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UNISYS

DATE: September 24, 1997 PPM-97-035
TO: J. Lohr/311
FROM: K. Sahu/300.1 KS
SUBJECT: Radiation Report on: OP470
Project: MAP/SC
Job #: C78078
Project part #: OP470 (5962-88565013A)

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A radiation evaluation was performed on OP470 (5962-88565013A) 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 Co^{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 5.0, 10.0, 15.0, 20.0 30.0, 50.0 and 100.0 kRads.* The dose rate was between 0.125 and 0.625 kRads/hour (0.035 to 0.17 Rads/sec). See Table II for the radiation schedule and dose rate calculation. After the 15.0 kRad irradiation, the parts were annealed for 214 hours at 25°C. After the 50.0 kRad exposure, the parts were annealed for 168 hours at 25°C. After each radiation exposure and annealing treatment, parts were electrically tested according to the test conditions and the specification limits** listed in Table III.

Initial electrical measurements were made on 10 samples. Eight samples (SN's 262, 263, 264, 265, 266, 268, 269, and 270) were used as radiation samples while SN's 261 and 267 were used as control samples. All parts passed all tests during initial electrical measurements.

All parts passed all tests to 10.0 kRads. No significant degradation was noted in any parameter.

After the 15.0 kRad irradiation, all parts fell below the specification limit of 1000V/mV for Avs_10k with readings in the range of 592 to 980V/mV. **All parts passed all other tests.**

After annealing the parts for 214 hours at 25°C, the parts showed some recovery in Avs_10k with most parts passing at least one of the four tests. Readings were from 843V/mV to greater than 1000V/mV. **All parts passed all other tests.**

After the 20.0 kRad irradiation, all parts fell below the specification limit for Avs_10k with readings in the range of 681 to 849V/mV. **All parts passed all other tests.**

After the 30.0 kRad irradiation, most parts exceeded the specification limit of 25nA for +ibias with readings in the range of 28.5 to 38.8nA. SN's 266 and 270 marginally exceeded the specification limit of 25nA for iio with readings of 26.4 and 26.9nA respectively. SN 262 fell marginally below the specification limit of 500V/mV for Avs_2k with a reading of 485V/mV. All parts continued to fall below the specification limit for Avs_10k with readings in the range of 511 to 791V/mV. **All parts passed all other tests.**

* The term Rads, as used in this document, means Rads (silicon). All radiation levels cited are cumulative.
** These are manufacturer's pre-irradiation data specification limits. The manufacturer provided no post-irradiation limits at the time these tests were performed.

After the 50.0 kRad irradiation, all parts exceeded the specification limit for +ibias with readings in the range of 31.2 to 65.9nA. All parts except SN 263 exceeded the specification limit of 25nA for –ibias with readings in the range of 31.8 to 48.9nA. All parts fell below the specification limit for Avs_2k with readings in the range of 302 to 470V/mV. All parts continued to fall below the specification limit for Avs_10k with readings in the range of 406 to 517V/mV. **All parts passed all other tests.**

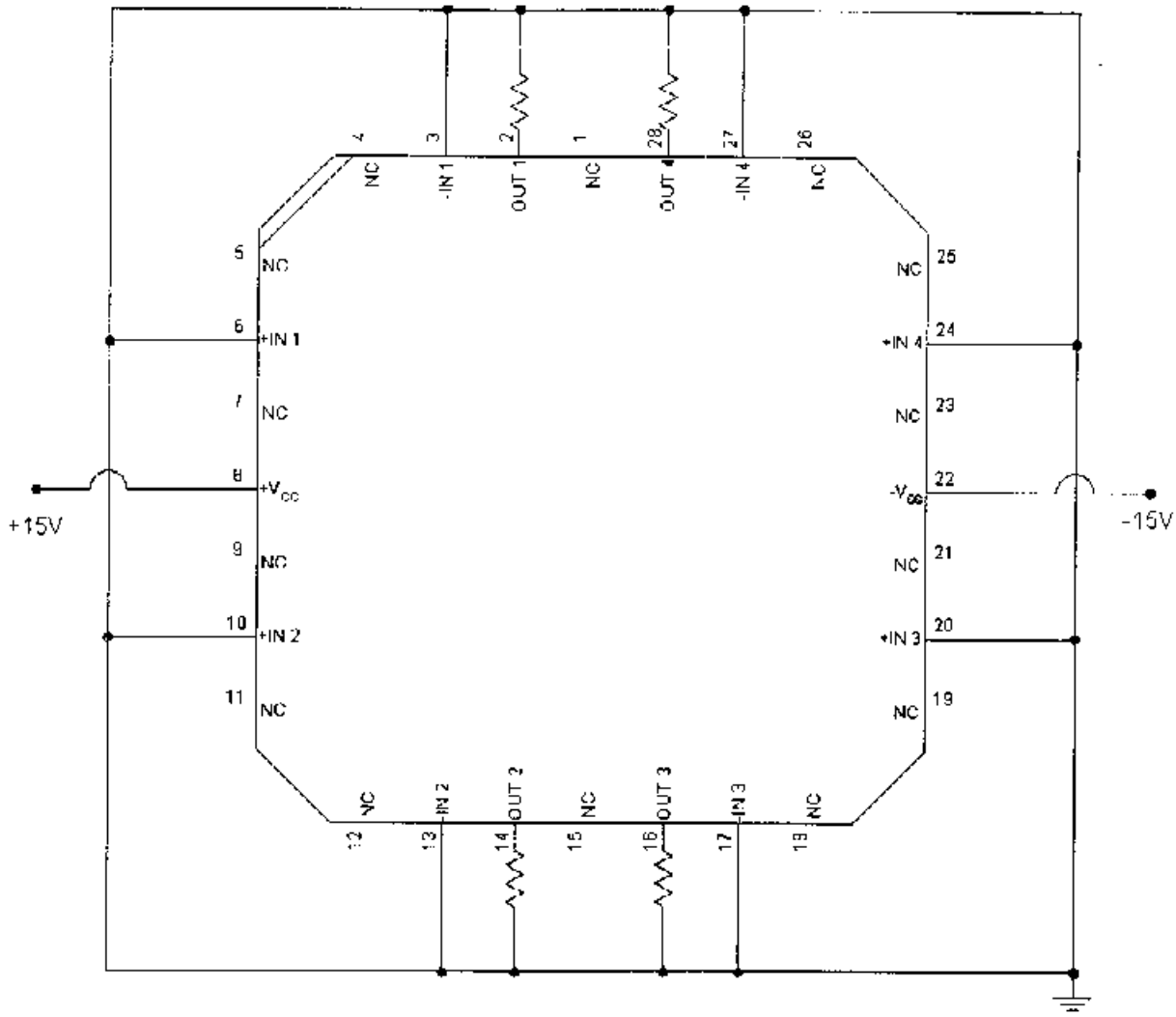
After the 100.0 kRad irradiation, all parts continued to exceed the specification limit for +ibias with readings in the range of 104 to 151nA. All parts exceeded the specification limit for –ibias with readings in the range of 75 to 140nA. SN 263 marginally exceeded the specification limit for iio with a reading of 27.1nA. All parts continued to fall below the specification limit for Avs_2k with readings in the range of 268 to 328V/mV. All parts continued to fall below the specification limit for Avs_10k with readings in the range of 313 to 369V/mV. **All parts passed all other tests.**

After annealing the parts for 168 hours at 25°C, parts showed modest recovery in +ibias, -ibias, Avs_2k, and Avs_10k; however, all readings continued to exceed or fall below specification limits.

Table IV provides a summary of the test results with the mean and standard deviation values for each parameter after each irradiation exposure and annealing step.

Any further details about this evaluation can be obtained upon request. If you have any questions, please call me at (301) 731-8954.

Figure 1. Radiation Bias Circuit for OP470



Resistors are 15kΩ ±10%, ½ W.

Use 28 pin LCC to 14 pin DIP adapters.

TABLE I. Part Information

Generic Part Number:	OP470
SMEX/LITE Part Number	5962-88565013A
Charge Number:	C78078
Manufacturer:	Analog Devices
Lot Date Code (LDC):	C9438
Quantity Tested:	10
Serial Number of Control Samples:	261, 267
Serial Numbers of Radiation Samples:	262, 263, 264, 265, 266, 268, 269, 270
Part Function:	Quad OP-AMP
Part Technology:	Bipolar
Package Style:	28 Pin LCC
Test Equipment:	A540
Test Engineer:	S. Norris

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

TABLE II. Radiation Schedule for OP470

EVENT	DATE
1) INITIAL ELECTRICAL MEASUREMENTS	08/08/97
2) 5.0 KRAD IRRADIATION (0.125 KRADS/HOUR)	08/11/97
POST-5.0 KRAD ELECTRICAL MEASUREMENT	08/13/97
3) 10.0 KRAD IRRADIATION (0.125 KRADS/HOUR)	08/13/97
POST-10.0 KRAD ELECTRICAL MEASUREMENT	08/15/97
4) 15.0 KRAD IRRADIATION (0.125 KRADS/HOUR)	08/15/97
POST-15.0 KRAD ELECTRICAL MEASUREMENT	08/18/97
5) 214 HOUR ANNEALING @25°C	08/18/97
POST-214 HOUR ANNEAL ELECTRICAL MEASUREMENT	08/27/97
6) 20.0 KRAD IRRADIATION (0.125 KRADS/HOUR)	08/27/97
POST-20.0 KRAD ELECTRICAL MEASUREMENT	08/29/97
7) 30.0 KRAD IRRADIATION (0.250 KRADS/HOUR)	08/29/97
POST-30.0 KRAD ELECTRICAL MEASUREMENT	09/03/97
8) 50.0 KRAD IRRADIATION (0.500 KRADS/HOUR)	09/03/97
POST-50.0 KRAD ELECTRICAL MEASUREMENT	09/05/97
9) 100.0 KRAD IRRADIATION (0.625 KRADS/HOUR)	09/05/97
POST-100.0 KRAD ELECTRICAL MEASUREMENT	09/08/97
10) 168 HOUR ANNEALING @25°C	09/08/97
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	09/17/97

Effective Dose Rate = 100,000 RADS/29 DAYS=143.7 RADS/HOUR=0.040 RADS/SEC

The interim annealing following the 15.0 kRad step was added due to degradation in the parts. The addition of an interim annealing step better simulates the space environment's lower dose rate for very sensitive devices. This may allow the parts to show satisfactory performance at higher doses or indicate that the part can not be used beyond the previous dose level.

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

Table III. Electrical Characteristics of OP470 /1

Test #	Parameter	Units	Test Conditions /2	Spec. min	Lim. max
1	$+I_{DD}$	mA	No Load	0.0	11.0
2	$-I_{DD}$	mA	No Load	-11.0	0.0
3-6	Voh_2k	V		12.0	
7-10	Vol_2k	V			-12.0
11-14	Vio	mV		-0.4	0.4
15, 18, 21, 24	+Ibias	nA	V_{CM}=0V	-25.0	25.0
16, 19, 22, 25	-Ibias	nA	V_{CM}=0V	-25.0	25.0
17, 20, 23, 26	Iio	nA	V_{CM}=0V	-25.0	25.0
27-30	Avs_2k	V/mV	V_O=±10V, R_L=2kΩ	500	
31-34	Avs_10k	V/mV	V_O=±10V, R_L=10kΩ	1000	
35-38	psrr	µV	V_{CC}=±4.5V to ±18V		1.80
39-42	cmrr	dB	V_{CM}=IVR=±11V	110	
43-47	+SR	V	A_{VCL}=±20, R_L=10kΩ	1.4	
48-51	-SR	V	A_{VCL}=±20, R_L=10kΩ	1.4	

Note:

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

2/ For all tests, V_{CC} = ±15V, R_S = 50Ω unless otherwise specified.

TABLE IV: Summary of Electrical Measurements after Total Dose Exposures and Annealing for OP470 /1

Test #	Parameters	Units	Spec. Lim. /2 min	Spec. Lim. /2 max	Total Dose Exposure (kRads) Initial mean	Initial sd	5.0 mean	5.0 sd	10.0 mean	10.0 sd	15.0 mean	15.0 sd	Annealing /4 24 hours @25°C mean	Annealing /4 24 hours @25°C sd	Total Dose Exposure (kRads) 20.0 mean	20.0 sd	30.0 mean	30.0 sd	50.0 mean	50.0 sd	100.0 mean	100.0 sd	Annealing 168 hours @25°C mean	Annealing 168 hours @25°C sd
1	+Idd	mA	0.0	11.0	7.8	0.1	7.8	0.1	7.9	0.1	7.8	0.1	7.8	0.1	7.9	0.1	7.9	0.1	7.8	0.1	7.7	0	7.6	0.1
2	-Idd	mA	-11.0	0.0	-7.8	0.1	-7.8	0.1	-7.9	0.1	-7.8	0.1	-7.8	0.1	-7.9	0.1	-7.9	0.1	-7.8	0.1	-7.7	0	-7.6	0.1
3-6	Voh_2k	V	12.0		13.2	0	13.2	0	13.2	0.1	13.2	0	13.2	0	13.2	0.1	13.1	0	13.1	0	13.1	0	13.1	0
7-10	Vol_2k	V		-12.0	-13.3	0.05	-13.3	0	-13.3	0	-13.3	0	-13.3	0	-13.3	0	-13.2	0	-13.2	0	-13.2	0	-13.2	0.1
11-14	Vio	mV	-0.4	0.4	0.2	0	-0.2	0	-0.2	0	-0.2	0.03	-0.2	0.03	-0.2	0.03	-0.2	0.03	-0.2	0.03	-0.2	0.03	-0.2	0.03
A	+Ibias /3	nA	-25.0	25.0	7.6	0.8	10.8	0.9	13.8	1.3	14.2	1.7	19.4	1.4	20.7	1.9	31.7	4.3	54.3	10.2	135	14.0	118	13.8
B	-Ibias /3	nA	-25.0	25.0	-16.4	1.0	-17.6	1.1	-15.1	1.2	-15.4	1.8	-10.0	1.8	-6.8	2.0	15.1	5.4	40.4	9.2	128	16	106	14
C	Iio /3	nA	-25.0	25.0	-14.6	1.6	-9.4	1.8	6.6	8.3	11.7	3.2	17.9	0.8	17.8	0.8	23.9	2.3	24.0	1.8	21.4	2.9	19.7	2.2
27-30	Avs_2k	V/mV	500		3313	247	1938	180	1253	87	691	97	970	94	728	46	548	48	412	29	302	17	287	19
31-34	Avs_10k	V/mV	1000		1888	162	1488	105	1158	126	675	81	886	145	724	30	566	53	441	33	340	15	319	18
35-38	psrr	µV		1.80	0.15	0.10	0.13	0.10	0.07	0.11	-0.03	0.14	0.02	0.11	-0.06	0.12	-0.15	0.10	-0.22	0.12	-0.35	0.17	-0.31	0.18
39-42	cmrr	dB	110		113	2.0	114	3.4	115	4.1	114	3.1	112	3.1	112	1.2	114	4.8	114	3.5	113	2.5	114	4.8
43-47	+SR	V	1.4		1.6	0	1.6	0	1.6	0.1	1.5	0.06	1.5	0	1.5	0	1.5	0	1.5	0	1.4	0.03	1.4	0.06
48-51	-SR	V	1.4		1.6	0	1.6	0	1.6	0.1	1.5	0.06	1.5	0	1.5	0	1.5	0	1.5	0	1.4	0.06	1.4	0.03

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 manufacturer's pre-irradiation data sheet specification limits. No post-irradiation limits were provided by the manufacturer at the time the tests were performed.

3/ A represents tests 15, 18, 21, and 24. B represents tests 16, 19, 22, and 25. C represents tests 17, 20, 23, and 26.

4/ The interim annealing step was added due to degradation in the parts at this level. The addition of this interim annealing step better simulates the space environment's lower dose rate for very sensitive devices. This may allow parts to show satisfactory performance at higher doses or indicate that the part can not be used beyond the previous dose level.

Radiation sensitive parameters: +ibias, -ibias, iio, Avs_2k, Avs_10k.