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TO: J. Lohr/311.1
FROM: K. Sahu/300.1 KS
SUBJECT: Radiation Report on CASSINI/CIRS
Part No. PA10A
Control No. 10903

cc: A. Sharma/311
Library/300.1

A radiation evaluation was performed on PA10A (Power operational amplifier) 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, five parts were irradiated under bias (see Figure 1 for bias configuration), and one part was used as a control sample. The total dose radiation levels were 5, 10, 15, 20, 30, 50, 75 and 100 krads*. The dose rate was between 0.075 and 1.25 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 tests up to the 5 krad level. After the 10 krad and 15 krad irradiation levels, S/N 14 exceeded the maximum specification limit of ± 30 nA for N_IIB, with readings of 31.3 nA and 41.2 nA. After the 20 krad irradiation, S/N 14 reading for N_IIB was within the specification limits. But S/N 12 and S/N 15 exceeded the maximum limit for N_IIB, with readings of 30.5 nA and 35.3 nA. After the 30 krad irradiation, the same failures continued, with readings of 35.9 nA and 31.0 nA. In addition, S/N 13 and S/N 14 exceeded the maximum limit for N_IIB, with readings of 33.5 nA and 42.4 nA. After the 50 krad irradiation, the same failures continued, with readings in the range of 41 nA to 61 nA. In addition S/N 11 exceeded the maximum limit for N_IIB, with a reading of 36.8 nA and S/N 14 exceeded the maximum specification limit of ± 30 nA for P_IIB, with a reading of 34.1 nA. After the 75 krad irradiation, all parts exceeded the maximum limit for N_IIB, with readings in the range of 45 nA to 63 nA. All parts except S/N 11 exceeded the maximum limit for P_IIB, with readings in the range of 37 nA to 43 nA. At the 100 krad irradiation level, all parts continued to exceed the maximum limit for N_IIB, with readings in the range of 51 nA to 77 nA respectively and all parts except S/N 11 continued to exceed the maximum limit for P_IIB, with readings in the range of 41 nA to 51 nA.

After annealing for 168 hours at 25°C, all parts continued to exceed the maximum limit for N_IIB, with readings in the range of 44 to 67 nA and all parts except S/N 11 continued to exceed the maximum limit for P_IIB, with readings in the range of 34 nA to 43 nA.

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

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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 Informati

Generic Part Number:	PA10A
CASSINI/CIRS Part Number:	PA10A
CASSINI/CIRS Control Number:	10903
Charge Number:	C44372
Manufacturer:	Apex Microtech Corp
Lot Date Code:	unknown
Quantity Tested:	6
Serial Number of Control Sample:	10
Serial Numbers of Radiation Sample:	10
Part Function:	Power OP-AMP
Part Technology:	Linear
Package Style:	TO-3
Test Equipment:	Sentry S-50
Test Engineer:	Tim Mondy

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

TABLE II. Radiation Schedule for PA10A

EVENTS	DATE
1) INITIAL ELECTRICAL MEASUREMENTS	06/22/94
2) 5 KRAD IRRADIATION (0.25 KRADS/HOUR)	06/22/94
POST-5 KRAD ELECTRICAL MEASUREMENT	06/23/94
3) 10 KRAD IRRADIATION (0.25 KRADS/HOUR)	06/23/94
POST-10 KRAD ELECTRICAL MEASUREMENT	06/24/94
4) 15 KRAD IRRADIATION (0.075 KRADS/HOUR)	06/24/94
POST-15 KRAD ELECTRICAL MEASUREMENT	06/27/94
5) 20 KRAD IRRADIATION (0.25 KRADS/HOUR)	06/27/94
POST-20 KRAD ELECTRICAL MEASUREMENT	06/28/94
6) 30 KRAD IRRADIATION (0.5 KRADS/HOUR)	06/28/94
POST-30 KRAD ELECTRICAL MEASUREMENT	06/29/94
7) 50 KRAD IRRADIATION (1 KRADS/HOUR)	06/29/94
POST-50 KRAD ELECTRICAL MEASUREMENT	06/30/94
8) 75 KRAD IRRADIATION (0.74 KRADS/HOUR)	07/01/94
POST-75 KRAD ELECTRICAL MEASUREMENT	07/06/94
(Power outage occured after 29 hrs. Parts annealed at room temperature under bias for 2.5 days. Dose rate was then adjusted to complete irradiation within 23 hrs)	
9) 100 KRAD IRRADIATION (1.25 KRADS/HOUR)	07/06/94
POST-100 KRAD ELECTRICAL MEASUREMENT	07/07/94
10) 168-HOUR ANNEALING @25°C	07/07/94
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	07/14/94
(Parts were stored under bias at 25°C for approximately 360 hours due to test equipment problems.)	
11) 168-HOUR ANNEALING @100°C**	07/14/94
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	07/21/94

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 PA10A

Unless Otherwise Specified: T_A =25°C, VCC = +/- 40Vdc, V_{OUT}=0V , Gain = 100

TEST NAME	SYMBOL	CONDITIONS	LIMITS	
			MIN	MAX
		SUPPLY CURRENT		
Plus_Icc	Icc	V_{OUT} = 0V	0.0ma	30.0mA
Minus_Icc	Icc	V_{OUT} = 0V	-30.0mA	0.0mA
		INPUT OFFSET TESTS		
VOS_10V	V_{IO}	V_{OUT} = 0V , V_{CC} = +/- 10Vdc	-12.00mV	12.00mV
VOS_40V	V_{IO}	V_{OUT} = 0V , V_{CC} = +/- 40Vdc	-6.00mV	6.00mV
VOS_45V	V_{IO}	V_{OUT} = 0V , V_{CC} = +/- 45Vdc	-7.00mV	7.00mV
P_IIB_0V	$+I_{IB}$	V_{OUT} = 0V	-30.00nA	30.00nA
N_IIB_0V	$-I_{IB}$	V_{OUT} = 0V	-30.00nA	30.00nA
IIOS_0V	I_{IO}	V_{OUT} = 0V	-30.00nA	30.00nA
CMRR	CMRR	V_{CC} = +/- 15Vdc , V_{CM} = +/- 9V	74dB	
		AMPLIFIER OUTPUT TESTS		
P_VOUT_1K	V_{OP}	Iout =80mA, V_{CC} = +/- 45Vdc	40.0V	
N_VOUT_2K	V_{OP}	Iout =-80mA, V_{CC} = +/- 45Vdc		-40.0V

Exceptions: The Following Tests are Not Performed Due to Tester Limitations:

- OutPut Voltage Swing at Iout = 2A
- OutPut Voltage Swing at Iout = 3A
- OutPut Voltage Swing at Iout = 5A
- Current Limit
- Slew Rate
- Open Loop Gain
- Stability/Noise

TABLE IV: Summary of Electrical Measurements after Total Dose Exposures and Annealing for PA10A /1

Parameters		Spec. Lim./2 min	max	Initials mean	sd	Total Dose Exposure (krads) 5 mean	sd	10 mean	sd	15 mean	sd	20 mean	sd	30 mean	sd	50 mean	sd	75 mean	sd	100 mean	sd	Annealing 168 hrs @25°C mean	sd	168 hrs @100°C mean	sd
Plus_Icc	mA	0	30	19.01	0.62	18.9	0.73	18.9	0.84	18.9	0.75	18.8	0.69	18.8	0.74	18.7	0.79	18.7	0.61	18.5	0.62	18.7	0.82	18.4	0.92
Minus_Icc	mA	-30	0	-18.9	0.65	-18.9	0.83	-18.9	0.82	-18.9	0.74	-18.8	0.73	-18.8	0.76	-18.7	0.81	-18.7	0.62	-18.5	0.59	-18.6	0.83	-18.3	0.92
VOS_10V	m	-12	12	0	0.27	0.20	0.48	1.1	1.26	1.01	1.14	1.04	0.72	1.14	1.47	1.56	0.97	1.09	1.11	1.69	0.59	1.44	0.67	1.82	0.97
VOS_40V	mV	-6	6	-0.19	0.04	-0.13	0.13	1.2	1.08	1.15	1.10	2.04	0.65	1.63	1.19	1.92	1.41	2.18	1.62	1.71	1.23	1.64	1.17	1.95	1.41
VOS_45V	mV	-7	7	-0.19	0.04	-0.22	-0.05	0.91	1.19	0.80	1.21	1.56	0.98	1.19	1.21	1.35	1.25	1.35	1.53	0.79	1.64	1.15	1.61	1.51	1.35
P_IIB_OV	nA	-30	30	4.84	5.15	6.45	4.7	7.9	5.01	10.6	4.91	10.6	4.12	16.7	5.17	25.7	6.37	35.6	6.82	42.1	7.29	35.1	7.01	20.5	4.94
N_IIB_OV	nA	-30	30	21.7	5.04	22.0	4.6	24.2	4.32	28.2	6.73	26.8	2.82	33.8	5.25	46.6	8.06	59.2	7.57	63.0	10.1	55.4	8.54	36.8	4.74
IIOS_OV	nA	-30	30	-11.2	2.71	-21.5	11.4	-15.8	2.53	-17.4	4.26	-16.1	2.19	-17.0	2.64	-20.8	3.88	-23.5	2.64	-20.9	5.56	-20.4	4.34	-16.3	2.16
CMR_18V	dB	74		124.1	11.32	121.5	11.4	107.5	16.11	112	9.74	108.8	5.92	110	10.5	102	5.40	98.0	9.07	104	13.9	102	10.0	110	11.7
P_VOUT	V	40		42.4	0.06	42.4	0.06	42.4	0.06	42.4	0.06	42.4	0.05	42.4	0.06	42.4	0.06	42.4	0.04	42.4	0.04	42.4	0.06	42.5	0.08
N_VOUT	V		-40	-41.4	0.13	-41.4	0.13	-41.4	0.13	-41.4	0.13	-41.4	0.13	-41.4	0.12	-41.4	0.12	-41.4	0.12	-41.4	0.14	-41.4	0.12	-41.4	0.12

1/ The mean and standard deviation values were calculated over the five parts irradiated in this testing. The control sample 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 N_IIB and P_IIB.

Figure 1. Radiation Bias Circuit for PA10A