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TO: T. Mecum/311.1
FROM: K. Sahu/300.1 KS
SUBJECT: Radiation Report on FUSE
Part No. LF411MH
Control No. 11121

cc: A. Sharma/311
Library/300.1

A radiation evaluation was performed on LF411MH (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 levels were 5, 10, 20, 30, 50, 75 and 100 krads*. The dose rate was between 0.08 and 1.32 krads/hour, depending on the total dose level (see Table II for radiation schedule). After the 100 krad irradiation, parts were annealed at 25°C for 168 hours, after which the parts were annealed at 100°C for 168 hours. After each radiation exposure and annealing treatment, parts were electrically tested according to the test conditions and the specification limits** listed in Table III.

All parts passed initial electrical measurements. All irradiated parts passed all electrical and functional tests up to and including the 30 krad irradiation level. At the 50 krad irradiation level, all parts exceeded the maximum specification limit of ± 200 pA for +Ibias and -Ibias, with readings in the range of 458 to 557 pA and 293 to 425 pA, respectively. In addition, all parts exceeded the maximum specification limit of ±100 pA for Iio, with readings in the range of 132 to 195 pA.

After the 75 krad irradiation, the same failures continued but with slightly lower values for +Ibias (290-371 pA) and slightly higher values for -Ibias (466-524 pA). The readings for Iio were approximately the same.

After the 100 krad irradiation, the same failures continued, with readings for +Ibias slightly higher again and readings for -Ibias approximately the same. All but two parts (S/N 56 and 59) recovered to within specification limits for Iio, with readings for S/N 56 and 59 being -125 and -102 pA, respectively.

After annealing for 168 hours at 25°C, the same failures continued for +Ibias and -Ibias, with readings in the ranges of 501-554 pA and 385-486 pA, respectively. S/N 56 read 169 pA for Iio, S/N 58 marginally exceeded the specification limits for Iio, with a reading of 103.34 pA, and S/N 59 recovered to within specification limits for Iio.

After annealing for 168 hours at 100°C, no rebound effects were observed.

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

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:	LF411
FUSE Part Number:	LF411MH
FUSE Control Number:	11121
Charge Number:	C44492
Manufacturer:	National Semiconductor
Lot Date Code:	9212B
Quantity Tested:	10
Serial Number of Control Samples:	50, 51
Serial Numbers of Radiation Sample:	52, 53,54, 55, 56, 57, 58, 59
Part Function:	Op Amp
Part Technology:	BiFET
Package Style:	8-pin TOx
Test Equipment:	A540
Test Engineer:	C. Nguyen

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

TABLE II. Radiation Schedule for LF411MH

EVENTS	DATE
1) INITIAL ELECTRICAL MEASUREMENTS	07/15/94
2) 5 RAD IRRADIATION (0.08 KRADS/HOUR)	07/15/94
POST-5 KRAD ELECTRICAL MEASUREMENT	07/18/94
3) 10 KRAD IRRADIATION (0.28 KRADS/HOUR)	07/19/94
POST-10 KRAD ELECTRICAL MEASUREMENT	07/20/94
4) 20 KRAD IRRADIATION (0.53 KRADS/HOUR)	07/20/94
POST-20 KRAD ELECTRICAL MEASUREMENT	07/21/94
5) 30 KRAD IRRADIATION (0.53 KRADS/HOUR)	07/21/94
POST-30 KRAD ELECTRICAL MEASUREMENT	07/22/94
6) 50 KRAD IRRADIATION (0.31 KRADS/HOUR)	07/22/94
POST-50 KRAD ELECTRICAL MEASUREMENT	07/25/94
7) 75 KRAD IRRADIATION (1.32 KRADS/HOUR)	07/25/94
POST-75 KRAD ELECTRICAL MEASUREMENT	07/28/94
8) 100 KRAD IRRADIATION (1.25 KRADS/HOUR)	07/28/94
POST-75 KRAD ELECTRICAL MEASUREMENT	07/29/94
9) 168-HOUR ANNEALING @25°C	07/29/94
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	08/05/94
10) 168-HOUR ANNEALING @100°C*	08/05/94
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	08/12/94

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

*High temperature annealing is performed to accelerate long term time dependent effects (TDE), namely, the "rebound" effect due to the growth of interface states after the radiation exposure. For more information on the need to perform this test, refer to MIL-STD-883D, Method 1019, Para. 3.10.1.

Table III. Electrical Characteristics of LF411MH

Test Name	Min.	Max.
Idd_15	0 mA	3.40 mA
Iss_15	-3.40 mA	0 mA
+Vo_10	12.00 V	–
-Vo_10	–	-12.00 V
Vio	-2.00 mV	2.00 mV
+Ibias	-200 pA	200 pA
-Ibias	-200 pA	200 pA
Iio	-100 pA	100 pA
Avs_2K	25 V/mV	–
CMRR	70 dB	–
+PSRR	70 dB	–
-PSRR	70 dB	–
+SR	8V	–
-SR	8V	–

TABLE IV: Summary of Electrical Measurements after Total Dose Exposures and Annealing for LF411MH /1

Parameters		Spec. Lim./2		Initials		Total Dose Exposure (krads)														Annealing			
						5		10		20		30		50		75		100		168 hrs @25°C		168 hrs @100°C	
		min	max	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
Idd_15	mA	0	3.4	2.31	.08	2.31	.08	2.30	.08	2.29	.08	2.27	.09	2.23	.09	2.19	.09	2.13	.09	2.21	.09	2.27	.08
Iss_15	mA	-3.4	0	-2.3	.08	-2.3	.08	-2.30	.08	-2.29	.08	-2.27	.09	-2.23	.10	-2.20	.09	-2.14	.09	-2.21	.08	-2.21	.08
+Vo_10	V	12		14.2	0	14.2	0	14.2	0	14.2	0	14.2	0	14.2	0	14.2	0	14.2	0	14.2	0	14.2	0
-Vo_10	V		-12	-13.4	.05	-13.4	.05	-13.4	.05	-13.4	.05	-13.4	.05	-13.4	.05	-13.3	.05	-13.4	.05	-13.4	.05	-13.4	.05
Vio	mV	-2	2	-.088	.36	-.076	.39	-.069	.40	-.050	.41	-.046	.47	-.029	.49	.035	.55	.223	.58	.168	.55	.075	.41
+Ibias	pA	-200	200	14.1	1.3	18.1	4.1	34.9	7.2	90.1	16	140	18	524	37	330	27	457	22	523	16	45.2	2.7
-Ibias	pA	-200	200	20.4	12	20.7	9.9	34.8	7.1	79.8	11	112	15	358	52	497	19	523	19	446	30	41.9	1.8
Iio	pA	-100	100	-6.29	11	-4.36	10	.053	1.7	18.6	21	27.6	5.4	166	22	-167	8.4	-30.1	69	77.5	45	3.33	1.4
Avs_2k	V/mV	25		174	77	168	67	156	56	147	42	130	33	113	29	103	22	94.4	17	95.3	18	133	47
CMRR	dB	70		104	8.9	105	9.1	107	12	104	10	107	11	105	10	104	9.2	102	7.5	103	8.2	102	10
+PSRR	dB	70		88.2	2.5	89.2	2.6	88.2	2.7	89.1	2.9	88.9	3.3	88.1	4.6	88.9	7.2	94.4	15	93.2	13	89.5	9.4
-PSRR	dB	70		88.5	3.1	88.1	3.0	87.9	2.8	88.1	3.1	87.9	3.0	88.9	3.7	87.4	5.6	89.5	19	89.9	9.3	91.2	12
+SR	V	8		10.6	.34	10.6	.33	10.7	.36	10.8	.41	10.9	.55	10.9	.56	11.1	.60	11.0	.62	11.1	.69	9.9	.70
-SR	V	8		10.1	.26	10.1	.26	10.1	.25	10.0	.21	10.1	.18	10.1	.16	10.2	.17	8.84	3.5	10.2	.25	10.3	.95

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 is not included in this table.

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

3/ The radiation sensitive parameters were +ibias, -ibias and iio.

Figure 1. Radiation Bias Circuit for LF411MH