.74	.01	-0.75	.01	-0.75	.01	-0.74	.01
Vos**	mV	-0.5	0.5	0.22	.13	0.83	.53	0.97	.58	1.67	.66	3.29	.74
Ios**	pA	-3.5	3.5	0.17	.03	4.93	.51	1.50	1.1	3.49	.54	4.93	.89
Ib+	pA	-5	5	2.17	.52	37.0	3.1	26.4	18	63.7	4.2	69.4	5.9
Ib-	pA	-5	5	2.34	.51	32.5	2.9	24.9	17	60.3	3.9	64.5	5.6
Ibias	pA	-5	5	2.25	.51	34.8	3.0	25.7	18	62.0	4.0	67.0	5.7
Aol	MV/V	1.0	-	15.1	6.0	7.60	2.9	7.29	3.1	4.81	1.0	5.43	1.5
CMRR	dB	100	-	120	10	120	10	119	9.2	118	8.1	120	10
+PSRR	dB	92	-	112	10	114	10	114	9.5	114	6.8	113	7.1
-PSRR	dB	92	-	112	6.7	114	7.8	114	7.5	115	7.2	112	7.0
-Vo	V	12.3	-	12.8	.03	12.8	.04	12.8	.03	12.8	.02	12.8	.02
-Vo	V	-12.3	-	-12.8	.01	-12.8	.01	-12.8	.01	-12.8	.02	-12.8	.02

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.

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.

\*Total Dose Exposure (krads)

\*\*Values of the mean for these parameters are computed from absolute values of the data.

Radiation sensitive parameters were Vos, Ios, Ib+, Ib-, Ibias and Aol.



TABLE IV(cont.): Summary of Electrical Measurements After Total Dose Exposures and Annealing Steps for OP43AJ 1/

Parameters	Spec. Lim./2	TDE (krads)										Anneal			
		20		30		50		75		100		168 hrs. @25°C			
		min	max	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd		
+Icc	mA	0	1.0	0.79	.02	0.79	.02	0.80	.02	0.81	.02	0.84	.02	0.80	.02
-Icc	mA	-1.0	0	-0.79	.01	-0.79	.01	-0.80	.01	-0.81	.02	-0.84	.02	-0.81	.02
Vos**	mV	-0.5	0.5	7.48	1.1	20.1	1.7	34.1	2.3	54.7	5.8	72.1	9.8	78.7	8.0
Ios**	pA	-3.5	3.5	8.87	1.0	34.4	1.6	15.6	2.0	12.4	12	11.4	11	10.1	6.8
Ib+	pA	-5	5	136	8.0	246	17	186	182	186	182	552	16	452	32
Ib-	pA	-5	5	127	7.0	211	16	356	30	356	30	555	25	440	28
Ibias	pA	-5	5	131	7.5	228	16	364	30	364	30	559	19	445	29
Aol	MV/V	1.0	-	3.34	1.3	5.87	7.1	3.11	2.7	3.21	2.7	1.63	.95	1.64	.53
CMRR	dB	100	-	117	5.6	117	6.1	117	7.3	116	8.0	116	8.9	113	6.1
+PSRR	dB	92	-	115	5.8	114	6.2	112	7.1	111	7.1	110	7.5	113	9.5
-PSRR	dB	92	-	116	4.4	115	4.4	112	4.5	111	4.7	109	4.8	114	7.9
+Vo	V	12.3	-	12.8	.02	12.8	.02	12.8	.03	12.8	.04	12.8	.05	12.7	.04
-Vo	V	-12.3	-	-12.7	.03	-12.7	.03	-12.7	.03	-12.7	.08	-12.6	.10	-12.7	.46

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.

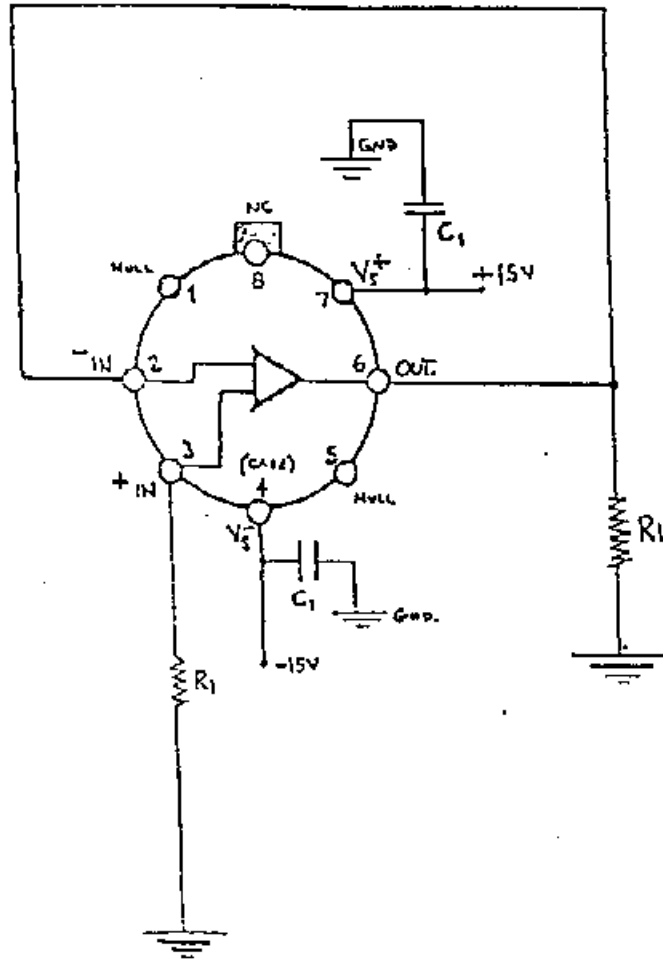
2/ These are manufacturers' non-irradiated data sheet specification limits. No post-irradiation limits were provided by the manufacturer at the time the tests were performed.

\*Total Dose Exposure (krads)

\*\*Values of the mean for these parameters are computed from absolute values of the data.

Radiation sensitive parameters were Vos, Ios, Ib+, Ib-, Ibias and Aol.

Figure 1. Radiation Bias Circuit for OP43AJ



Ta = 25°C

R1 = RL = 1K or 2K ohms, 10%, 1/2W

C1 = 0.1 uF (per board)

Vs+ = +15 ± 0.5 V

Vs- = -15 ± 0.5 V