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.

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Total Dose Radiation Test Summary

- Output voltage deteriorated to -4.7V after 200k Rad(Si) exposure. All samples met room temperature V_{OUT} spec at 100k Rad(Si) and failed at 200kRad(Si). All samples met extended temperature V_{OUT} specs throughout the test.

- Quiescent current did not have any significant degradation throughout the test.

- Line regulation started to deteriorate after 10k Rads(Si). Its final value was roughly 40mV. Datasheet limit for room and extended temperature is 40mV.

- Load regulation some intermittent failures which are potentially due to measurement errors. In general, samples do not show a significant deterioration for this parameter. At 200k Rad(Si), two devices fall outside the extended temperature spec limits.

- With load current of 100mA, dropout voltage showed very small effect due to radiation exposure. On average, V_{DO} from 0.114V to 0.137V post 200k Rad(Si). With 1A load current, Two devices failed after 200k Rad(Si). On average V_{DO} changed from 0.65V to 1.031V post 200k Rad(Si).

- Ripple rejection started to deteriorate at 30k Rad(Si) and all samples failed at 200k Rad(Si). All samples were within specs at 100k Rad(Si).

- Short circuit current and dropout quiescent current showed little or no effect due to radiation.

Test Details:

Test Date:	10/25/96	Dose Rate:	123.57 Rad(Si)/sec
Wafer Run #:	A0061273	Samples:	8
Program:	RAD2990RA		
MDS:	MNLM2990-X-5.0 REV 0A0		
Bias Circuit:	6324RA		

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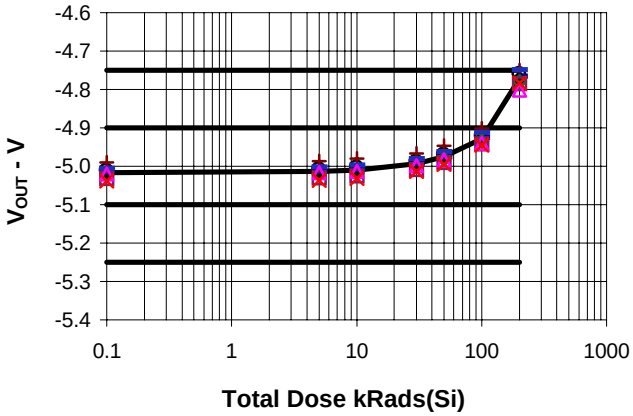
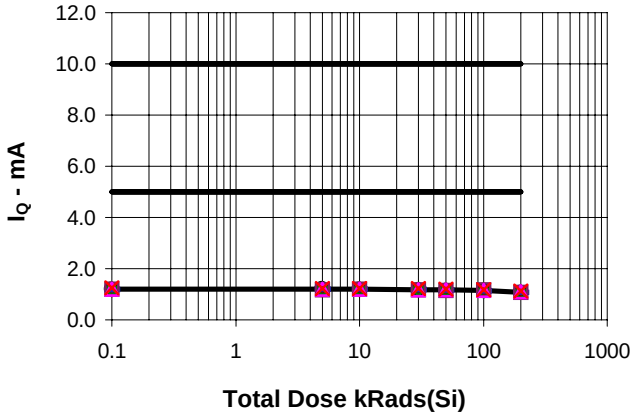
Total Dose Radiation Characteristics

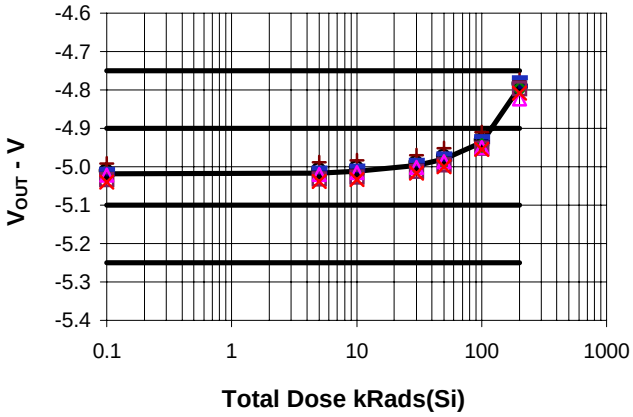
Output Voltage vs Total Dose (V_{IN} = -5V, I_O = 5mA)



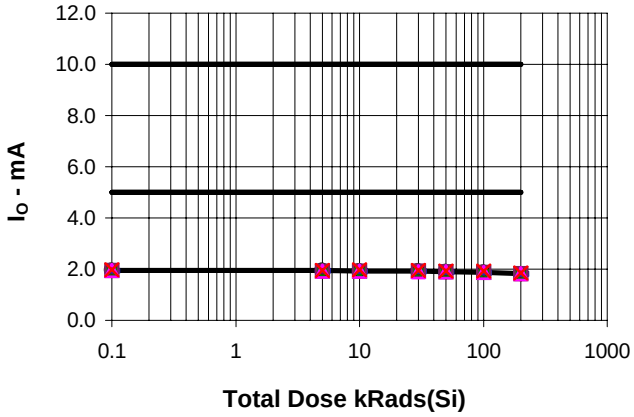
Quiescent Current vs Total Dose (V_{IN} = -17V, I_O = 5mA)



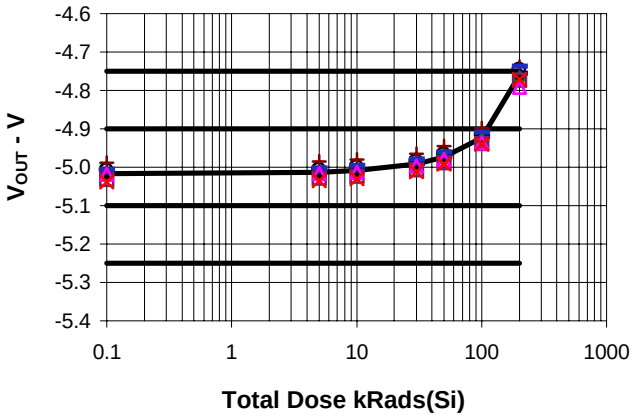
Output Voltage vs Total Dose (V_{IN} = -26V, I_O = 5mA)



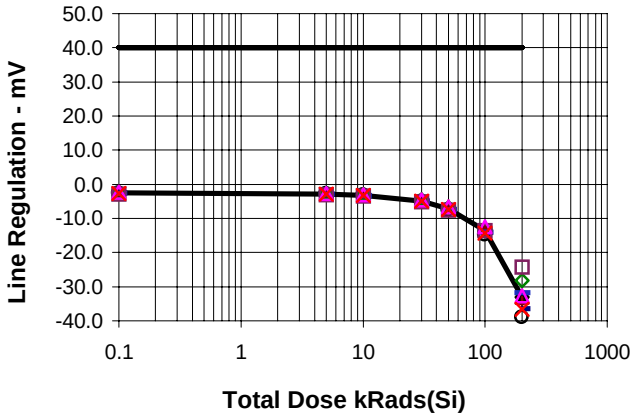
Quiescent Current vs Total Dose (V_{IN} = -26V, I_O = 5mA)



Output Voltage vs Total Dose (V_{IN} = -13V, I_O = 5mA)



Line Regulation vs Total Dose (V_{IN} = -13V > -26V, I_O = 5mA)



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Total Dose Radiation Characteristics

Output Voltage vs Total Dose (V_{IN} = -5V, I_O = 5mA)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	-5.017	-5.039	-4.990	0.016	0
5	-5.014	-5.036	-4.986	0.016	0
10	-5.009	-5.031	-4.981	0.016	0
30	-4.993	-5.014	-4.966	0.016	0
50	-4.975	-4.994	-4.947	0.016	0
100	-4.928	-4.944	-4.901	0.016	0
200	-4.771	-4.801	-4.749	0.019	0

Quiescent Current vs Total Dose (V_{IN} = -17V, I_O = 5mA)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	1.201	1.175	1.248	0.023	0
5	1.198	1.183	1.218	0.014	0
10	1.196	1.180	1.215	0.010	0
30	1.183	1.163	1.228	0.021	0
50	1.168	1.145	1.196	0.017	0
100	1.149	1.128	1.183	0.020	0
200	1.087	1.063	1.113	0.016	0

Output Voltage vs Total Dose (V_{IN} = -26V, I_O = 5mA)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	-5.019	-5.041	-4.991	0.016	0
5	-5.016	-5.038	-4.988	0.016	0
10	-5.011	-5.034	-4.983	0.016	0
30	-4.997	-5.017	-4.969	0.016	0
50	-4.980	-4.999	-4.952	0.016	0
100	-4.937	-4.954	-4.910	0.016	0
200	-4.793	-4.824	-4.769	0.018	0

Quiescent Current vs Total Dose (V_{IN} = -26V, I_O = 5mA)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	1.946	1.916	1.968	0.015	0
5	1.939	1.916	1.958	0.013	0
10	1.934	1.906	1.963	0.017	0
30	1.916	1.891	1.943	0.016	0
50	1.904	1.881	1.933	0.017	0
100	1.880	1.858	1.916	0.017	0
200	1.822	1.798	1.848	0.015	0

Output Voltage vs Total Dose (V_{IN} = -13V, I_O = 5mA)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	-5.016	-5.038	-4.989	0.016	0
5	-5.013	-5.035	-4.985	0.016	0
10	-5.008	-5.030	-4.980	0.016	0
30	-4.992	-5.012	-4.965	0.016	0
50	-4.973	-4.992	-4.945	0.016	0
100	-4.924	-4.940	-4.898	0.016	0
200	-4.760	-4.791	-4.737	0.019	3

Line Regulation vs Total Dose (V_{IN} = -13V > -26V, I_O = 5mA)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	-2.563	-2.800	-2.300	0.169	0
5	-2.800	-3.000	-2.600	0.120	0
10	-3.200	-3.400	-3.000	0.141	0
30	-4.850	-5.100	-4.500	0.245	0
50	-7.150	-7.600	-6.600	0.370	0
100	-13.638	-14.800	-12.500	0.776	0
200	-32.988	-39.000	-24.200	4.896	0

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

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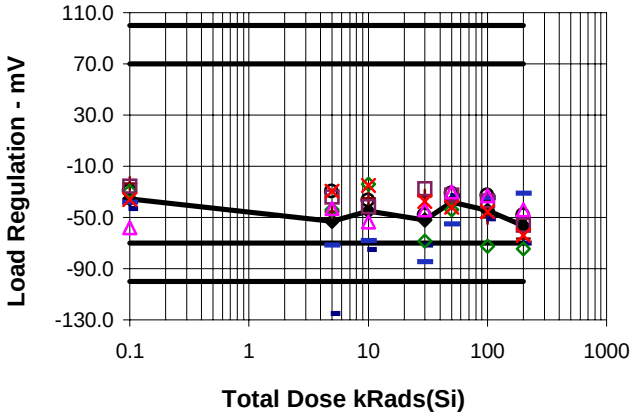
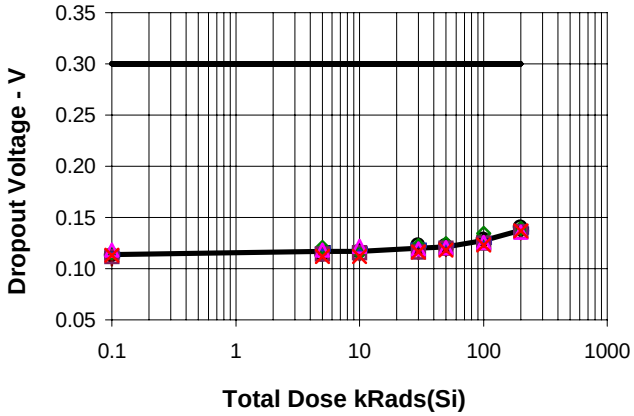
Total Dose Radiation Characteristics

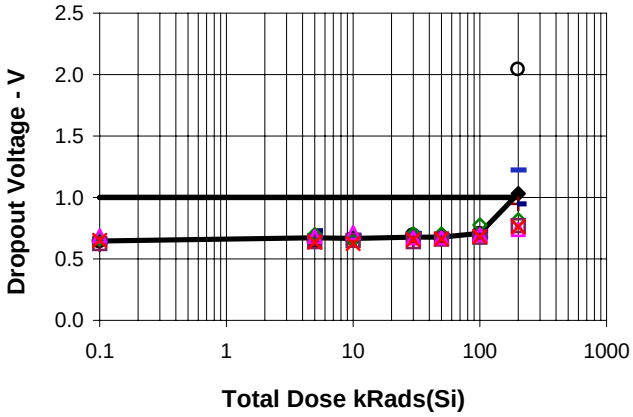
Load Regulation vs Total Dose (V_{IN} = -17V, I_O = 50mA > 1.0A)



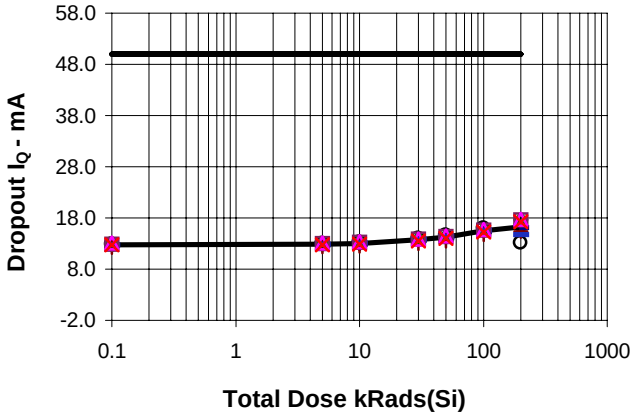
Dropout Voltage vs Total Dose (I_O = 100mA)



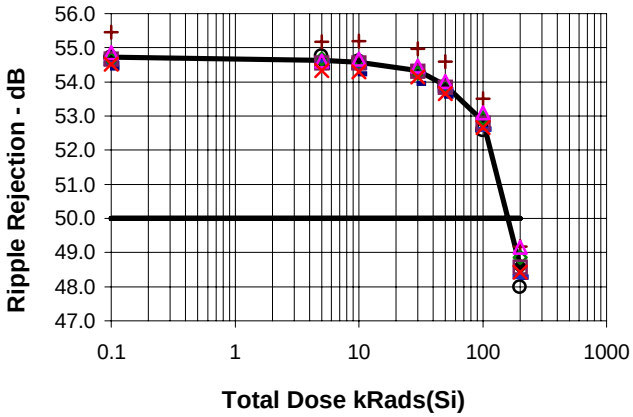
Dropout Voltage vs Total Dose (I_O = 1.0A)



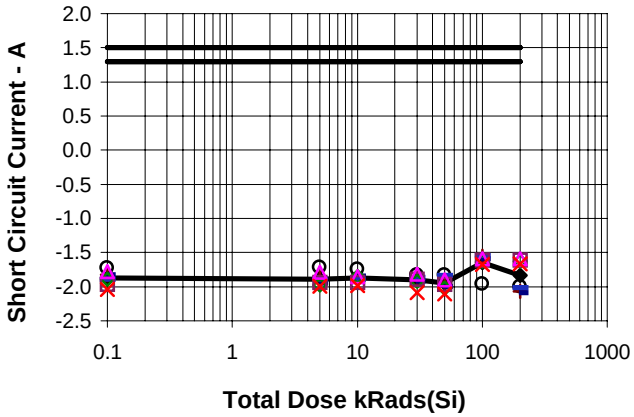
Dropout Quiescent Current vs Total Dose (V_{IN} = -12V, I_O = 1.0A)



Ripple Rejection vs Total Dose (V_{IN} = -17V(DC)+1V(RMS)(F = 1KHZ), I_O = 5mA)



Short Circuit Current vs Total Dose (V_{IN} = -17V, R_L = 1.00 OHM)



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Total Dose Radiation Characteristics

Load Regulation vs Total

Dose (V_{IN} = -17V, I_O = 50mA > 1.0A)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	-35.263	-57.9	-23.3	11.284	0
5	-52.800	-124.9	-29.3	32.115	2
10	-44.800	-75.0	-23.9	18.966	0
30	-51.850	-84.5	-27.4	20.549	1
50	-38.025	-55.0	-30.2	8.450	0
100	-44.513	-72.6	-32.7	13.573	1
200	-56.700	-74.5	-31.1	14.803	2

Dropout Voltage vs Total

Dose (I_O = 100mA)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	0.114	0.109	0.118	0.003	0
5	0.117	0.112	0.121	0.003	0
10	0.117	0.112	0.122	0.003	0
30	0.120	0.116	0.123	0.003	0
50	0.121	0.118	0.124	0.002	0
100	0.127	0.123	0.134	0.003	0
200	0.137	0.135	0.141	0.002	0

Dropout Voltage vs Total

Dose (I_O = 1.0A)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	0.647	0.615	0.690	0.023	0
5	0.672	0.634	0.729	0.033	0
10	0.666	0.625	0.713	0.028	0
30	0.678	0.643	0.707	0.027	0
50	0.676	0.661	0.704	0.016	0
100	0.706	0.677	0.777	0.034	0
200	1.031	0.738	2.040	0.438	2

Dropout Quiescent Current vs Total

Dose (V_{IN} = -12V, I_O = 1.0A)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	12.780	12.29	13.07	0.238	0
5	12.855	12.34	13.12	0.245	0
10	13.040	12.49	13.32	0.264	0
30	13.694	13.02	13.94	0.313	0
50	14.245	13.54	14.62	0.354	0
100	15.536	14.77	16.04	0.383	0
200	16.216	13.17	17.72	1.681	0

Ripple Rejection vs Total Dose

(V_{IN} = -17V(DC)+1V(RMS)(F = 1KHZ), I_O = 5mA)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	54.729	54.41	55.46	0.326	0
5	54.638	54.33	55.18	0.255	0
10	54.576	54.24	55.20	0.298	0
30	54.333	53.96	54.96	0.292	0
50	53.896	53.59	54.59	0.311	0
100	52.849	52.57	53.51	0.324	0
200	48.591	47.98	49.18	0.433	8

Short Circuit Current vs Total

Dose (V_{IN} = -17V, R_L = 1.00 OHM)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	-1.869	-2.045	-1.732	0.101	0
5	-1.891	-1.995	-1.720	0.095	0
10	-1.874	-1.987	-1.747	0.070	0
30	-1.900	-2.087	-1.815	0.084	0
50	-1.950	-2.107	-1.837	0.093	0
100	-1.645	-1.970	-1.542	0.138	0
200	-1.835	-2.085	-1.595	0.227	0

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