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.

LM2991J Total Dose Radiation Test Summary

Summary:

This report includes data for eleven parameters specified in the MDS for the LM2991J. Data shows that all samples remained inside the room temperature limits at 10kRads. At 30kRads, all output voltage tests failed and the devices functionally failed. Actual radiation tolerance of LM2991J is somewhere between 10kRads and 30kRads. There was negligible difference in performance between the three wafer runs. Summary of the parameters that were included in the test is shown in the following table.

Parameter	Average % Change Pre-rad to 10k rad
Output Voltage V_{OUT} = -3V, V_{IN} = -10V, I_L = 1A	0.24
Output Voltage V_{OUT} = -24V, V_{IN} = -26V, I_L = 5mA	0.22
Quiescent Current V_{OUT} = -3V, V_{IN} = -10V, I_L = 1A	-0.30
Line Regulation V_{OUT} = -3V, I_L = 5mA	11.66
Load Regulation I_L < 1.2A	-3.14
Dropout Voltage I_L = 1A	0.32
ON/OFF Pin Current (OFF) V_{IN} = -10V, I_L = 5mA	-1.73
ON/OFF Pin Current (ON) V_{IN} = -10V, I_L = 5mA	2.17
Leakage Current Device OFF	-0.61
Output Impedance V_{IN} = -10V, I_L = 1A	7.13
V_{OUT} Recovery V_{IN} = -10V, I_L = 5mA	0.25

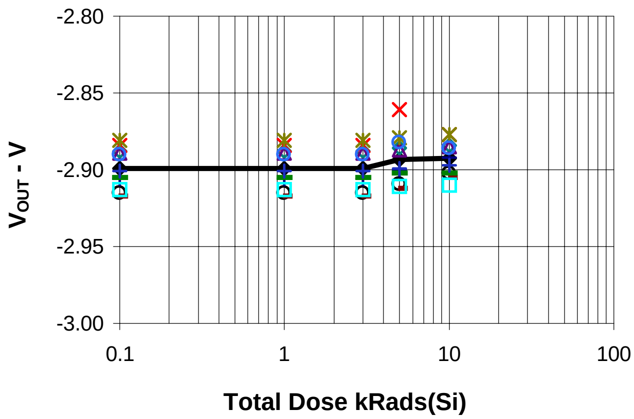
Test Details:

Sample Size:	11	
Lot #:	STM633978	(Samples 1 - 3)
	STM63977	(Samples 4 - 7)
	STM63976A	(Samples 8 - 11)
Die Run#:	AM057029X	(Samples 1 - 3)
	AM05B559X	(Samples 4 - 7)
	AM05B562A	(Samples 8 - 11)
Date Code:	9549	(All samples)

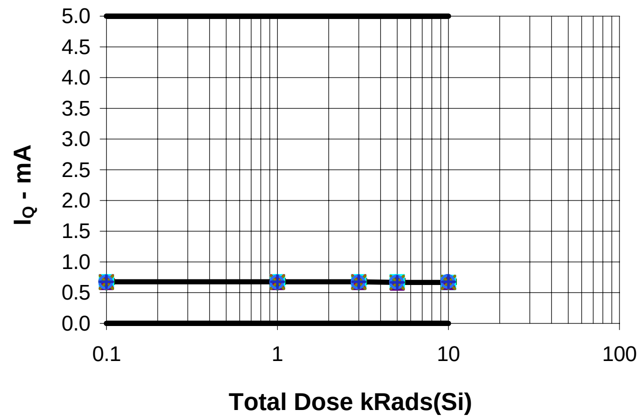
Test Date:	9 May 1996
Dose Rate:	104.10 +/- 10%
MDS:	MNLM2991-X Revision 0A0
Bias Circuit:	06323HR
Test Program:	RAD2991RA

LM2991J Total Dose Radiatioan Test Performance Characteristics[1]

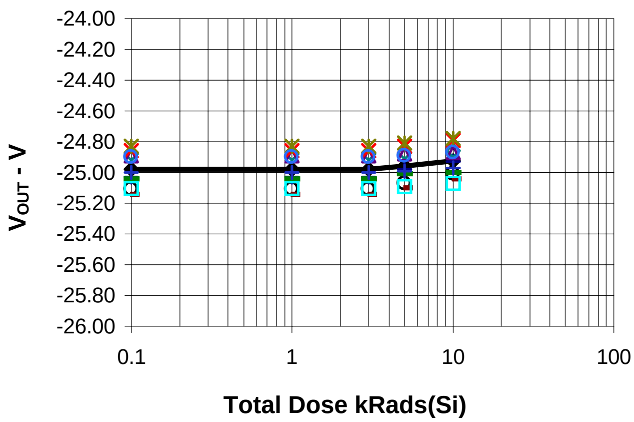
V_{OUT} vs Total Dose[2]
(V_{OUT} = -3V, V_{IN} = -4V, I_L = 1A)



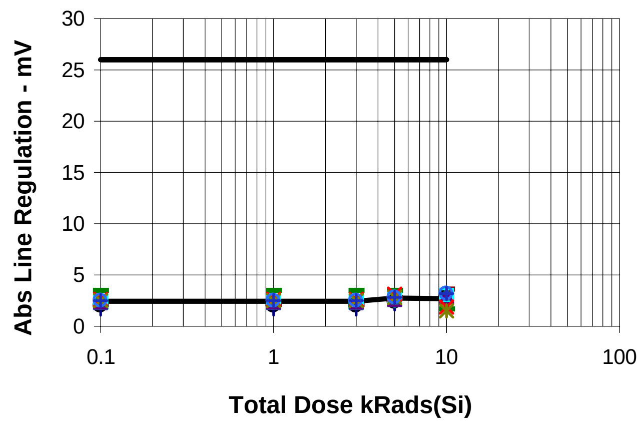
I_Q vs Total Dose
(V_{OUT} = -3V, V_{IN} = -10V, I_L = 1A)



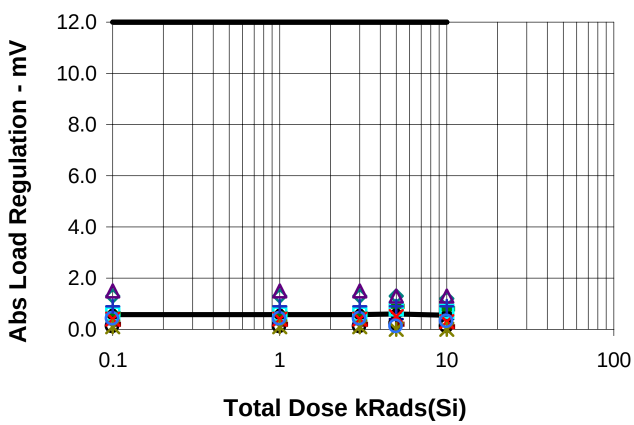
V_{OUT} vs Total Dose[2]
(V_{OUT} = -24V, V_{IN} = -26V, I_L = 5mA)



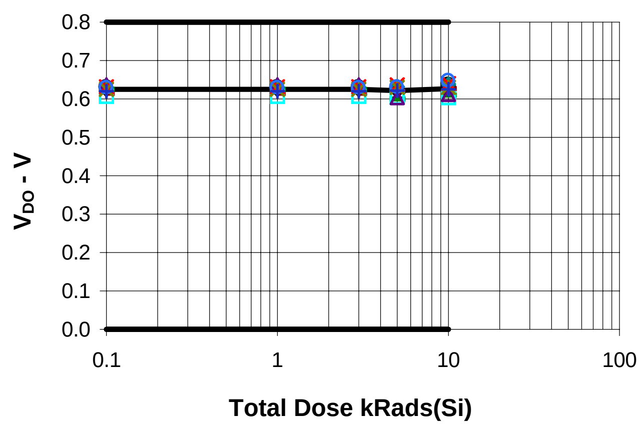
Line Regulation vs Total Dose (V_{OUT} = -3V, I_L = 5mA)



Load Regulation vs Total Dose (I_L < 1.2A)



V_{DO} vs Total Dose
(I_L = 1A)



Note 1: Dose Rate = 104.10 Rads(Si)/sec.

Note 2: Spec limits are +/-2% of V_{OUT}. No failures up to 10kRads(Si).

LM2991J Total Dose Radiatioan Test Performance Characteristics

V_{OUT} vs Total Dose
(V_{OUT} = 3V, V_{IN} = 4V, I_L = 1A)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	-2.899	-2.917	-2.881	0.013	0
1	-2.899	-2.917	-2.881	0.013	0
3	-2.899	-2.917	-2.881	0.013	0
5	-2.893	-2.912	-2.861	0.016	0
10	-2.892	-2.910	-2.877	0.011	0
30	N/A	N/A	N/A	N/A	11
50	N/A	N/A	N/A	N/A	11
100	N/A	N/A	N/A	N/A	11
200	N/A	N/A	N/A	N/A	11

I_Q vs Total Dose
(V_{OUT} = -3V, V_{IN} = -10V, I_L = 1A)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	0.673	0.661	0.699	0.010	0
1	0.673	0.661	0.699	0.010	0
3	0.673	0.661	0.699	0.010	0
5	0.672	0.661	0.694	0.009	0
10	0.671	0.662	0.690	0.007	0
30	N/A	N/A	N/A	N/A	11
50	N/A	N/A	N/A	N/A	11
100	N/A	N/A	N/A	N/A	11
200	N/A	N/A	N/A	N/A	11

V_{OUT} vs Total Dose
(V_{OUT} = -24V, V_{IN} = -26V, I_L = 5mA)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	-24.980	-25.140	-24.830	0.112	0
1	-24.980	-25.140	-24.830	0.112	0
3	-24.980	-25.140	-24.830	0.112	0
5	-24.956	-25.100	-24.810	0.105	0
10	-24.926	-25.070	-24.780	0.099	0
30	N/A	N/A	N/A	N/A	11
50	N/A	N/A	N/A	N/A	11
100	N/A	N/A	N/A	N/A	11
200	N/A	N/A	N/A	N/A	11

Line Regulation vs Total Dose (V_{OUT} = -3V, I_L = 5mA)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	2.418	1.700	3.500	0.449	0
1	2.418	1.700	3.500	0.449	0
3	2.418	1.700	3.500	0.449	0
5	2.736	2.200	3.500	0.350	0
10	2.700	1.500	3.600	0.681	0
30	N/A	N/A	N/A	N/A	11
50	N/A	N/A	N/A	N/A	11
100	N/A	N/A	N/A	N/A	11
200	N/A	N/A	N/A	N/A	11

Load Regulation vs Total Dose (I_L < 1.2A)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	0.573	0.100	1.500	0.478	0
1	0.573	0.100	1.500	0.478	0
3	0.573	0.100	1.500	0.478	0
5	0.600	0.000	1.300	0.467	0
10	0.555	0.000	1.300	0.452	0
30	N/A	N/A	N/A	N/A	11
50	N/A	N/A	N/A	N/A	11
100	N/A	N/A	N/A	N/A	11
200	N/A	N/A	N/A	N/A	11

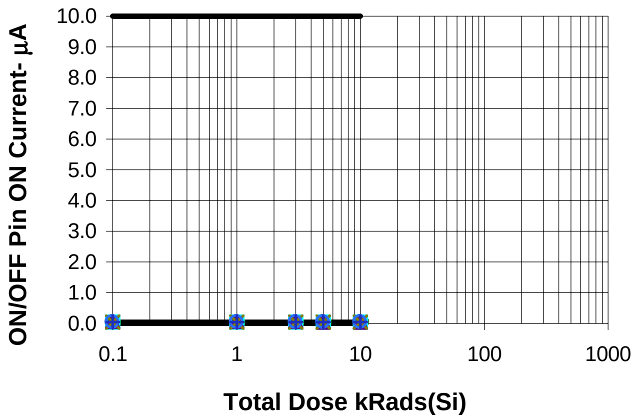
V_{DO} vs Total Dose
(I_L = 1A)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	0.625	0.607	0.637	0.008	0
1	0.625	0.607	0.637	0.008	0
3	0.625	0.607	0.637	0.008	0
5	0.621	0.599	0.636	0.013	0
10	0.627	0.603	0.646	0.014	0
30	N/A	N/A	N/A	N/A	11
50	N/A	N/A	N/A	N/A	11
100	N/A	N/A	N/A	N/A	11
200	N/A	N/A	N/A	N/A	11

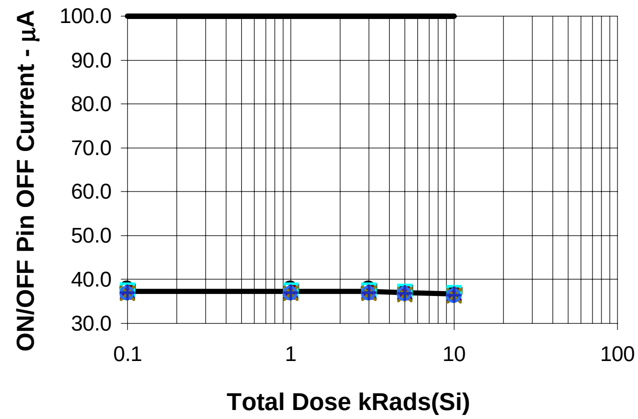
Note 1: Number of devices that were outside MDS sub group 1 limits.

LM2991J Total Dose Radiatioan Test Performance Characteristics[1]

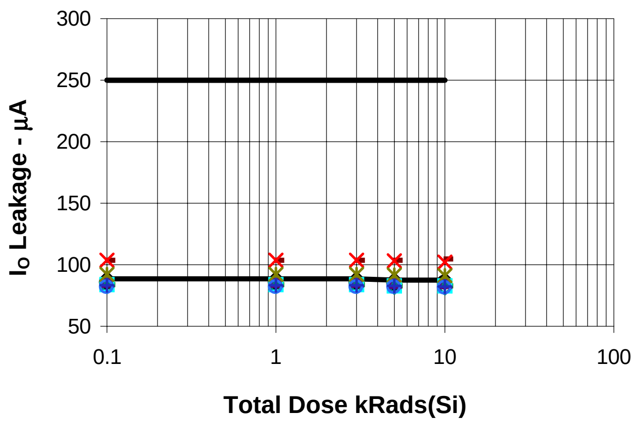
ON/OFF Pin ON Current vs Total Dose (V_{IN} = -10V, I_L = 5mA)



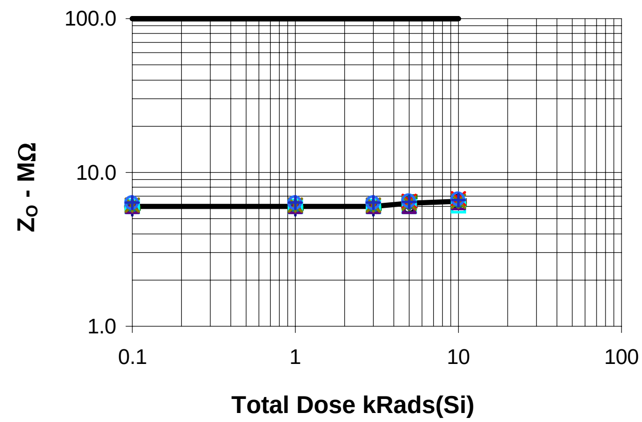
ON/OFF Pin OFF Current vs Total Dose (V_{IN} = -10V, I_L = 5mA)



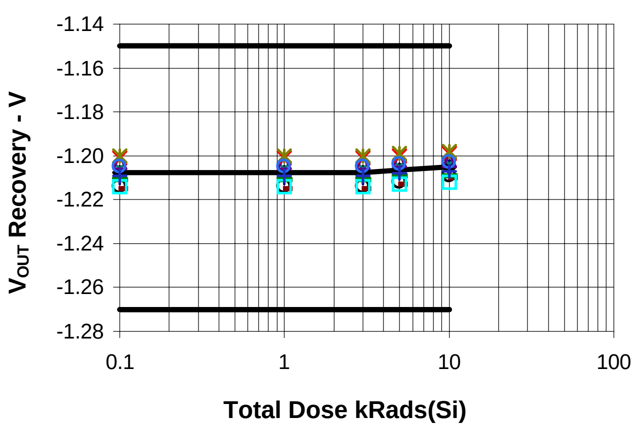
Output Leakage Current vs Total Dose (Device OFF)



Output Impedance vs Total Dose (V_{IN} = -10V, I_L = 1A)



V_{OUT} Recovery vs Total Dose (V_{IN} = -10V, I_L = 5mA)



Note 1: Dose Rate = 104.10 Rads(Si)/sec.

LM2991J Total Dose Radiatioan Test Performance Characteristics

ON/OFF Pin ON Current vs Total Dose (V_{IN} = -10V, I_L = 5mA)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	0.046	0.035	0.055	0.005	0
1	0.046	0.035	0.055	0.005	0
3	0.046	0.035	0.055	0.005	0
5	0.045	0.040	0.047	0.002	0
10	0.047	0.042	0.055	0.004	0
30	N/A	N/A	N/A	N/A	11
50	N/A	N/A	N/A	N/A	11
100	N/A	N/A	N/A	N/A	11
200	N/A	N/A	N/A	N/A	11

ON/OFF Pin OFF Current vs Total Dose (V_{IN} = -10V, I_L = 5mA)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	37.363	36.790	38.510	0.523	0
1	37.363	36.790	38.510	0.523	0
3	37.363	36.790	38.510	0.523	0
5	37.050	36.580	38.180	0.455	0
10	36.718	36.200	37.700	0.440	0
30	N/A	N/A	N/A	N/A	11
50	N/A	N/A	N/A	N/A	11
100	N/A	N/A	N/A	N/A	11
200	N/A	N/A	N/A	N/A	11

Output Leakage Current vs Total Dose (Device OFF)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	88.29	81.90	103.70	8.07	0
1	88.29	81.90	103.70	8.07	0
3	88.29	81.90	103.70	8.07	0
5	87.75	81.70	103.70	8.27	0
10	87.75	81.20	104.70	8.26	0
30	N/A	N/A	N/A	N/A	11
50	N/A	N/A	N/A	N/A	11
100	N/A	N/A	N/A	N/A	11
200	N/A	N/A	N/A	N/A	11

Output Impedance vs Total Dose (V_{IN} = -10V, I_L = 1A)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	6.041	5.770	6.340	0.178	0
1	6.041	5.770	6.340	0.178	0
3	6.041	5.770	6.340	0.178	0
5	6.296	5.940	6.930	0.293	0
10	6.472	6.070	6.780	0.214	0
30	N/A	N/A	N/A	N/A	11
50	N/A	N/A	N/A	N/A	11
100	N/A	N/A	N/A	N/A	11
200	N/A	N/A	N/A	N/A	11

V_{OUT} Recovery vs Total Dose (V_{IN} = -10V, I_L = 5mA)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	-1.208	-1.215	-1.200	0.006	0
1	-1.208	-1.215	-1.200	0.006	0
3	-1.208	-1.215	-1.200	0.006	0
5	-1.206	-1.213	-1.199	0.005	0
10	-1.205	-1.212	-1.198	0.005	0
30	N/A	N/A	N/A	N/A	11
50	N/A	N/A	N/A	N/A	11
100	N/A	N/A	N/A	N/A	11
200	N/A	N/A	N/A	N/A	11

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