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DATE: September 24, 1997 PPM-97-038
TO: J. Lohr/311
FROM: K. Sahu/300.1
SUBJECT: Radiation Report on: OP07
Project: MAP INST.
Job #: M78220
Project part #: OP07 (5962-82036012A)

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A radiation evaluation was performed on OP07 (5962-82036012A) 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^{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 5.0, 10.0, 15.0, 20.0 30.0, 50.0, 75.0, and 100.0 kRads.* The dose rate was between 0.06 and 0.625 kRads/hour (0.017 to 0.174 Rads/s). See Table II for the radiation schedule and effective dose rate calculation. After the 15.0 kRad irradiation, the parts were annealed for 120 hours at 25°C. After the 100.0 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.

Initial electrical measurements were made on 10 samples. Eight samples (SN's 82, 83, 84, 85, 86, 87, 88, and 89) were used as radiation samples while SN's 80 and 81 were used as control samples. All parts passed all tests during initial electrical measurements.

All parts passed all tests to 5.0 kRads. No significant degradation was noted in any parameter.

After the 10.0 kRad irradiation, SN's 86 and 88 fell marginally below the specification limit of –25µV for VOS_0V with readings of –26.6 and –32.3µV respectively. All parts marginally exceeded the specification limit of ±2.0nA for P_IIB_0V and N_IIB_0V with readings in the ranges of 2.2 to 2.8nA and 2.1 to 2.7nA respectively. **All parts passed all other tests.**

After the 15.0 kRad irradiation, all parts except SN 82 fell below the specification limit for VOS_0V with readings in the range of –32.4 to –57.1µV. All parts exceeded the specification limit for P_IIB_0V and N_IIB_0V with readings in the ranges of 4.6 to 6.2nA and 4.5 to 6.2nA respectively. **All parts passed all other tests.**

After the annealing the parts for 120 hours at 25°C, parts showed little recovery with all parts except SN 82 falling below the specification limit for VOS_0V with readings in the range of –32.6 to –46.9µV. All parts continued to exceed the specification limit for P_IIB_0V and N_IIB_0V with readings in the range of 4.4 to 5.8nA for both. **All parts passed all other tests.**

After the 20.0 kRad irradiation, all parts except SN 82 fell below the specification limit for VOS_0V with readings in the range of –29.7 to –49.1µV. All parts continued to exceed the specification limit for P_IIB_0V and N_IIB_0V with readings in the ranges of 7.9 to 10.3nA and 8.1 to 10.6nA 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 30.0 kRad irradiation, all parts except SN 82 fell below the specification limit for VOS_0V with readings in the range of –28.1 to –54.1μV. All parts continued to degrade in P_IIB_0V and N_IIB_0V with readings in the ranges of 14.8 to 16.1nA and 15.2 to 16.6nA respectively. **All parts passed all other tests.**

After the 50.0 kRad irradiation, all parts except for SN 82 had VOS_0V readings in the range of –38.6 to –67.5μV. SN 82 had a reading of >160μV. This very high VOS_0V reading accompanied by the fact that the sign changed from negative to positive, may represent a functional failure of the part. All parts continued to degrade in P_IIB_0V and N_IIB_0V with readings in the ranges of 17.1 to 18.6nA and 18.0 to 19.5nA respectively. SN 82 suffered catastrophic failures in the CMRR, +PSRR, -PSRR, P_AOL, and N_AOL tests. **All parts passed all other tests.**

After the 75.0 kRad irradiation, all parts failed VOS_0V with some readings negative and others positive. Readings were in the range of –36.7 to –93.7μV and >160μV. This may be an indication of functional failures in the parts. All parts continued to exceed the specification limit for P_IIB_0V and N_IIB_0V with readings in the ranges of 11.5 to 14.3nA and 12.2 to 15.3nA respectively. **All parts passed all other tests.**

After the 100.0 kRad irradiation, all parts continued to fail VOS_0V as before. All parts continued to exceed the specification limit for P_IIB_0V and N_IIB_0V with readings in the ranges of 7.8 to 11.7nA and 8.8 to 12.7nA respectively. **All parts passed all other tests.**

After annealing the parts for 168 hours at 25°C, parts showed no significant recovery 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 me at (301) 731-8954.

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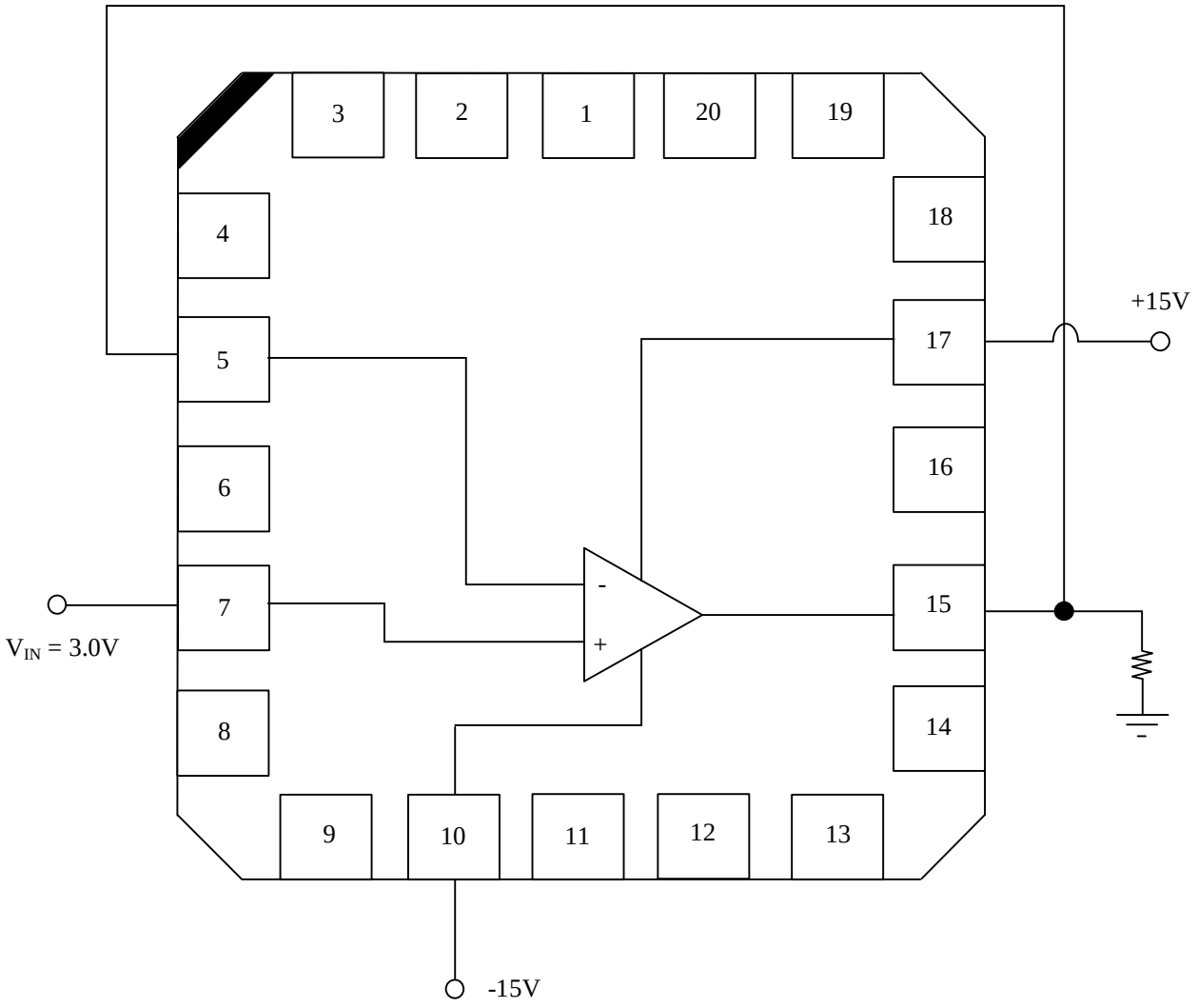
Figure 1. Radiation Bias Circuit for OP07



Pin connection list:

1: NC	2: V_{OS}	3: NC	4: NC	5: -IN	6: NC	7: +IN	8: NC	9: NC	10: -V
11: NC	12: NC	13: NC	14: NC	15: OUT	16:NC	17: +V	18: NC	19: NC	20: V_{OS}

Resistor is 402Ω ± 5%, ½ W.

TABLE I. Part Information

Generic Part Number:	OP07
MAP INST. Part Number	5962-82036012A
Charge Number:	M78220
Manufacturer:	PMI
Lot Date Code (LDC):	9446B
Quantity Tested:	10
Serial Number of Control Samples:	80, 85
Serial Numbers of Radiation Samples:	81, 82, 83, 84, 86, 87, 88, and 89
Part Function:	OP-AMP
Part Technology:	Bipolar
Package Style:	20 Pin LCC
Test Equipment:	A540
Test Engineer:	D. Davis

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

TABLE II. Radiation Schedule for OP07

EVENT	DATE
1) INITIAL ELECTRICAL MEASUREMENTS	08/01/97
2) 5.0 KRAD IRRADIATION (0.125 KRADS/HOUR)	08/06/97
POST-5.0 KRAD ELECTRICAL MEASUREMENT	08/08/97
3) 10.0 KRAD IRRADIATION (0.125 KRADS/HOUR)	08/08/97
POST-10.0 KRAD ELECTRICAL MEASUREMENT	08/11/97
4) 15.0 KRAD IRRADIATION (0.125 KRADS/HOUR)	08/11/97
POST-15.0 KRAD ELECTRICAL MEASUREMENT	08/13/97
5) 120 HOUR ANNEALING @25°C	08/13/97
POST-120 HOUR ANNEAL ELECTRICAL MEASUREMENT	08/18/97
6) 20.0 KRAD IRRADIATION (0.125 KRADS/HOUR)	08/18/97
POST-20.0 KRAD ELECTRICAL MEASUREMENT	08/20/97
7) 30.0 KRAD IRRADIATION (0.250 KRADS/HOUR)	08/20/97
POST-30.0 KRAD ELECTRICAL MEASUREMENT	08/22/97
8) 50.0 KRAD IRRADIATION (0.500 KRADS/HOUR)	08/22/97
POST-50.0 KRAD ELECTRICAL MEASUREMENT	08/25/97
9) 75.0 KRAD IRRADIATION (0.625 KRADS/HOUR)	08/25/97
POST-75.0 KRAD ELECTRICAL MEASUREMENT	08/27/97
10) 100.0 KRAD IRRADIATION (0.625 KRADS/HOUR)	08/27/97
POST-100.0 KRAD ELECTRICAL MEASUREMENT	08/29/97
11) 168 HOUR ANNEALING @25°C	08/29/97
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	09/04/97

Effective Dose Rate = 100,000 RADS/24 DAYS=173.6 RADS/HOUR=0.048 RADS/SEC
The effective dose rate is lower than that of the individual radiation steps as it takes into account the interim-annealing step.

The interim annealing following the 15.0 kRad step was added due to degradation in the parts. The addition of an interim annealing step better simulates the space environment's lower dose rate for very sensitive devices. This may allow the parts to show satisfactory performance at higher doses or indicate that the part can not be used beyond the previous dose level.

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

Table III. Electrical Characteristics of OP07 /1

Test #	Parameter	Units	Test Conditions /2	Spec. min	Lim. max
1	$+I_{CC}$	mA		0.0	4.0
2	$-I_{CC}$	mA		-4.0	0.0
3	VOS_0V	mV	V_{CM} = 0V	-25.0	25.0
4	P_IIB_0V	nA	V_{CM} = 0V	-2.0	2.0
5	N_IIB_0V	nA	V_{CM} = 0V	-2.0	2.0
6	IIOS_0V	nA	V_{CM} = 0V	-2.0	2.0
7	CMRR	dB	V_{CM} = ±10V	110	
8	+PSRR	dB	$+V_{CC}$ = 20V to 5V, $-V_{CC}$ = -15V	100	
9	-PSRR	dB	$-V_{CC}$ = -20V to -5V, V_{CC} = +15V	93	
10	P_VOUT_1k	V	R_L = 1kW	10.0	
11	P_VOUT_2k	V	R_L = 2kW	12.0	
12	N_VOUT_1k	V	R_L = 1kW		-10.0
13	N_VOUT_2k	V	R_L = 2kW		-12.0
14	P_AOL	V/mV	V_{CM} = 0V	300	
15	N_AOL	V/mV	V_{CM} = 0V	300	
16	+ISC	mA	V_{CM} = 0V	-60.0	
17	-ISC	mA	V_{CM} = 0V		50.0

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.

2/ For all tests, $+V_{CC}$ = +15V, $-V_{CC}$ = -15V unless otherwise specified.

TABLE IV: Summary of Electrical Measurements after Total Dose Exposures and Annealing for OP07 /1

					Initial		Total Dose Exposure (kRads) 5.0		10.0		15.0		Annealing /3 120 hours @25°C		Total Dose Exposure (kRads) 20.0		30.0		50.0 /4 /5		75.0		100.0		Annealing 168 hours @25°C	
Test #	Parameters	Units	Spec. Lim. /2 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	+ICC	mA	0.0	4.0	1.4	0.1	1.4	0.1	1.3	0.1	1.3	0.1	1.3	0.1	1.3	0.1	1.2	0.1	1.1	0	1.1	0.1	1.1	0.1	1.1	0.1
2	-ICC	mA	-4.0	0.0	-1.4	0.1	-1.4	0.1	-1.3	0.1	-1.3	0.1	-1.3	0.1	-1.3	0.1	-1.2	0.1	-1.1	0	-1.1	0.1	-1.1	0.1	-1.1	0.1
3	VOS_0V	mV	-25.0	25.0	-8.35	10.0	-10.6	8.4	-17.8	8.9	-44.5	11.2	-33.0	10.3	-33.6	10.8	-37.8	10.7	F		F		F		F	
4	P_IIB_0V	nA	-2.0	2.0	0.6	0.05	1.3	0.1	2.3	0.1	5.0	0.5	4.8	0.4	8.5	0.7	15.7	1.1	17.9	0.9	13.3	1.0	10.9	1.2	14.5	1.1
5	N_IIB_0V	nA	-2.0	2.0	0.6	0.05	1.2	0.1	2.1	0.1	5.0	0.5	4.8	0.4	8.8	0.8	16.3	1.1	18.8	0.8	14.3	0.9	11.8	1.2	15.7	0.8
6	IIOS_0V	nA	-2.0	2.0	0.01	0.01	0.12	0.01	0.14	0.01	0.11	0.02	0.02	0.01	-0.2	0.1	-0.4	0.1	-0.8	0.2	-1.0	0.1	-0.9	0.1	-0.9	0.1
7	CMRR	dB	110		149	6.7	146	6.6	141	4.8	130	3.4	133	4.8	133	9.3	130	6.2	7P/1F		6P/2F		6P/2F		5P/3F	
8	+PSRR	dB	100		130	1.4	131	1.6	129	1.2	131	2.2	129	1.5	126	1.2	124	1.3	7P/1F		6P/2F		5P/3F		5P/3F	
9	-PSRR	dB	93		127	1.6	127	2.2	126	2.3	139	6.3	133	4.4	133	6.5	129	5.1	7P/1F		6P/2F		6P/2F		5P/3F	
10	P_VOUT_1k	V	10.0		13.8	0	13.8	0	13.8	0	13.8	0	14.3	0	14.4	0	14.3	0	13.7	0.1	13.6	0.1	13.6	0.1	13.7	0.1
11	P_VOUT_2k	V	12.0		14.0	0	14.0	0	14.0	0	14.0	0	14.5	0	14.7	0	14.6	0	14.0	0	14.0	0	14.0	0	14.0	0
12	N_VOUT_1k	V		-10.0	-12.6	0	-12.5	0	-12.5	0	-12.5	0	-12.5	0	-12.4	0	-12.3	0	-12.2	0	-12.1	0.1	-12.1	0.1	-12.2	0.1
13	N_VOUT_2k	V		-12.0	-13.0	0	-12.9	0	-12.9	0	-12.9	0	-12.9	0	-12.8	0	-12.7	0	-12.6	0	-12.6	0	-12.6	0.1	-12.6	0
14	P_AOL	V/mV	300		6950	507	4833	316	4412	242	6450	870	4975	405	4038	418	3000	339	7P/1F		6P/2F		5P/3F		5P/3F	
15	N_AOL	V/mV	300		6838	583	6112	968	5775	1113	4463	1110	4938	906	1250	132	559	64	7P/1F		6P/2F		6P/2F		5P/3F	
16	+ISC	mA	-60.0		-26.4	0.3	-26.1	0.3	-25.9	0.3	-25.5	0.3	-25.8	0.3	-25.9	0.3	-25.6	0.3	-25.3	0.2	-24.9	0.4	-24.5	0.5	-25.0	0.3
17	-ISC	mA		50.0	36.2	0.6	35.5	0.8	34.9	0.9	34.3	1.0	34.6	1.0	33.7	1.0	32.5	1.2	30.9	1.1	29.4	1.3	28.1	1.0	29.1	1.3

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 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/ The interim annealing step was added due to degradation in the parts at this level. The addition of this interim annealing step better simulates the space environment's lower dose rate for very sensitive devices. This may allow parts to show satisfactory performance at higher doses or indicate that the part can not be used beyond the previous dose level.

4/ "F" indicates that all parts failed this test at this irradiation or annealing level. "nPmF" indicates that n parts passed and m parts failed this test at this irradiation or annelaing step. The use of these indicators implies that no meaningful mean and standard deviation could be provided at this level for these tests.

5/ SN 82 showed contradictory readings indicating a possible functional failure of the part at this level. Any further failures like this will be shown as nPmF as stated in /4.

Radiation sensitive parameters: VOS_0V, P_IIB_0V, N_IIB_0V, CMRR, +PSRR, -PSRR, P_AOL, N_AOL.