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 SUBJECT: Radiation Report on: OP467  
           Project: MIDEX/MAP  
           Job #: EE71381  
           Project part #: OP467

PPM-97-021

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A radiation evaluation was performed on OP467 (S962-9325801MCA) 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<sup>60</sup> gamma ray source. During the radiation testing, six 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, 5.0, 7.5, 10.0, 15.0, 20.0, 30.0 and 50.0 kRads.\* The dose rate was between 0.06 and 0.250 kRads/hour (see Table II for radiation schedule). 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, except for slew rate. See the note for slew rate test in tables III and IV.

Initial electrical measurements were made on 8 samples. Six samples (SN's 22, 23, 24, 25, 26, and 27) were used as radiation samples while SN's 20 and 21 were used as control samples. All parts passed all tests during initial electrical measurements.

After the 2.5 kRad irradiation, SN's 25, 26 and 27 exceeded the specification limit for iio3 with readings of 109, 136, and 121nA respectively, against the specification limit of 100nA. SN 24 marginally exceeded the specification limit for iio4 with a reading of 102nA, against the specification limit of 100nA. **All parts passed all other tests.**

After the 5.0 kRad irradiation, SN 22 marginally exceeded the specification limit for iio2 and iio3 with readings of 115nA and 103nA respectively. SN's 25 and 26 exceeded the specification limit for iio4 with readings of 118nA and 126nA respectively against the specification limit of 100nA. **All parts passed all other tests.**

After the 7.5 kRad irradiation, SN 22 marginally exceeded the specification limit for iio3 with a reading of 107nA. SN's 25 and 26 exceeded the specification limit for iio4 with readings of 158nA and 134nA respectively. **All parts passed all other tests.**

After the 10.0 kRad irradiation, SN 22 exceeded the specification limit for iio2 with a reading of 127nA. SN's 22, 24 and 26 exceeded the specification limit for iio3 with readings of 145, 128, and 130nA respectively. SN's 25 and 26 exceeded the specification limit for iio4 with readings of 166nA and 161nA respectively. **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 15.0 kRad irradiation, SN 26 exceeded the specification limit for iio3 with a reading of 187nA. SN's 24 and 25 exceeded the specification limit for iio4 with readings of 102nA and 156nA respectively. **All parts passed all other tests.**

After the 20.0 kRad irradiation, all parts except SN 27 exceeded the specification limits for +ibias and -ibias. Readings were within the ranges of 614 to 977nA and 604 to 937nA respectively against the specification limit of 600nA. SN 22 exceeded the specification limits for iio2 and iio3 with readings of 171 and 198nA respectively. SN's 24, 25 and 26 exceeded the specification limit for iio4 with readings of 160, 158, and 141nA. **All parts passed all other tests.**

After the 30.0 kRad irradiation, SN 25 fell marginally below the specification limit of -13.0V for Vol<sub>t</sub>\_2k with a reading of -12.9V. All parts exceeded the specification limit for +ibias with readings in the range of 605 to 835nA. All parts except SN 27 exceeded the specification limit for -ibias with readings in the range of 614 to 963nA. SN 22 exceeded the specification limits for iio2, iio3, and iio4 with readings of 175, 170, and 117nA respectively. SN 25 exceeded the specification limit for iio4 with a reading of 190nA. **All parts passed all other tests.**

After the 50.0 kRad irradiation, SN's 22 and 23 marginally exceeded the specification limit of 10.0mA for +Idd with readings of 10.4 and 10.1mA respectively. SN's 22 and 25 marginally fell below the specification limit of -10.0mA for -Idd with readings of -10.2mA for both. All parts exceeded the specification limit for Vol\_2k with readings in the range of -9.9 to -12.8V. All parts showed significant degradation in both +ibias and -ibias with readings in the range of 708 to 1196nA. SN 22 exceeded the specification limit for iio2 with a reading of 161nA. SN's 22 and 24 exceeded the limit for iio3 with readings of 212nA and 158nA respectively. SN's 24, 25 and 26 exceeded the specification limit for iio4 with readings of 104, 208, and 127nA. **All parts passed all other tests.**

After annealing the parts for 168 hours at 25°C, parts showed some recovery in the +Ibias and -Ibias tests with readings in the range of 420 to 749nA for both. All other parameters were much the same as at 50.0 kRads.

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.

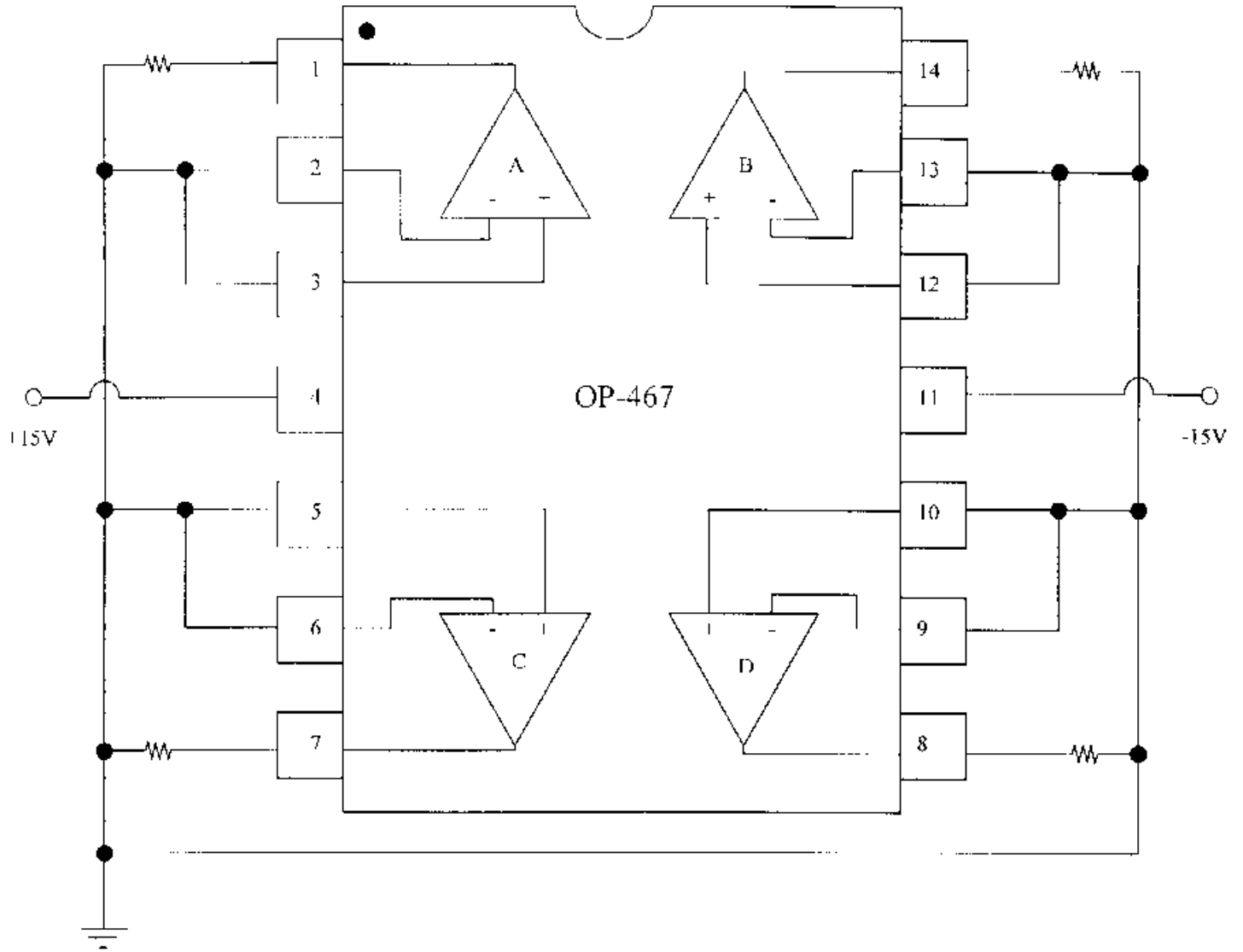
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Figure 1 Radiation Bias Circuit for OP467



Pin Connection List.

- |          |          |           |        |           |           |           |
|----------|----------|-----------|--------|-----------|-----------|-----------|
| 1: OUT A | 2: -IN A | 3: +IN A  | 4: V-  | 5: +IN B  | 6: -IN B  | 7: OUT B  |
| 8: OUT C | 9: -IN C | 10: +IN C | 11: V- | 12: +IN D | 13: -IN D | 14: OUT D |

Note: R - 15kΩ, ±10%, ½ W.

TABLE I. Part Information

Generic Part Number:	OP467
MIDEX/MAP Part Number	5962-9325801MCA
Charge Number:	EE78118
Manufacturer:	Analog Devices
Lot Date Code (LDC):	9647A
Quantity Tested:	8
Serial Number of Control Samples:	20, 21
Serial Numbers of Radiation Samples:	22, 23, 24, 25, 26, and 27
Part Function:	Quad OP-AMP
Part Technology:	Bipolar
Package Style:	14 Pin LCC
Test Equipment:	A540
Test Engineer:	A. Najj

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

TABLE II. Radiation Schedule for OP467

EVENT.....	DATE.....
1) INITIAL ELECTRICAL MEASUREMENTS.....	04/02/97
2) 2.5 KRAD IRRADIATION (0.062 KRADS/HOUR) .....	05/02/97
POST-2.5 KRAD ELECTRICAL MEASUREMENT .....	05/05/97
3) 5 KRAD IRRADIATION (0.062 KRADS/HOUR) .....	05/05/97
POST-5 KRAD ELECTRICAL MEASUREMENT .....	05/08/97
4) 7.5 KRAD IRRADIATION (0.062 KRADS/HOUR) .....	05/08/97
POST-7.5 KRAD ELECTRICAL MEASUREMENT .....	05/12/97
5) 10.0 KRAD IRRADIATION (0.062 KRADS/HOUR) .....	05/12/97
POST-10.0 KRAD ELECTRICAL MEASUREMENT .....	05/14/97
6) 15.0 KRAD IRRADIATION (0.125 KRADS/HOUR) .....	05/14/97
POST-15.0 KRAD ELECTRICAL MEASUREMENT .....	05/16/97
7) 20.0 KRAD IRRADIATION (0.125 KRADS/HOUR) .....	05/16/97
POST-20.0 KRAD ELECTRICAL MEASUREMENT .....	05/19/97
8) 30.0 KRAD IRRADIATION (0.250 KRADS/HOUR) .....	05/19/97
POST-30.0 KRAD ELECTRICAL MEASUREMENT .....	05/21/97
9) 50.0 KRAD IRRADIATION (0.250 KRADS/HOUR) .....	05/21/97
POST-50.0 KRAD ELECTRICAL MEASUREMENT .....	05/23/97
10) 168 HOUR ANNEALING @25°C .....	05/23/97
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT .....	06/05/97

Effective Dose Rate – 50,000 RADS/28DAYS – 74.4 RADS/HOUR–0.021 RADS/SEC

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

Table III. Electrical Characteristics of OP467 /1

Test #	Parameter /2	Units	Test Conditions	Spec. min	Lim. max
1	+I <sub>dd</sub>	mA	V <sub>CC</sub> = +5V, +15V, V <sub>OUT</sub> = 0V	0.0	10.0
2	-I <sub>dd</sub>	mA	V <sub>CC</sub> = -5V, -15V, V <sub>OUT</sub> = 0V	-10.0	0.0
3-6	V <sub>oh_2k</sub>	V	R <sub>L</sub> = 2k $\Omega$	13.0	-
7-10	V <sub>ol_2k</sub>	V	R <sub>L</sub> = 2k $\Omega$	-	-13.0
11-14	V <sub>io</sub>	mV	V <sub>CC</sub> = $\pm$ 5V, $\pm$ 15V	-0.5	0.5
15-18	+I <sub>bias</sub>	nA	V <sub>CC</sub> = +5V, +15V, V <sub>CM</sub> = 0V	-600	600
19-22	-I <sub>bias</sub>	nA	V <sub>CC</sub> = -5V, -15V, V <sub>CM</sub> = 0V	-600	600
23-26	I <sub>io</sub>	nA	V <sub>CC</sub> = $\pm$ 5V, $\pm$ 15V, V <sub>CM</sub> = 0V	-100	100
27-30	A <sub>vs_2k</sub>	V/mV	V <sub>CC</sub> = $\pm$ 5V, $\pm$ 15V, R <sub>L</sub> = 2k $\Omega$	14.2	-
31-34	PSRR	dB	V <sub>CC</sub> = $\pm$ 4.5V to $\pm$ 18V	96	-
35-38	CMRR	dB	V <sub>CC</sub> = $\pm$ 15V, V <sub>CM</sub> = $\pm$ 12V	80	-
39-42	SR /3	V/ $\mu$ s	V <sub>CC</sub> = $\pm$ 15V, A <sub>v</sub> = $\pm$ 1, V <sub>IN</sub> = 10V step, R <sub>L</sub> = 2k $\Omega$ C <sub>L</sub> = 30pF, T <sub>A</sub> = +25 $^{\circ}$ C	125	-

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.

V<sub>io</sub> = input offset voltage, I<sub>io</sub> = input offset current.

2/ For the tests beginning with V<sub>oh\_2k</sub>, the tests indicated were combined for simplicity. Since this is a quad OPAMP, each OPAMP is tested for each specific parameter with exactly the same test conditions.

3/ Slew rate measurements were added after the 2.5 kRad exposure.

**TABLE IV: Summary of Electrical Measurements after Total Dose Exposures and Annealing for OP467 /1**

Test #	Parameters /3	Units	Spec. Lim. /2	Total Dose Exposure (kRads)												Annealing						
				2.5		5.0		7.5		10.0		15.0		20.0		30.0		50.0		165 hours @ 25°C		
				mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	
1	+Idd	mA	0.0	10.0	9.3	0.2	9.3	0.2	9.3	0.2	9.3	0.1	9.3	0.2	9.3	0.2	9.4	0.2	9.9	0.3	9.5	0.2
2	-Idd	mA	-10.0	0.0	-9.4	0.2	-9.4	0.2	-9.4	0.2	-9.3	0.2	-9.4	0.2	-9.3	0.2	-9.5	0.1	-9.9	0.3	-9.7	0.2
3-6	Voh_2k	V	13.0		13.4	0	13.4	0.05	13.3	0.07	13.2	0.1	13.3	0.05	13.3	0.04	13.3	0.04	13.3	0	13.4	0.05
7-10	Vol_2k	V		-13.0	-13.6	0.05	-13.6	0.05	-13.6	0.05	-13.6	0.08	-13.6	0.04	-13.6	0.04	-13.5	0.07	-12.4	0.4	-12.4	0.3
11-14	Vio	mV	-0.5	0.5	0.2	0	0.2	0	0.2	0	0.2	0	0.2	0	0.2	0	0.2	0	0.3	0.04	0.3	0.04
15-18	+Ibias /4	nA	-600	600	77	24	36	11	65	40	150	29	219	40	330	29	648	66	855	67	520	34
19-22	-Ibias /4	nA	-600	600	84	37	51	8	72	41	163	51	238	34	362	48	658	106	932	99	536	36
26-26	Iio /4	nA	-100	100	39	8.8	60	11	53	16	56	19	70	22	63	18	71	23	69	26	64	17
27-30	Avs_2k	V/mV	14.2		246	0.7	123	0.8	122	0.6	121	0.6	121	0.6	120	0.4	119	0.5	118	0.7	119	0.4
31-34	PSRR	dB	96		122	1.2	123	1.1	124	1.6	128	0.9	133	2.9	132	1.8	67		67		67	
35-38	CMRR	dB	80		100	0.9	100	0.4	100	0.7	101	1.1	100	0.4	100	2.1	100	0.7	97	6.2	90	5.9
39-42	+SR /5	V/us	125						193	78	153	7.0	160	8.0	161	7.4	159	4.7	163	5.9	158	5.8

**Notes**

- 1/ The mean and standard deviation values were calculated over the six 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/ For each parameter beginning with Voh\_2k, four measurements were made, one for each OPAAMP in the quad pack OP467. The values listed here are the mean and standard deviation over all four measurements.
- 4/ The data analysis for these parameters is based on the absolute value of the measurement. This allows a much more meaningful interpretation of the data.
- 5/ Slow rate measurements were added after the 2.5 kRad exposure
- 6/ No reliable measurements were possible for this parameter at this level.

**Radiation sensitive parameters: +Idd, Voh\_2k, -Ibias, Iio, PSRR.**