TOTAL DOSE RADIATION TEST

I. INTRODUCTION

Total dose radiation tests are designed to characterize changes in device performance due to total dose radiation. These tests are not intended to classify maximum radiation tolerance of any particular device, rather, they simply show trends in the critical parameters as a function of total dose. Whether a device meets tolerance requirements is left up to the designer. In many occasions, designers have the ability to circumvent radiation effects by adding appropriate shielding or compensating for the variations in performance.

MIL-STD-883 method 1019 is used as a guideline for these tests. National's gamma radiation source is kept in compliance with method 1019 and radiation test samples are irradiated under dose rate condition A, which tests for total-dose effects. Samples are kept biased while irradiating. Dose rate is maintained between 50 - 300 Rads(Si)/sec and all samples are exposed to a total dose of 200 kRads(Si).

II. RADIATION SOURCE

A. Type

Atomic Energy of Canada Limited cobalt 60 irradiation unit model Gammacell 220 is used to irradiate the devices under test. The Gammacell 220 produces gamma radiation photons approximately 1.25MeV in energy. Dose rate in the gammacell is maintained between 50 and 300 Rads(Si)/sec with an accuracy of +/- 10%.

B. Dosimetery

Thermoluminescence Dosimetery is performed according to MIL-STD-883 method 1019. Actual dose rate for individual test is calculated from the exponential decay approximation of the dosimetery data.

III. TEST SETUP AND PROCEDURE

A. Pre-radiation Electrical Test

All test samples are verified to be functionally and parameterically working prior to irradiation. They are subject to group A qualification test including burn in. Samples are also verified to be within room temperature acceptance limits.

B. Test Environment

Samples are enclosed in a lead/aluminum container vertically aligned with the source of radiation while being irradiated. Ambient temperature throughout the test is approximately 25^{o}C.

C. Biasing

All devices under test are kept biased during irradiation. Bias circuit used for burn-in is also used for irradiation.

C. Electrical Test

Remote electrical tests are performed on the irradiated devices at several total dose levels. All samples are short circuited while transporting to the automatic electrical tester. Electrical tests are completed within two hours of each irradiation step.

IV. DATA PRESENTATION

A Test Summary sheet provides details on the origins of test samples, dose rate, list of parameters tested and total variation in those parameters. Details of the test consists of select device parameter plotted and tabulated as a function of total dose. Test conditions for each parameter are also specified. Acceptance limits specified in RETS or MDS are also plotted on the graph for reference purpose.

This RHA report is supplied only as a guideline to demonstrate the characteristics of our product in a Total Dose Radiation environment. The results reported are representative only of the lot tested in this specific sample and should not be used as generic RHA qualification data. National Semiconductor uses different process flows for different product qualification levels, and National Semiconductor will not guarantee the RHA performance of any product unless National Semiconductor has tested and certified the specific manufacturing lot. At each radiation exposure level, minimum and maximum shows a plausible variation in the parameter values. It is important to remember that this variation includes variation due to radiation exposure as well as variation between lots and variation between wafers. Measurement variation is assumed insignificant. Whenever possible, radiation test reports will provide an estimate of the percentage of total variation that can be attributed to radiation exposure. This estimate is calculated by analysis of variance (ANOVA) or similar statistical method.

LP2953J Total Dose Radiation Test Summary

November 4, 1996

Summary:

This report presents total dose radiation test data for twelve parameters of the LP2953 adjustable micropower low dropout voltage regulator. Four parts, all from one wafer, were exposed to 200k rads and data was collected after 5k, 10k, 30k, 50k, 100k and 200k rad exposure.

Worst case regulated output voltage, occurring at 200k rads was within 2.5% of the expected output of 5V. Data shows a gradual degradation in the average and increasing variation from part to part with the increasing exposure. Line regulation had a potential measurement problem at 100k rad. At that level, three of the four data points were off the scale. At 200k rads, worst case line regulation was 6.5mV. Worst case load regulation, occurring at 200k rads was 3.7mV. Ground current degraded from an average of 138μA prerad to an average of 178μA after 200k rads. Ground current in shut down degraded exponentially from 163μA prerad to 731 μA after 200k rads.

Reference output voltage followed similar trends as the regulated output voltage. Worst case reference output voltage occurring at 200k rads was about 5% higher than the expected output of 1.23V. Reference voltage line regulation also read off the scale data at 100k rads and had a worst case deviation of -0.8mV at 200k rads. Reference output load regulation had negligible degradation upto 100k rads. At 200k rads all of its data points were off the scale.

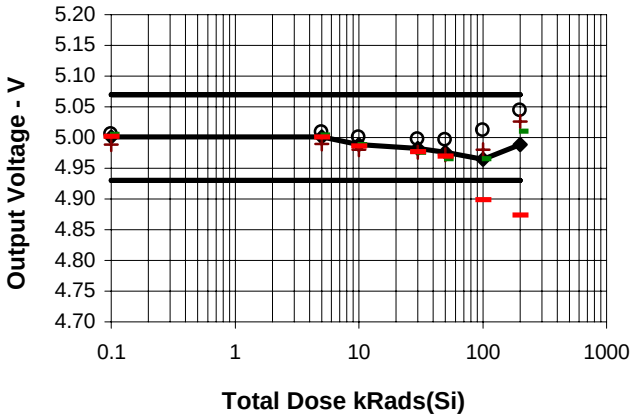
Test Details:

Sample Size:	4
Lot #:	ID9527E019
Wafer Run #:	AM05B188X
Date Code:	9629
Test Date:	17 October 1996
Dose Rate:	123.93 Rads(Si)/sec
MDS:	MNLP2953AM-X 0B0
Bias Circuit:	6261HR
Test Program:	RAD2953RA

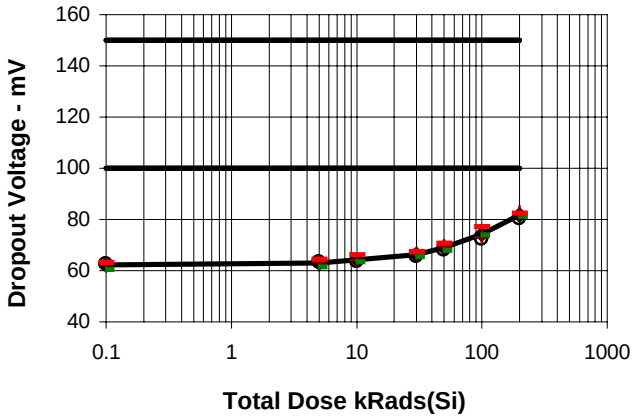
LP2953J
Total Dose Radiation Test Characteristics

November 4, 1996

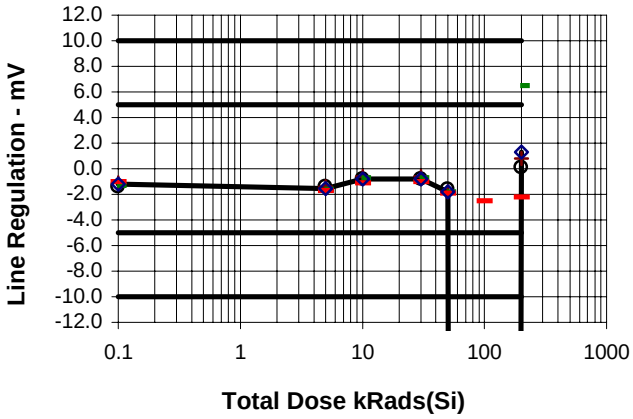
Output Voltage vs Total Dose (V_{IN} = 6V, I_L = 1mA)



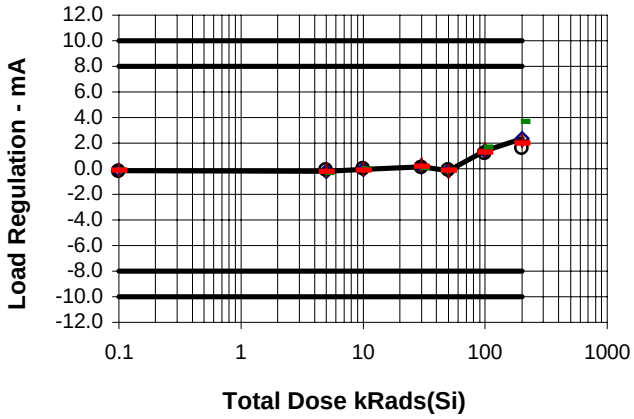
Dropout Voltage vs Total Dose (I_{OUT} = 1 mA)



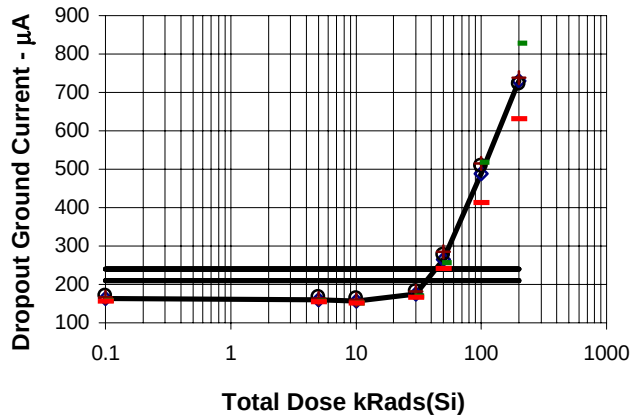
Line Regulation vs Total Dose (V_{IN} = 6 - 30V)



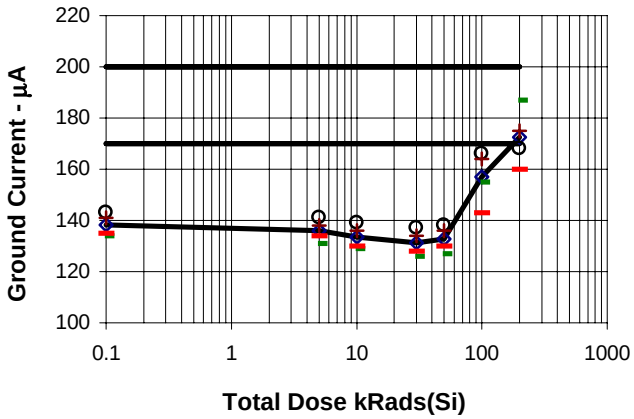
Load Regulation vs Total Dose (I_L = 1 - 0.1mA)



Dropout Ground Current vs Total Dose (V_{IN} = 4.5V, I_L = 100uA)



Ground Pin Current vs Total Dose (I_L = 1mA)



Dose Rate:123.93 Rads(Si)/sec, see table page for standard conditions.

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Total Dose Radiation Test Characteristics

November 4, 1996

Output Voltage vs Total Dose (V_{IN} = 6V, I_L = 1mA)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	5.001	4.989	5.006	0.008	0
5	5.001	4.990	5.009	0.008	0
10	4.989	4.980	5.001	0.009	0
30	4.982	4.976	4.998	0.011	0
50	4.976	4.965	4.997	0.014	0
100	4.964	4.899	5.012	0.048	1
200	4.989	4.874	5.045	0.078	1

Dropout Voltage vs Total Dose (I_{OUT} = 1 mA)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	62.18	60.40	63.20	1.239	0
5	63.13	61.50	64.40	1.204	0
10	64.35	63.40	66.20	1.258	0
30	66.35	65.50	67.60	0.933	0
50	69.10	67.90	70.70	1.299	0
100	74.20	72.50	77.20	2.109	0
200	81.80	80.60	82.80	1.030	0

Line Regulation vs Total Dose (V_{IN} = 6 - 30V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	-1.200	-1.400	-1.000	0.183	0
5	-1.525	-1.700	-1.400	0.150	0
10	-0.800	-1.100	-0.600	0.216	0
30	-0.775	-1.000	-0.600	0.171	0
50	-1.775	-1.900	-1.600	0.126	0
100	-1111.2	-1623.3	-2.500	748.37	3
200	1.300	-2.200	6.500	3.696	1

Load Regulation vs Total Dose (I_L = 1 - 0.1mA)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	-0.13	-0.20	-0.10	0.050	0
5	-0.18	-0.30	-0.10	0.096	0
10	-0.03	-0.10	0.00	0.050	0
30	0.18	0.10	0.30	0.096	0
50	-0.13	-0.20	-0.10	0.050	0
100	1.43	1.20	1.70	0.222	0
200	2.38	1.60	3.70	0.918	0

Dropout Ground Current vs Total Dose (V_{IN} = 4.5V, I_L = 100µA)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	163	157	170	6.055	0
5	160	155	167	5.737	0
10	157	152	164	6.000	0
30	175	167	182	7.890	0
50	265	242	285	19.613	4
100	489	413	519	50.704	4
200	731	632	829	80.724	4

Ground Pin Current vs Total Dose (I_L = 1µA)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	138	134	143	4.425	0
5	136	131	141	4.397	0
10	134	129	139	4.796	0
30	131	126	137	5.123	0
50	133	127	138	5.123	0
100	157	143	166	10.488	0
200	173	160	187	11.446	2

Conditions:

V_{IN} = 6V, I_L = 1mA, C_L = 2.2µF, V_{OUT} = 5V. Feedback pin is tied to 5V Tap pin, Output pin is tied to Output Sense Pin.

Dose Rate:123.93 Rads(Si)/sec

Note 1: Number of devices that were outside MDS sub group 1 limits.

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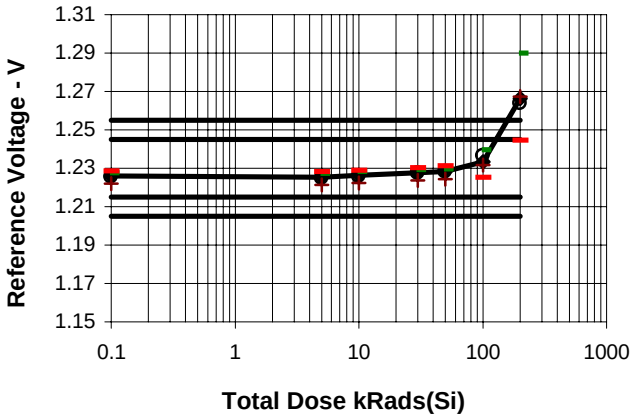
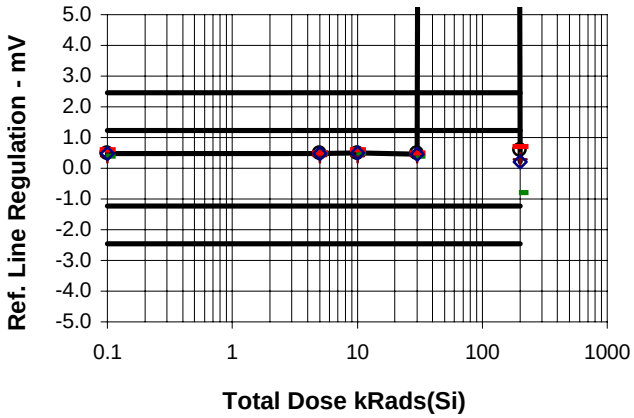
Total Dose Radiation Test Characteristics

November 4, 1996

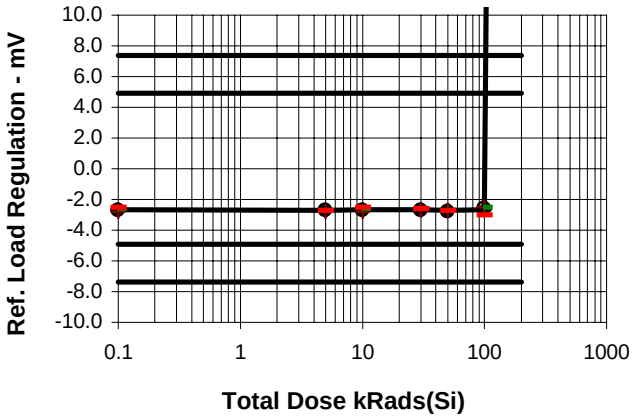
Reference Voltage vs Total Dose



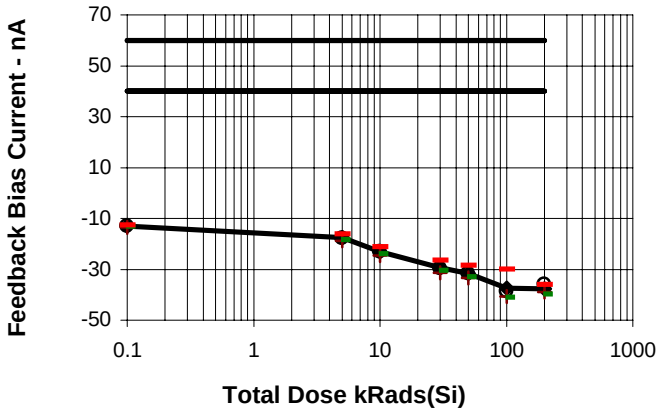
Reference Line Regulation vs Total Dose (V_{IN} = 6V - 30V)



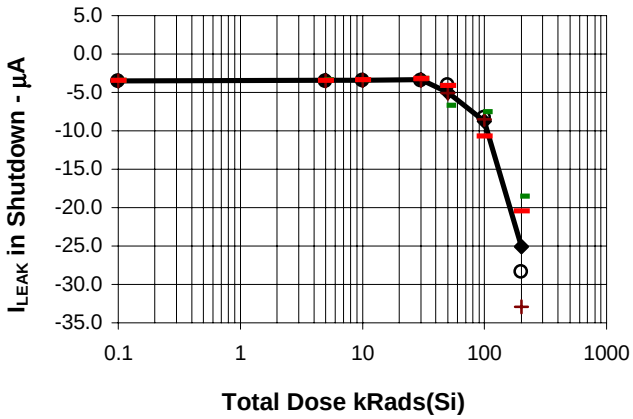
Reference Load Regulation vs Total Dose (I_{REF} = 0 - 200µA)



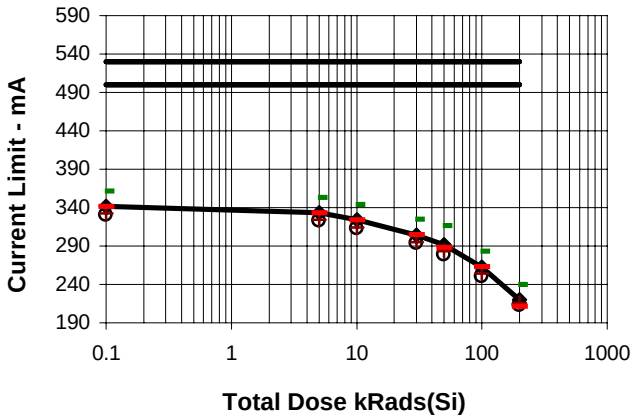
Feedback Pin Bias Current vs Total Dose



Reg. Output Leakage Current in Shutdown vs Total Dose (V_{OUT} = 0V, V_{IN} = 30V)



Current Limit vs Total Dose (V_{OUT} = 0)



Dose Rate: 123.93 Rads(Si)/sec, see table page for standard conditions.

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Total Dose Radiation Test Characteristics

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Reference Voltage vs Total Dose

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	1.226	1.222	1.229	0.003	0
5	1.225	1.221	1.228	0.003	0
10	1.226	1.222	1.229	0.003	0
30	1.228	1.224	1.231	0.003	0
50	1.228	1.224	1.231	0.003	0
100	1.233	1.225	1.240	0.006	0
200	1.266	1.245	1.290	0.019	3

Reference Line Regulation vs Total Dose (V_{IN} = 6V - 30V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	0.475	0.400	0.600	0.096	0
5	0.475	0.400	0.500	0.050	0
10	0.500	0.400	0.600	0.082	0
30	0.450	0.400	0.500	0.058	0
50	327.03	224.60	485.20	115.82	4
100	447.78	352.40	636.40	128.48	4
200	0.200	-0.800	0.700	0.688	0

Reference Load Regulation vs Total Dose (I_{REF} = 0 - 200mA)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	-2.65	-2.80	-2.50	0.129	0
5	-2.73	-2.80	-2.70	0.050	0
10	-2.65	-2.80	-2.50	0.129	0
30	-2.65	-2.70	-2.60	0.058	0
50	-2.73	-2.80	-2.70	0.050	0
100	-2.65	-3.00	-2.50	0.238	0
200	267.80	263.70	271.40	3.216	4

Feedback Pin Bias Current vs Total Dose

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	-13.01	-13.50	-12.42	0.450	0
5	-17.66	-18.78	-15.96	1.213	0
10	-23.21	-24.66	-21.12	1.519	0
30	-29.37	-31.26	-26.40	2.104	0
50	-31.65	-33.48	-28.38	2.300	0
100	-37.53	-40.86	-29.82	5.243	0
200	-37.58	-39.78	-35.82	2.030	0

Reg. Output Leakage Current in Shutdown vs Total Dose (V_{OUT} = 0V, V_{IN} = 30V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	-3.48	-3.60	-3.40	0.096	N/A
5	-3.45	-3.60	-3.30	0.129	N/A
10	-3.38	-3.50	-3.30	0.096	N/A
30	-3.33	-3.50	-3.20	0.150	N/A
50	-5.00	-6.70	-4.10	1.227	N/A
100	-8.75	-10.70	-7.50	1.370	N/A
200	-25.05	-32.90	-18.50	6.767	N/A

Current Limit vs Total Dose (V_{OUT} = 0V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	341.5	330.3	361.7	14.36	0
5	333.2	322.2	353.4	14.32	0
10	323.8	312.6	344.2	14.58	0
30	304.5	293.4	324.7	14.35	0
50	291.7	278.1	317.0	17.41	0
100	262.7	250.1	283.5	14.91	0
200	220.0	211.6	240.0	13.47	0

Conditoins:

V_{IN} = 6V, I_L = 1mA, C_L = 2.2µF, V_{OUT} = 5V. Feedback pin is tied to 5V Tap pin, Output pin is tied to Output Sense Pin.

Dose Rate:123.93 Rads(Si)/sec

Note 1: Number of devices that were outside MDS sub group 1 limits.