Unisys

DATE: November 03, 1998 PPM-99-004
TO: S Hull/562
FROM: K. Sahu/S. Kniffin/300.1
SUBJECT: Radiation Report on **OP467 (Analog Devices) (LDC 9812A)**
PROJECT: IRAC

cc: R. Williams/722.0, R. Reed/562, A. Sharma/562, OFA Library/300.1

A radiation evaluation was performed on **OP467 (M5962/9325801MCA) Quad Precision, High Speed Operational Amplifier (Analog Devices)** to determine the total ionizing dose (TID) tolerance of these parts. The TID 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 2.5, 5.0, 10.0, 15.0, 20.0, 30.0, and 50.0kRads.[1] The dose rate was 0.149kRads/hour (0.04 Rads/s). See Table II for the radiation schedule and effective dose rate calculation. After the 50.0kRad irradiation, the parts were annealed under bias at 25°C for 168 hours.[2] After each radiation exposure and annealing treatment, parts were electrically tested according to the test conditions and the specification limits[3] listed in Table III.

An executive summary of the test results is provided below in bold, followed by a detailed summary of the test results after each radiation level and annealing step. For detailed information, refer to Tables I through IV and Figures 1 and 2.

All parts passed all tests up to 10kRads with no significant degradation observed in any parameter. All parts showed degradation in all +Ib and -Ib measurements from 15 to 50kRads. The parts showed marginal degradation in Icc and some degradation in all Voh_2k measurements with a specification limit of -13.0V at 30 and 50kRads. After annealing for 168 hours at 25°C, the parts showed complete recovery in Icc, some recovery in +Ib and -Ib, and significant recovery in Voh_2k. Figure 2 shows the degradation of Ib with increasing TID and annealing.

Initial electrical measurements were made on 10 samples. Eight samples (SN's 8, 9, 10, 11, 12, 13, 14, and 15) were used as radiation samples while SN's 6 and 7 were used as control samples. All parts passed all tests during initial electrical measurements.

All parts passed all tests up to 10kRads.

After the 15.0kRad irradiation, some parts exceeded the specification limit of 600nA for all of the +Ib and -Ib tests with readings in the range of 602 to 635nA for all. **All parts passed all other tests.**

After the 20.0kRad irradiation, all parts exceeded the specification limit for all of the +Ib and -Ib tests with readings in the range of 608 to 728nA for all. **All parts passed all other tests.**

After the 30.0kRad irradiation, four parts marginally exceeded the specification limit of 10.0mA for Icc with readings in the range of 10.3 to 14.5mA. All parts exceeded the specification limit all of the +Ib and -Ib tests with readings in the range of 644 to 835nA for all. Some parts exceeded the specification limit of -13.0V for all Voh_2k measurements (with this specification limit, see Table 4) with readings in the range of -12.5 to -12.0V. **All parts passed all other tests.**

[1] The term Rads, as used in this document, means Rads (silicon). All radiation levels cited are cumulative.
[2] The temperature 25°C as used in this document implies room temperature.
[3] These are manufacturer's pre-irradiation data specification limits. The manufacturer provided no post-irradiation limits at the time these tests were performed.

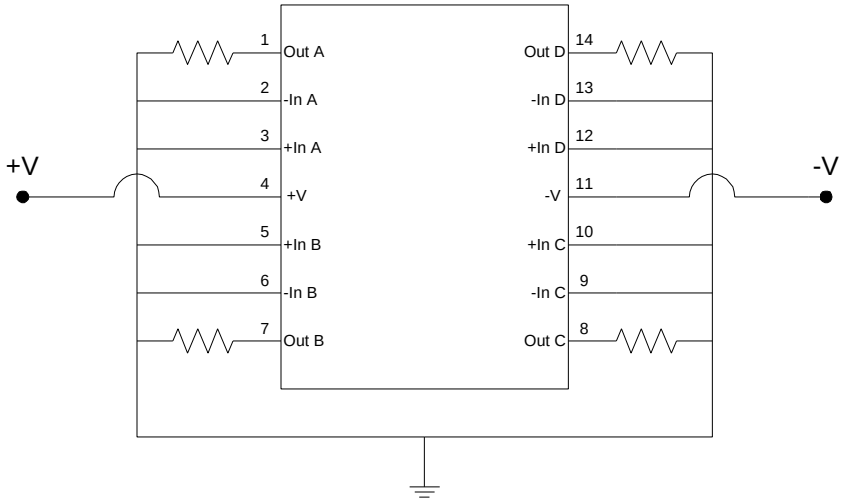
After the 50.0kRad irradiation, four parts marginally exceeded the specification limit for Icc with readings in the range of 11.1 to 16.7mA. All parts exceeded the specification limit all of the +Ib and -Ib tests with readings in the range of 750 to 956nA for all. All parts exceeded the specification limit for all Voh_2k measurements (with this specification limit, see Table 4) with readings in the range of -11.6 to -9.9V. **All parts passed all other tests.**

After annealing the parts for 168 hours at 25°C, the parts showed complete recovery in Icc with all parts passing. All parts showed some recovery in +Ib and -Ib, however al parts continued to exceed the specification limits for all Ib tests. Most parts showed significant recovery in Voh_2k with most parts passing all Voh_2k tests.

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 us at (301) 731-8954.

Figure 1. Radiation Bias Circuit for OP467



Notes:
1. V_{CC} = +15V ±0.5V, V_{SS} = -15V ±0.5V.
2. R = 15kΩ ±10%, ½W.

TABLE I. Part Information

Generic Part Number:	OP467
IRAC Part Number:	M5962/9325801MCA
Charge Number:	M88565
Manufacturer:	Analog Devices
Lot Date Code (LDC):	9812A
Quantity Tested:	10
Serial Number of Control Samples:	6, 7
Serial Numbers of Radiation Samples:	8, 9, 10, 11, 12, 13, 14, and 15
Part Function:	Quad Precision, High Speed Op Amp
Part Technology:	Bipolar
Package Style:	14 Pin Dip
Test Equipment:	A540
Test Engineer:	A. Duvalsaint

- The manufacturer for this part guaranteed no radiation tolerance/hardness.

TABLE II. Radiation Schedule for OP467

EVENT	DATE
1) INITIAL ELECTRICAL MEASUREMENTS	10/05/98
2) 2.5 KRAD IRRADIATION (0.038 KRADS/HOUR)	10/05/98
POST-2.5 KRAD ELECTRICAL MEASUREMENT	10/06/98
3) 5.0 KRAD IRRADIATION (0.147 KRADS/HOUR)	10/06/98
POST-5.0 KRAD ELECTRICAL MEASUREMENT	10/07/98
4) 10.0 KRAD IRRADIATION (0.121 KRADS/HOUR)	10/07/98
POST-10.0 KRAD ELECTRICAL MEASUREMENT	10/09/98
5) 15.0 KRAD IRRADIATION (0.121 KRADS/HOUR)	10/09/98
POST-15.0 KRAD ELECTRICAL MEASUREMENT	10/13/98
6) 20.0 KRAD IRRADIATION (0.077 KRADS/HOUR)	10/13/98
POST-20.0 KRAD ELECTRICAL MEASUREMENT	10/15/98
7) 30.0 KRAD IRRADIATION (0.244 KRADS/HOUR)	10/15/98
POST-30.0 KRAD ELECTRICAL MEASUREMENT	10/19/98
8) 50.0 KRAD IRRADIATION (0.488 KRADS/HOUR)	10/19/98
POST-50.0 KRAD ELECTRICAL MEASUREMENT	10/21/98
9) 168 HOUR ANNEALING @25°C	10/21/98
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	10/28/98

Effective Dose Rate = 50,000 RADS/14 DAYS=148.8 RADS/HOUR=0.04 RADS/SEC
The effective dose rate is lower than that of the individual radiation steps as it takes into account the time needed to test the parts.

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

Table III. Electrical Characteristics of OP467 /1

Test #	Parameter	Units	Test Conditions /2	Spec. Lim. min	Spec. Lim. max
1	Icc	mA			10.0
2	Out_A	mV		-500	500
3	Out_B	mV		-500	500
4	Out_C	mV		-500	500
5	Out_D	mV		-500	500
6	+Ib_A	nA	V_{CM} = 0V	-3	600
7	-Ib_A	nA	V_{CM} = 0V	-3	600
8	Ios_A	nA	V_{CM} = 0V	-100	100
9	+Ib_B	nA	V_{CM} = 0V	-3	600
10	-Ib_B	nA	V_{CM} = 0V	-3	600
11	Ios_B	nA	V_{CM} = 0V	-100	100
12	+Ib_C	nA	V_{CM} = 0V	-3	600
13	-Ib_C	nA	V_{CM} = 0V	-3	600
14	Ios_C	nA	V_{CM} = 0V	-100	100
15	+Ib_D	nA	V_{CM} = 0V	-3	600
16	-Ib_D	nA	V_{CM} = 0V	-3	600
17	Ios_D	nA	V_{CM} = 0V	-100	100
18	P_PSRR_A	dB	V_S = ±4.5V to ±18V	96	
19	P_PSRR_B	dB	V_S = ±4.5V to ±18V	96	
20	N_PSRR_C	dB	V_S = ±4.5V to ±18V	96	
21	N_PSRR_D	dB	V_S = ±4.5V to ±18V	96	
22	CMRR_A	dB	V_{CM} = ±12V	80	
23	CMRR_B	dB	V_{CM} = ±12V	80	
24	CMRR_C	dB	V_{CM} = ±12V	80	
25	CMRR_D	dB	V_{CM} = ±12V	80	
26	Gain_2k_A	dB	V_O = ±10V, R_L = 2kW	83	
27	Gain_2k_B	dB	V_O = ±10V, R_L = 2kW	83	
28	Gain_2k_C	dB	V_O = ±10V, R_L = 2kW	83	
29	Gain_2k_D	dB	V_O = ±10V, R_L = 2kW	83	
30	Voh_2k_A	V	R_L = 2kW	13.0	
31	Voh_2k_A	V	R_L = 2kW		-13.0
32	Voh_2k_B	V	R_L = 2kW	13.0	
33	Voh_2k_B	V	R_L = 2kW		-13.0
34	Voh_2k_C	V	R_L = 2kW	13.0	
35	Voh_2k_C	V	R_L = 2kW		-13.0
36	Voh_2k_D	V	R_L = 2kW	13.0	
37	Voh_2k_D	V	R_L = 2kW		-13.0
38	Slew Rate A	V/ms	V_{IN} = 10V Step, R_L = 2kW, C_L = 30pF, A_V = +1	125	
39	Slew Rate B	V/ms	V_{IN} = 10V Step, R_L = 2kW, C_L = 30pF, A_V = +1	125	
40	Slew Rate C	V/ms	V_{IN} = 10V Step, R_L = 2kW, C_L = 30pF, A_V = +1	125	
41	Slew Rate D	V/ms	V_{IN} = 10V Step, R_L = 2kW, C_L = 30pF, A_V = +1	125	

Notes:

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

2/ V_S = ±15V unless otherwise specified.

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

					Total Dose Exposure (kRads Si)																Annealing	
					Initial		2.5		5.0		10.0		15.0		20.0		30.0		50.0		168 hours @25°C	
Test #	Parameters	Units	Spec. Lim. /2 min	Spec. Lim. /2 max	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
1	Icc	mA		10.0	7.3	0.5	7.5	0.3	7.5	0.3	8.1	0.2	8.1	0.3	7.7	0.4	10.0	2.8	11.5	3.0	8.8	0.1
2	Out_A	?V	-500	500	17	271	-138	145	-184	36	-181	24	-190	41	-194	45	-215	36	-222	28	-22	4
3	Out_B	?V	-500	500	14	275	-136	145	-174	19	-193	35	-180	27	-197	41	-225	31	-235	31	-20	5
4	Out_C	?V	-500	500	17	271	-143	148	-182	31	-191	33	-196	43	-189	30	-227	29	-236	30	-23	8
5	Out_D	?V	-500	500	10	278	-149	152	-188	44	-192	36	-194	47	-193	36	-214	34	-232	38	-15	4
6	+Ib_A	nA	-3.0	600	129	38	221	37	312	43	464	44	575	44	659	47	746	52	865	60	675	51
7	-Ib_A	nA	-3.0	600	135	34	228	34	320	36	467	37	589	39	675	36	767	40	903	44	692	40
8	Ios_A	nA	-100	100	-6	11	-8	10	-8	13	-13	16	-14	15	-16	20	-22	22	-38	30	-18	20
9	+Ib_B	nA	-3.0	600	128	38	220	38	312	43	462	45	575	44	659	46	745	52	864	59	675	51
10	-Ib_B	nA	-3.0	600	134	35	228	33	321	37	476	38	590	40	676	37	767	39	904	45	692	40
11	Ios_B	nA	-100	100	-6	9	-8	10	-9	15	-14	12	-15	16	-17	20	-22	24	-40	29	-17	19
12	+Ib_C	nA	-3.0	600	129	38	221	38	312	43	462	45	575	44	659	46	745	52	864	59	675	51
13	-Ib_C	nA	-3.0	600	135	34	227	33	319	37	475	38	590	40	676	37	767	39	903	45	692	41
14	Ios_C	nA	-100	100	-6	11	-7	10	-7	12	-13	15	-15	16	-17	21	-22	23	-39	29	-18	19
15	+Ib_D	nA	-3.0	600	128	38	220	38	312	42	462	45	575	44	659	46	745	52	864	59	675	51
16	-Ib_D	nA	-3.0	600	134	35	228	33	320	38	476	38	590	39	676	37	769	40	904	45	696	47
17	Ios_D	nA	-100	100	-6	9	-8	10	-9	12	-13	15	-15	16	-17	19	-23	23	-40	30	-21	20
18	P_PSRR_A	dB	96		112	2	113	2	113	2	114	3	116	3	115	1	113	2	111	1	116	3
19	P_PSRR_B	dB	96		113	1	114	2	114	3	114	2	116	3	114	3	113	2	111	1	117	2
20	N_PSRR_C	dB	96		113	3	114	4	114	1	115	2	116	2	116	5	113	2	111	1	113	1
21	N_PSRR_D	dB	96		113	1	113	2	115	4	115	2	116	4	115	2	113	2	111	1	111	1
22	CMRR_A	dB	80		110	15	113	16	105	8	106	11	109	8	114	14	106	7	102	5	104	7
23	CMRR_B	dB	80		99	4	114	15	103	5	107	8	102	5	104	10	107	12	107	6	101	7
24	CMRR_C	dB	80		106	12	108	10	108	11	110	14	103	9	104	11	109	12	108	7	108	12
25	CMRR_D	dB	80		106	5	103	7	108	10	105	6	107	8	107	6	105	7	109	9	117	15
26	Gain_2k_A	dB	83		101	2	109	19	100	1	107	8	108	6	101	1	109	9	106	6	105	7
27	Gain_2k_B	dB	83		101	1	100	1	101	1	102	3	102	6	101	2	105	7	103	4	112	7
28	Gain_2k_C	dB	83		101	1	101	1	101	1	100	1	100	1	102	1	101	1	101	1	115	13
29	Gain_2k_D	dB	83		100	1	100	1	100	1	100	1	99	1	100	1	101	2	101	1	113	5
30	Voh_2k_A	V	13.0		13.8	0	13.8	0	13.8	0	13.7	0	13.7	0	13.8	0	13.8	0	13.8	0	13.1	0.2
31	Voh_2k_A	V		-13.0	-13.4	0	-13.4	0	-13.4	0	-13.4	0	-13.4	0	-13.4	0	-12.9	0.5	-10.7	0.6	-13.0	0.7
32	Voh_2k_B	V	13.0		13.8	0	13.8	0	13.8	0	13.7	0	13.7	0	13.8	0	13.8	0	13.8	0	13.3	0
33	Voh_2k_B	V		-13.0	-13.4	0	-13.4	0	-13.4	0	-13.4	0	-13.4	0	-13.4	0	-12.9	0.5	-10.7	0.6	-13.1	0.4
34	Voh_2k_C	V	13.0		13.8	0	13.8	0	13.8	0	13.7	0	13.7	0	13.8	0	13.8	0	13.8	0	13.2	0
35	Voh_2k_C	V		-13.0	-13.4	0	-13.4	0	-13.4	0	-13.4	0	-13.4	0	-13.4	0	-12.9	0.5	-10.7	0.6	-13.4	0
36	Voh_2k_D	V	13.0		13.8	0	13.8	0	13.8	0	13.7	0	13.7	0	13.8	0	13.8	0	13.8	0	13.3	0
37	Voh_2k_D	V		-13.0	-13.4	0	-13.4	0	-13.4	0	-13.4	0	-13.4	0	-13.4	0	-12.9	0.5	-10.7	0.6	-13.3	0.1
38	Slew Rate A	V/ms	125		195	7	256	8	252	4	250	5	251	4	253	4	248	8	253	4	265	6
39	Slew Rate B	V/ms	125		191	11	254	6	253	5	249	7	252	7	253	6	252	8	258	6	266	7
40	Slew Rate C	V/ms	125		184	11	255	7	253	4	249	5	252	4	252	5	253	5	255	4	264	5
41	Slew Rate D	V/ms	125		186	10	254	4	255	4	254	4	254	4	256	4	255	5	255	4	264	6

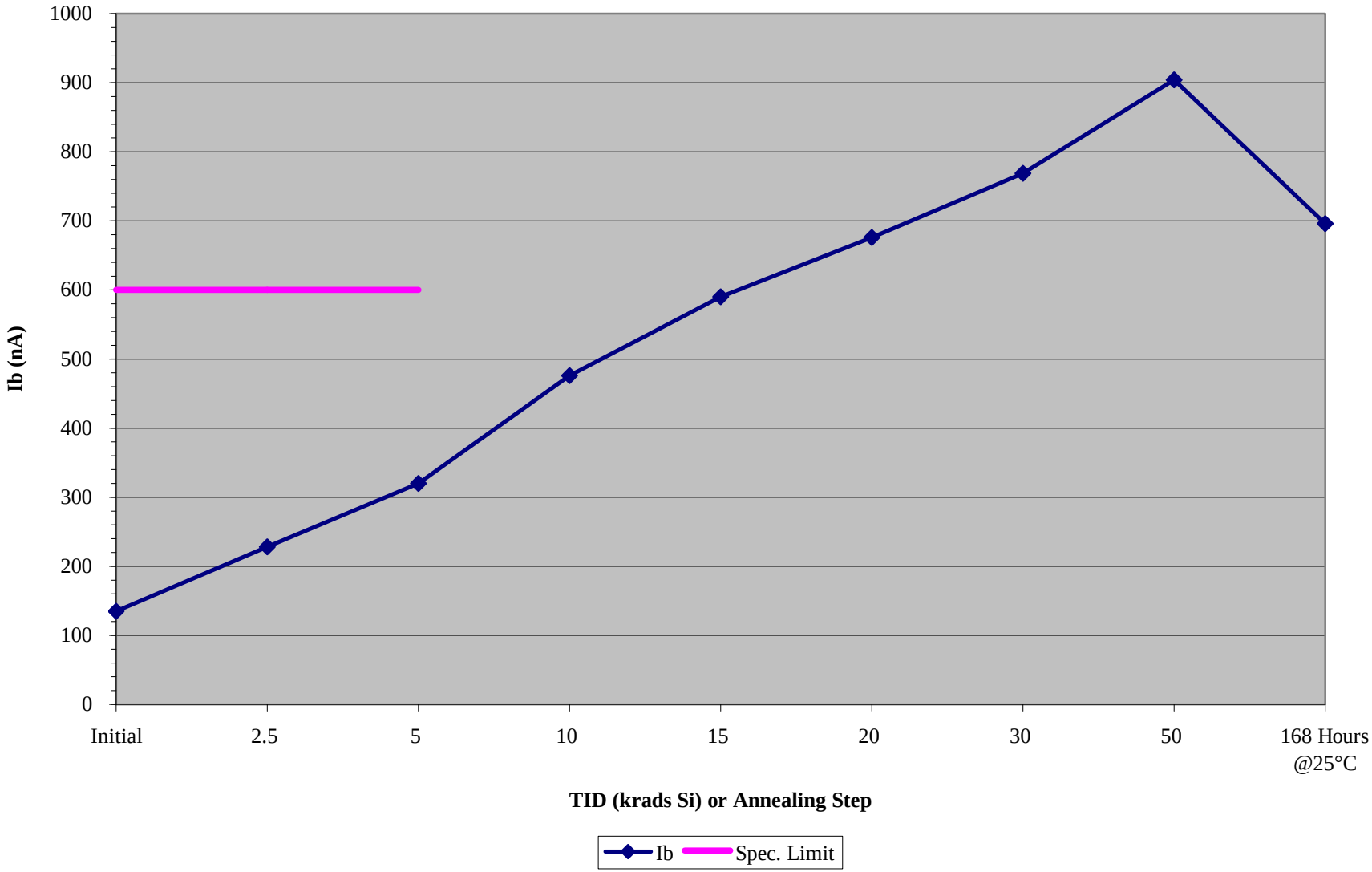
Notes:

1/ The mean and standard deviation values were calculated over the eight parts irradiated in this testing. The control samples remained constant throughout testing and are not included in this t

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 perform

Radiation sensitive parameters: +Ib, -Ib, Icc, Voh_2k.

Figure 2: Ib vs Total Ionizing Dose (kRads Si) for OP467



The values of Ib shown correspond to the one of the four OpAmps that had the most degradation at that TID or annealing step.