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Memorandum

PPM-93-033

DATE: Feb. 18, 1993
TO: B. Fafaul/311
FROM: K. Sahu/300.1 KS
SUBJECT: Radiation Report on FAST/MUE
Part No. M38510/13501BPA (OP 07A)
Control No. 6137

cc: R. Kolecki/740.4
T. Miccolis/300.1
A. Sharma/311
Library/300.1 ✓
L. Cusick/740.4
SMEX, PPM File

A radiation evaluation was performed on OP 07A (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 steps were 5, 10, 20, 40 and 60 krads*. After 60 krads, parts were annealed at +25°C for 168 hours. The irradiation was then continued to 100 krads (cumulative). The dose rate was between 0.05 and 2 krads/hour, depending on the total dose level (see Table II for radiation schedule). After each radiation exposure and annealing treatment, parts were electrically tested at 25°C according to the test conditions and the specification limits** listed in Table III.

All ten parts passed initial (pre-rad) electrical tests. After the 5-krad exposure, three parts (SN 43, 45 and 47) marginally exceeded the maximum specification limit of 2.00 nA for input bias current (Ib+ or Ib-), with readings ranging from 2.04 to 2.11 nA. After the 10-krad exposure, all eight irradiated parts failed the input bias current tests, with readings ranging from 2.22 to 3.43 nA. After the 20-krad irradiation, all eight

*The term rads, as used in this document, means rads(silicon).

**These are manufacturers' non-irradiated data sheet specification limits. No post-irradiation limits were provided by the manufacturer at the time these tests were performed.

irradiated parts exceeded the specification limit of 2 nA for I_{os} , I_{b+} , I_{b-} and I_{bias} , with readings ranging from 3.89 to 12.38 nA. In addition, one part (SN 43) exceeded the maximum specification limit of 25 μ V for V_{os1} and V_{os2} , with reading of 28.4 μ V and 26.48 μ V, respectively.

After the 40-krad exposure, all eight irradiated parts continued to fail input bias current tests and all input port current tests, with readings ranging from 7.63 to 29.04 nA. Three parts (SN 44, 46 and 49) had readings below the minimum specification limit of 110 dB for CMRR, with readings ranging from 105.8 to 109.8 dB, and three parts (SN 43, 44 and 49) exceeded the specification limits of ± 25 μ V for V_{os} , with positive readings of 45.65 μ V for V_{os1} and 45.77 μ V for V_{os2} and negative readings ranging from -21.78 to -45.71 μ V.

After the 60-krad irradiation, the eight irradiated parts continued to fail the same test parameters. Readings for input bias and input port currents ranged from 8.37 to 40.37 nA. Two parts (SN 43 and 49) failed V_{os} . Negative readings were -36.43 and -37.77 μ V and positive readings were 51.87 and 53.09 μ V. The same three parts failed CMRR, with readings ranging from 105.9 to 109.9 dB.

After annealing for 168 hours at 25°C, little or no recovery was observed.

After irradiation to 100 krad (cumulative), the eight irradiated parts continued to fail the same test parameters. Readings for input bias and input port currents ranged from 9.24 to 72.95 nA. Seven parts (SN 42, 43, 45, 46, 47, 48 and 49) failed V_{os} . Negative readings were -37.04 and -37.89 μ V and positive readings ranged from 31.73 to 90.56 μ V. Two parts (SN 46 and 49) failed CMRR, with readings of 105 and 108.5 dB. In addition, one part (SN 45) marginally failed A_{ol} , with a reading of 298.5 KV/V against a minimum specification limit of 300 KV/V.

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

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:	OP 07A
Part Number:	M38510/13501BPA
FAST/MUE Control Number:	6137
Charge Number:	C23987
Manufacturer:	PMI
Lot Date Code:	9233
Quantity Tested:	10
Serial Numbers of Radiation Samples:	42, 43, 44, 45, 46, 47, 48, 49
Serial Numbers of Control Samples:	40, 41
Part Function:	Op Amp
Part Technology:	Bipolar
Package Style:	8-lead DIP package
Test Equipment:	Genrad mod. 1731
Test Engineer:	T. Mondy

TABLE II. Radiation Schedule for OP 07A

EVENTS	DATE
1) Initial Electrical Measurements	01/08/93
2) 5 KRAD IRRADIATION (0.26 krads/hour) POST-5 KRAD ELECTRICAL MEASUREMENT	01/14/93 01/15/93
3) 10 KRAD IRRADIATION (0.05 krads/hour) POST-10 KRAD ELECTRICAL MEASUREMENT	01/15/93 01/19/93
4) 20 KRAD IRRADIATION (0.22 krads/hour) POST-20 KRAD ELECTRICAL MEASUREMENT	01/19/93 01/21/93
5) 40 KRAD IRRADIATION (1.0 KRAD/HOUR) POST-40 KRAD ELECTRICAL MEASUREMENT	01/21/93 01/22/93
6) 60 KRAD IRRADIATION (0.30 KRADS/HOUR) POST-60 KRAD ELECTRICAL MEASUREMENT	01/22/93 01/25/93
7) 168 HOUR ANNEALING @25°C POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	01/28/93 02/01/93
8) 100 KRAD IRRADIATION (2.0 KRADS/HOUR) POST-100 KRAD ELECTRICAL MEASUREMENT	02/01/93 02/02/93
9) 168 HOUR ANNEALING @100°C* POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	02/02/93 02/09/93

ALL ELECTRICAL MEASUREMENTS WERE PERFORMED AT 25°C.

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 OP 07A

Test	Units	Specification Limits		Conditions
		Min	Max	
+Icc1	mA	0	4.0	Rs = 50 Kohms
-Icc1	mA	-4.0	0	"
+Icc2	mA	0	4.0	"
-Icc2	mA	-4.0	0	"
Vos1	uV	-25	25	"
Vos2	uV	-25	25	"
Ios	nA	0	2	"
Ib+	nA	-2	2	"
Ib-	nA	-2	2	"
Ibias	nA	0	2	"
Ao1	kV/V	300	-	R1 = 2 Kohms, Vo = ± 10 VDC
CMRR	dB	110	-	Vcm = ± 13 VDC
+PSRR	dB	100	-	Vs = ± 18 VDC
-PSRR	dB	100	-	"
+Vo1	V	10	-	R1 = 2 Kohms
-Vo1	V	10	-	"
+Vo2	V	12	-	"
-Vo2	V	12	-	"

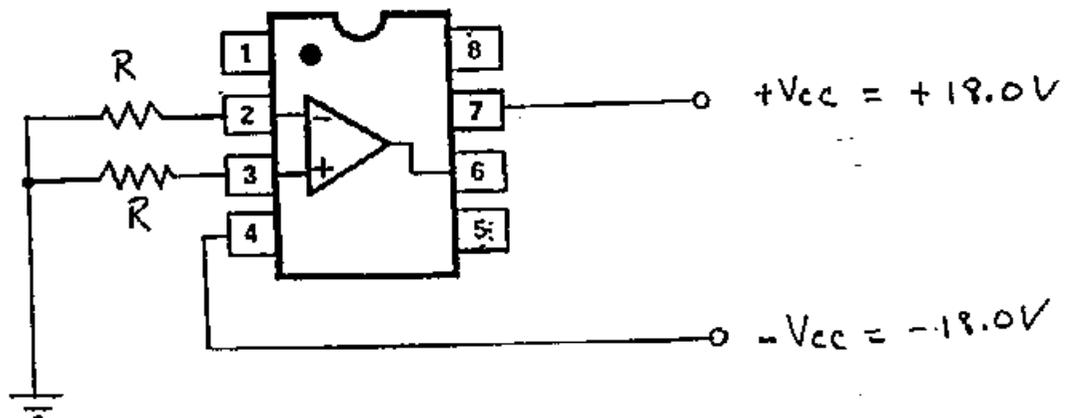
TABLE IV: Summary of Electrical Measurements After Total Dose Exposures and Annealing Steps for OP 07A 1/

Parameters	Spec. Lim./2 min max	Total Dose Exposure (TDE) (krads)												Anneal 168 hrs @25°C		TDE 100 krads		Anneal 158 hrs @+100°C	
		0		5		10		20		40		60		mean	sd	mean	sd	mean	sd
		mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
+ICCl	mA	0	4.0	1.54	.02	1.46	.02	1.39	.02	1.26	.02	1.24	.02	1.31	.02	1.18	.02	1.48	.02
-ICCl	mA	-4.0	0	-1.53	.02	-1.47	.02	-1.38	.02	-1.26	.02	-1.24	.02	-1.30	.02	-1.19	.02	-1.48	.02
+ICc2	mA	0	4.0	1.54	.02	1.48	.02	1.39	.02	1.26	.02	1.24	.02	1.31	.02	1.18	.02	1.48	.03
-ICc2	mA	-4.0	0	-1.53	.02	-1.47	.02	-1.38	.02	-1.26	.02	-1.24	.02	-1.31	.02	-1.18	.02	-1.48	.02
Vos1*	UV	-25	25	4.72	5.1	5.87	5.5	5.16	8.8	18.2	19	21.4	17	13.3	11	38.9	23	5.56	62
Vos2*	UV	-25	25	5.35	5.9	5.48	6.0	6.27	8.9	17.6	18	20.9	16	13.0	12	38.8	23	5.91	5.4
Ios	nA	0	2	0.36	0.4	0.58	.42	0.55	0.5	0.95	.77	0.97	.95	0.29	.78	11.6	1.3	0.84	.55
Ib+	nA	-2	2	0.32	.21	0.32	.28	0.4	0.7	26.2	1.9	25.9	2.7	27.5	1.8	66.7	4.2	6.48	.56
Ib-	nA	-2	2	0.75	.33	1.54	.43	2.44	0.4	4.80	.61	34.1	2.2	18.2	1.4	55.1	3.5	5.63	0.4
Ibias	nA	0	2	0.83	.21	1.72	.27	2.73	.27	6.08	.61	31.9	2.4	23.4	1.6	60.9	3.8	6.05	0.4
Aol**	kV/V	300	-	PASS		PASS		7P1F		PASS									
CMRR	dB	110	-	136	2.6	125	4.0	119	3.9	115	3.6	114	4.2	113	5.9	113	6.4	122	4.6
+PSRR	dB	100	-	118	1.4	118	1.1	118	0.9	117	.57	117	1.0	118	1.6	119	3.1	117	.93
-PSRR	dB	100	-	111	0.9	110	.95	109	1.0	108	1.4	107	1.9	107	2.2	107	2.9	109	1.2
+V01	V	10	-	13.9	0	13.9	.01	13.9	.01	13.9	.01	13.9	.01	13.9	.01	13.8	.02	13.9	.01
-V01	V	10	-	-12.7	.02	-12.7	.02	-12.6	.02	-12.6	.02	-12.4	.02	-12.4	.02	-12.4	.02	-12.6	.02
+V02	V	12	-	14.1	0	14.1	.01	14.0	.01	14.0	.01	14.0	.01	14.0	.01	14.0	0	14.1	0
-V02	V	12	-	-13.6	.33	-13.6	.03	-13.9	.02	-13.8	.01	-12.7	.02	-12.8	.02	-12.7	.02	-12.9	.02

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 manufacturers' non-irradiated data sheet specification limits. No post-irradiation limits were provided by the manufacturer at the time the tests were performed.
 - * Values for mean and standard deviation for Vos1 and Vos2 are given in the table for absolute values of the parameters.
 - ** The single failure at 100 krads was marginal (<1% below minimum specification limit).
- Radiation-sensitive parameters were: Ib+, Ib-, Ios, Ibias, Vos1, Vos2 and CMRR.

Figure 1. Radiation Bias Circuit for OP 07A



$T_a = 25^\circ\text{C}$

$R = 10 \text{ Kohms}, 1/4 \text{ watt}$

$+V_{cc} = 18.0 \pm 0.5 \text{ VDC}$

$-V_{cc} = 18.0 \pm 0.5 \text{ VDC}$