Unisys

DATE: January 08, 1999 PPM-99-002
TO: S Hull/562
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SUBJECT: Radiation Report on **LF147 (National Semiconductor) (LDC 9803)**
PROJECT: IRAC

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

A radiation evaluation was performed on **AD780 (M38510/11906BCA) Wide Bandwidth Quad JFET Input Op Amps (National Semiconductor)** 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 at the effective dose rate of 83Rads/hr (0.02R/s) and four more parts were irradiated at the effective dose rate of 15Rads/hr (0.004R/s). (See Figure 1 for bias configuration.) Two parts were used as control samples. The TID radiation levels were 2.5, 5.0, 7.5, 10.0, 15.0, 20.0, 30.0, and 50.0kRads at the higher dose rate and 2.5, 5.0, 7.5, and 10.0kRads for the lower dose rate.[1] See Table IIA and IIB for the radiation schedules and effective dose rate calculations. At the higher dose rate, the parts were annealed under bias for 72 hours at 25°C after the 5.0kRad irradiation and for 168 hours at 25°C after the 50kRad irradiation. At the lower dose rate, the parts were annealed under bias for 168 hours at 25°C after the 10kRad irradiation.[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 Figure 1.

Under the higher dose rate (0.02R/s), all parts passed all electrical tests initially and up to 2.5kRads. After 5kRads the parts showed excessive degradation in all parameters (including Ibias, Slew Rate, PSRR, etc.). After annealing the parts for 72 hours at 25°C, all parts recovered to within specification limits on all tests. Also, the parts passed all tests from 7.5 to 50kRads. All parts showed no significant change after annealing for 168 hours at 25°C.

The excessive degradation at 5kRads was rather surprising since no degradation occurred at higher total doses up to 50kRads. Therefore, this testing was followed by the testing of four more samples at a lower dose rate (0.004R/s) to determine the suitability of these parts for use in the space environment. Under lower dose rate testing, all parts passed all electrical tests initially and upon irradiation to 10kRads. All parts showed no significant change in any parameter after annealing for 168 hours at 25°C.

Initial electrical measurements were made on 10 samples. Eight samples (SN's 7, 8, 9, 10, 11, 12, 13, and 14) were used as radiation samples at the higher dose rate and four samples (SN's 380, 381, 382, and 383) were used at the lower dose rate while SN's 5 and 6 were used as control samples. All parts passed all tests during initial electrical measurements.

Higher Dose Rate Test Results (0.02R/s)

[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.

All parts passed all tests up to 2.5kRads.

After the 5.0kRad irradiation, all parts fell outside the specification limits for all tests.

After annealing the parts for 72 hours at 25°C, the parts recovered to within the specification limits on all tests.

All parts passed all tests from 7.5kRads to 50.0kRads.

After annealing the parts for 168 hours at 25°C, the parts showed no significant change in any parameter.

Lower Dose Rate Test Results (0.004R/s)

This lower dose rate testing was performed to ensure that the failures seen at 5kRads under the higher dose rate of 0.02R/s did not occur at the lower dose rate of the space environment.

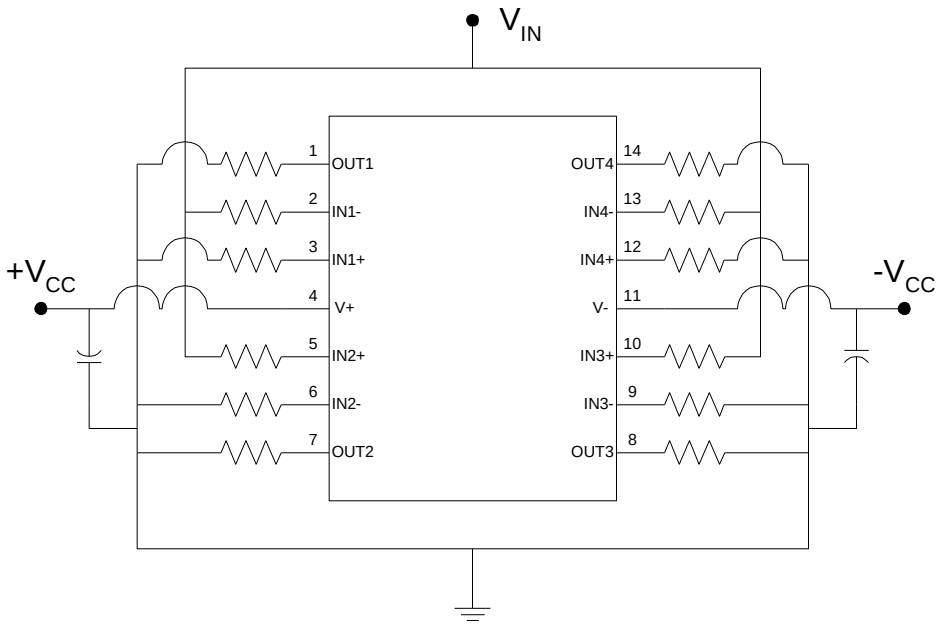
All parts passed all tests up to 10kRads.

After annealing the parts for 168 hours at 25°C, the parts showed no significant change in any parameter.

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 LF147



Notes:
1. $+V_{CC}$ = +15.0V ±0.5V, $-V_{CC}$ = -15.0V ±0.5V, V_{IN} = +1.0V ±0.1V.
2. All R = 10kΩ ±5%, ¼W.
3. All C = 0.01µf, 50VDC.

TABLE I. Part Information

Generic Part Number:	LF147
IRAC Part Number:	LF147 (M38510/11906BCA)
Charge Number:	M88552
Manufacturer:	National Semiconductor
Lot Date Code (LDC):	9803
Quantity Tested:	14
Serial Number of Control Samples:	5, 6
Serial Numbers of Radiation Samples:	7, 8, 9, 10, 11, 12, 13, 14 (HDR), 380, 381, 382, 383 (LDR)
Part Function:	Wide Bandwidth Quad JFET Input Op Amps
Part Technology:	JFET
Package Style:	14 Pin DIP
Test Equipment:	A540
Test Engineer:	A. Duvalsaint

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

TABLE IIA. Radiation Schedule for LF147 (Higher Dose Rate)

EVENT	DATE
1) INITIAL ELECTRICAL MEASUREMENTS	10/29/98
2) 2.5 KRAD IRRADIATION (0.147 KRADS/HOUR)	10/29/98
POST-2.5 KRAD ELECTRICAL MEASUREMENT	10/30/98
3) 5.0 KRAD IRRADIATION (0.039 KRADS/HOUR)	10/30/98
POST-5.0 KRAD ELECTRICAL MEASUREMENT	11/02/98
4) 72 HOUR ANNEALING @25°C	11/02/98
POST-72 HOUR ANNEAL ELECTRICAL MEASUREMENT	11/05/98
5) 7.5 KRAD IRRADIATION (0.084 KRADS/HOUR)	11/05/98
POST-7.5 KRAD ELECTRICAL MEASUREMENT	11/09/98
6) 10.0 KRAD IRRADIATION (0.031 KRADS/HOUR)	11/09/98
POST-10.0 KRAD ELECTRICAL MEASUREMENT	11/12/98
7) 15.0 KRAD IRRADIATION (0.056 KRADS/HOUR)	11/12/98
POST-15.0 KRAD ELECTRICAL MEASUREMENT	11/16/98
8) 20.0 KRAD IRRADIATION (0.125 KRADS/HOUR)	11/16/98
POST-20.0 KRAD ELECTRICAL MEASUREMENT	11/18/98
9) 30.0 KRAD IRRADIATION (0.250 KRADS/HOUR)	11/18/98
POST-30.0 KRAD ELECTRICAL MEASUREMENT	11/20/98
10) 50.0 KRAD IRRADIATION (0.307 KRADS/HOUR)	11/20/98
POST-50.0 KRAD ELECTRICAL MEASUREMENT	11/23/98
11) 168 HOUR ANNEALING @25°C	11/23/98
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	11/30/98

Effective Dose Rate = 50,000 RADS/25 DAYS=83.3 RADS/HOUR=0.02 RADS/SEC
The effective dose rate is lower than that of the individual radiation steps as it takes into account the interim annealing step and time needed to test the parts.

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

TABLE IIB. Radiation Schedule for LF147 (Lower Dose Rate)

EVENT	DATE
1) INITIAL ELECTRICAL MEASUREMENTS	10/29/98
2) 2.5 KRAD IRRADIATION (0.015 KRADS/HOUR)	11/09/98
POST-2.5 KRAD ELECTRICAL MEASUREMENT	11/16/98
3) 5.0 KRAD IRRADIATION (0.015 KRADS/HOUR)	11/16/98
POST-5.0 KRAD ELECTRICAL MEASUREMENT	11/23/98
4) 7.5 KRAD IRRADIATION (0.015 KRADS/HOUR)	11/23/98
POST-7.5 KRAD ELECTRICAL MEASUREMENT	11/30/98
5) 10.0 KRAD IRRADIATION (0.015 KRADS/HOUR)	11/30/98
POST-10.0 KRAD ELECTRICAL MEASUREMENT	12/07/98
6) 168 HOUR ANNEALING @25°C	12/07/98
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	12/14/98

Effective Dose Rate = 10,000 RADS/28 DAYS=14.9 RADS/HOUR=0.004 RADS/SEC

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

Table III. Electrical Characteristics of LF147 /1

Test #	Parameter	Units	Test Conditions	Spec. Lim. min	Spec. Lim. max
1	+Idd	mA	V_{CC} = +15V	0	14
2	-Idd	mA	V_{CC} = -15V	-14	0
3-6	Voh_2k	V	V_{CC} = +15V, R_L = 2kW	10.0	
7-10	Vol_2k	V	V_{CC} = -15V, R_L = 2kW		-10.0
11-14	Voh_10k	V	V_{CC} = +15V, R_L = 10kW	12.0	
15-18	Vol_10k	V	V_{CC} = -15V, R_L = 10kW		-12.0
19-22	Vio	mV	V_{CC} = ±15V, V_{CM} = ±11V	-5.0	5.0
23,26,29,32	+Ibias	pA	V_{CC} = +5V, V_{CM} = +11V	-200	1200
24,27,30,33	-Ibias	pA	V_{CC} = -5V, V_{CM} = +11V	-200	1200
25,28,31,34	+Iio	pA	V_{CC} = ±5V, V_{CM} = 0V	-200	200
35-38	Avs_2k	V/mV	V_{CC} = +15V, R_L = 2kW, V_{SET} = ±10V	50	
39-42	PSRR	dB	$+V_{CC}$ = +20V, $-V_{CC}$ = -15V	80	
43-46	PSRR	dB	$+V_{CC}$ = +15V, $-V_{CC}$ = -20V	80	
47-50	CMRR	dB	V_{CC} = ±15V, V_{CM} = +11V or -11V	80	
51,53,55,57	+Slew Rate	V/ms	V_{CC} = ±15V	7.0	
52,54,56,58	-Slew Rate	V/ms	V_{CC} = ±15V	7.0	

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.

TABLE IVa: Summary of Electrical Measurements after Total Dose Exposures and Annealing for LF147 /1
Dose Rate = 0.02R(Si)/s

							Total Dose Exposure (kRads Si)				Annealing		Total Dose Exposure (kRads Si)												Annealing	
Test			Spec. Lim. /2		Initial		2.5		5.0		72 hours @25°C		7.5		10.0		15.0		20.0		30.0		50.0		168 hours @25°C	
#	Parameters	Units	min	max	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
1	+Idd	mA	0	14.0	8.6	0	8.6	0	50	0	8.5	0	8.5	0	8.5	0	8.5	0	8.5	0	8.5	0	8.4	0	8.4	0
2	-Idd	mA	-14.0	0	-8.6	0	-8.6	0	-68	1	-8.6	0	8.5	0	-8.5	0	-8.5	0	-8.5	0	-8.5	0	-8.5	0	-8.4	0
3-6	Voh_2k	V	10.0		13.9	0	13.9	0	0	0	13.8	0	13.8	0	13.8	0	13.8	0	13.8	0	13.8	0	13.8	0	13.8	0
7-10	Vol_2k	V		-10.0	-12.8	0	-12.8	0	-0.8	0	-12.8	0	-12.8	0	-12.8	0	-12.8	0	-12.8	0	-12.8	0	-12.8	0	-13.8	0
11-14	Voh_10k	V	12.0		14.1	0	14.1	0	-2.7	0	14.1	0	14.1	0	14.1	0	14.1	0	14.1	0	14.1	0	14.1	0	14.1	0
15-18	Vol_10k	V		-12.0	-13.2	0	-13.2	0	-2.7	0	-13.2	0	-13.2	0	-13.2	0	-13.2	0	-13.2	0	-13.2	0	-13.2	0	-13.2	0
19-22	Vio	mV	-5.0	5.0	0.2	0.1	0.2	0.1	-6.4	0	0.2	0.1	0.2	0.1	0.2	0.2	0.2	0.1	0.2	0.1	0.2	0.1	0.2	0.2	0.2	0.1
23,26,29,32	+Ibias	pA	-200	1200	92	3	107	3	>2719		76	3	212	3	74	3	123	4	103	3	183	3	249	6	203	5
24,27,30,33	-Ibias	pA	-200	1200	141	3	147	2	>2822		116	3	98	3	122	2	135	4	162	3	158	3	294	5	190	6
25,28,31,34	+Iio	pA	-200	200	-121	1	-73	1	-106	0	-99	1	153	1	-96	1	79	1	-79	1	146	1	-186	1	63	1
35-38	Avs_2k	V/mV	50		61	2	60	1	31	0	60	1	60	2	60	2	60	2	60	2	60	2	60	1	59	1
39-42	PSRR	dB	80		111	1	112	2	3/		112	1	113	2	113	2	113	2	113	2	114	2	113	2	112	2
43-46	PSRR	dB	80		109	9	106	6	3/		101	6	99	2	99	2	99	2	103	4	101	3	104	5	102	3
47-50	CMRR	dB	80		98	5	101	6	77	0	100	8	98	5	98	5	98	5	101	8	100	6	100	6	99	5
51,53,55,57	+Slew Rate	V/?s	7.0		10.5	0.1	10.5	0.2	4787	290	10.4	0.2	10.3	0.2	10.3	0.2	10.3	0.2	10.3	0.2	10.2	0.2	9.8	0.2	9.9	0.3
52,54,56,58	-Slew Rate	V/?s	7.0		13.6	0.2	13.6	0.2	5016	325	13.6	0.2	13.6	0.2	13.6	0.2	13.6	0.2	13.6	0.2	13.6	0.2	13.6	0.2	13.6	0.2

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 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/ No reliable measurement was possible for this parameter at this level.

TABLE IVb: Summary of Electrical Measurements after Total Dose Exposures and Annealing for LF147 /1

Dose Rate = 0.004R(Si)/s

					Total Dose Exposure (kRads Si)										Annealing	
					Initial		2.5		5.0		7.5		10.0		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
1	+Idd	mA	0	14.0	8.6	0.1	8.6	0.1	8.6	0.1	8.5	0.1	8.5	0.1	8.6	0.1
2	-Idd	mA	-14.0	0	-8.6	0.1	-8.6	0.1	-8.6	0.1	-8.5	0.1	-8.5	0.1	-8.6	0.1
3-6	Voh_2k	V	10.0		13.8	0	13.8	0	13.8	0	13.8	0	13.8	0	13.8	0
7-10	Vol_2k	V		-10.0	-12.8	0	-12.8	0	-12.8	0	-12.8	0	-12.8	0	-12.8	0
11-14	Voh_10k	V	12.0		14.1	0	14.1	0	14.1	0	14.1	0	14.1	0	14.1	0
15-18	Vol_10k	V		-12.0	-13.2	0	-13.2	0	-13.2	0	-13.2	0	-13.2	0	-13.2	0
19-22	Vio	mV	-5.0	5.0	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
23,26,29,32	+Ibias	pA	-200	1200	71	3	108	4	128	3	98	4	98	4	84	3
24,27,30,33	-Ibias	pA	-200	1200	112	2	119	2	174	3	70	2	70	2	118	2
25,28,31,34	+Iio	pA	-200	200	-99	1	-78	1	-161	6	56	1	56	1	-101	1
35-38	Avs_2k	V/mV	50		60	1	59	1	59	1	61	1	61	1	60	2
39-42	PSRR	dB	80		110	6	109	7	115	3	110	6	111	6	109	6
43-46	PSRR	dB	80		105	7	99	2	99	2	109	9	109	9	108	7
47-50	CMRR	dB	80		96	3	98	7	101	7	102	9	102	9	101	8
51,53,55,57	+Slew Rate	V/?s	7.0		10.4	0.1	10.2	0.1	10.4	0.1	9.8	0.1	9.8	0.1	9.8	0.1
52,54,56,58	-Slew Rate	V/?s	7.0		13.5	0.2	13.4	0.3	13.5	0.2	13.6	0.3	13.6	0.2	13.5	0.2

Notes:

1/ The mean and standard deviation values were calculated over the four parts irradiated in this testing. The control samples remained constant throughout 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.

Radiation sensitive parameter: None.