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.

LM111H Total Dose Radiation Test Summary

Summary:

This report includes data for six parameters specified in RETS for the LM111H. Data shows that the samples remained inside the room temperature limits only up to 5kRads(Si). At 10kRads(Si), input bias current in two of the four samples was just outside the spec limit. At 100kRads(Si), saturation voltage in all four samples were outside the spec limits. Other four parameters were well within room temperature spec limits for the duration of the exposure. All four samples were functional at 200kRads(Si). Summary of those six parameters is shown in the following table.

Parameter	Average % Change Pre-rad to post 200k rad
Input Offset Voltage V_{CM} = 13.5V	434.29
Input Offset Current V_{CM} = 13.5V, R_L = 14kΩ	-5894.11
Positive Supply Current V_{CM} = 13.5V, R_L = 14kΩ	-0.385
Input Bias Current V_{CM} = -14.5V, R_L = 14kΩ	427.83
Gain ΔV_{OUT} = 48V, R_L = 1kΩ	-53.88
Saturation Voltage V_{IN} = Unknown, I_L = 50mA	331.59

V_{56} = 0V, R_S = 0Ω, V_{CC} = 30V, V_{OUT} = 1.4V w.r.t. -V_{CC} unless specified otherwise

Test Details:

Sample Size: 4

Lot #: MU0765K027

Die Run#: HL05B171

Date Code: 9606

Test Date: 3 May 1996

Dose Rate: 104.32 +/- 10%

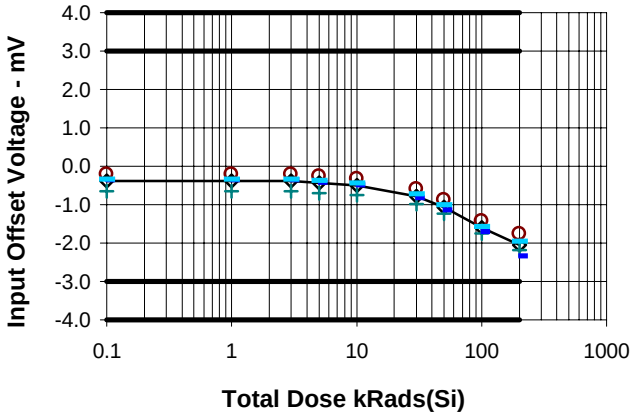
RETS: RETS111X Revision 9A

Bias Circuit: 8358HR

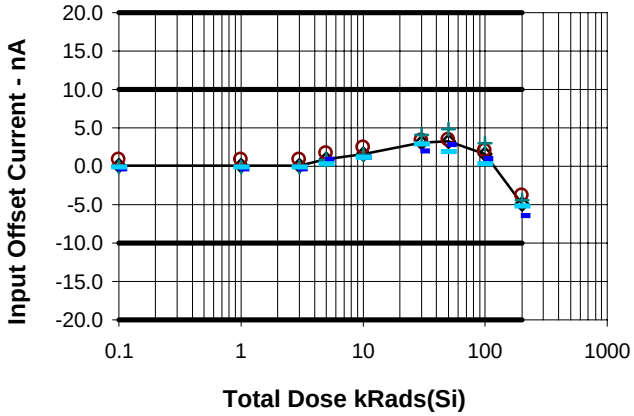
Test Program: RAD111XRA

LM111H
Total Dose Radiation Test Characteristics

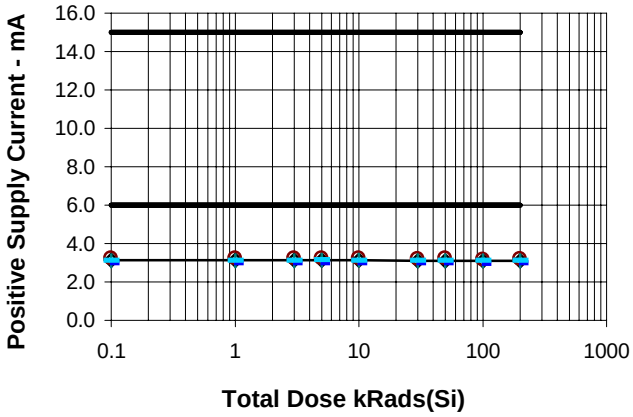
Input Offset Voltage vs Total Dose (V_{CM} = 13.5V)



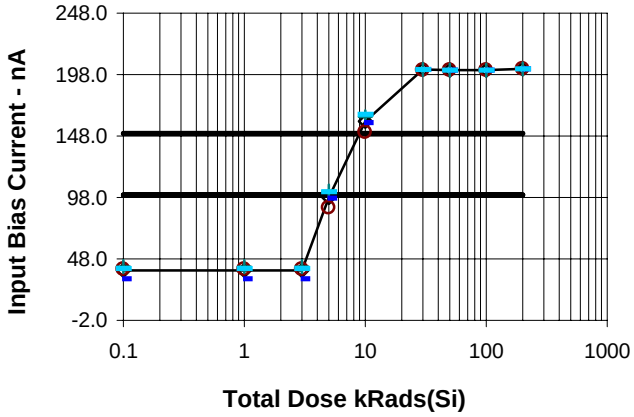
Input Offset Current vs Total Dose (V_{CM} = 13.5V, R_L = 14kΩ)



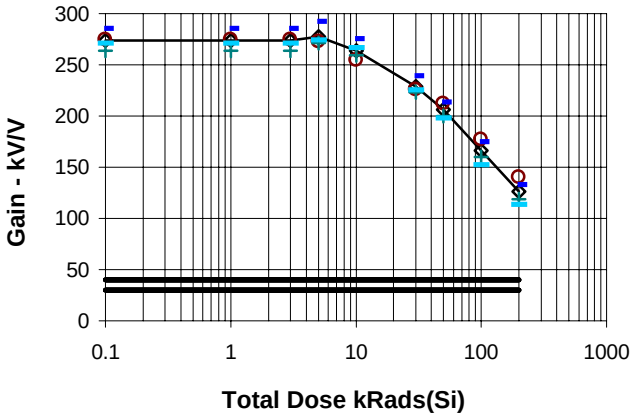
Supply Current vs Total Dose (V_{CM} = 13.5V, R_L = 14kΩ)



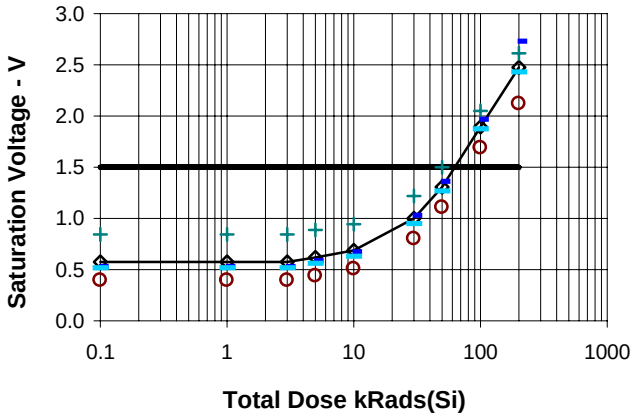
Bias Current vs Total Dose (V_{CM} = -14.5V, R_L = 14kΩ)



Gain vs Total Dose (ΔV_{OUT} = 48V, R_L = 1kΩ)



Saturation Voltage vs Total Dose (I_L = 50mA, V_{IN} = Unknown)



LM111H
Total Dose Radiation Test Characteristics

Input Offset Voltage vs Total Dose (V_{CM} = 13.5V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	-0.385	-0.654	-0.203	0.191	0
1	-0.385	-0.654	-0.203	0.191	0
3	-0.385	-0.654	-0.203	0.191	0
5	-0.436	-0.697	-0.255	0.187	0
10	-0.497	-0.749	-0.309	0.185	0
30	-0.777	-0.990	-0.583	0.172	0
50	-1.059	-1.238	-0.867	0.159	0
100	-1.608	-1.743	-1.423	0.145	0
200	-2.057	-2.340	-1.757	0.256	0

Input Offset Current vs Total Dose (V_{CM} = 13.5V, R_L = 14kΩ)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	0.085	-0.340	0.880	0.542	0
1	0.085	-0.340	0.880	0.542	0
3	0.085	-0.340	0.880	0.542	0
5	0.955	0.320	1.740	0.587	0
10	1.600	1.140	2.520	0.638	0
30	3.095	1.980	4.080	0.883	0
50	3.285	1.940	4.860	1.229	0
100	1.600	0.320	3.000	1.194	0
200	-4.925	-6.400	-3.740	1.142	0

Supply Current vs Total Dose (V_{CM} = 13.5V, R_L = 14kΩ)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	3.120	2.990	3.240	0.104	0
1	3.120	2.990	3.240	0.104	0
3	3.120	2.990	3.240	0.104	0
5	3.138	3.010	3.220	0.090	0
10	3.128	3.000	3.230	0.095	0
30	3.110	2.990	3.200	0.088	0
50	3.115	3.000	3.220	0.090	0
100	3.095	2.980	3.180	0.085	0
200	3.108	2.990	3.190	0.085	0

Bias Current vs Total Dose (V_{CM} = -14.5V, R_L = 14kΩ)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	38.38	31.71	41.62	4.51	0
1	38.38	31.71	41.62	4.51	0
3	38.38	31.71	41.62	4.51	0
5	98.20	89.60	103.20	6.33	2
10	159.80	150.90	165.60	6.53	4
30	202.10	201.90	202.20	0.14	4
50	201.90	201.90	201.90	0.00	4
100	201.40	201.40	201.40	0.00	4
200	202.58	202.50	202.70	0.10	4

Gain vs Total Dose (ΔV_{OUT} = 48V, R_L = 1kΩ)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	273.61	263.78	285.38	8.975	0
1	273.61	263.78	285.38	8.975	0
3	273.61	263.78	285.38	8.975	0
5	277.53	271.11	292.22	9.871	0
10	264.03	254.17	275.71	9.317	0
30	228.47	222.83	239.22	7.308	0
50	206.15	198.37	214.04	8.098	0
100	166.06	152.50	176.81	11.755	0
200	126.18	113.49	139.83	12.292	0

Saturation Voltage vs Total Dose (I_L = 50mA, V_{IN} = Unknown)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	0.573	0.391	0.844	0.192	0
1	0.573	0.391	0.844	0.192	0
3	0.573	0.391	0.844	0.192	0
5	0.620	0.440	0.885	0.189	0
10	0.690	0.508	0.946	0.184	0
30	1.000	0.800	1.217	0.174	0
50	1.308	1.104	1.498	0.166	0
100	1.894	1.685	2.050	0.157	4
200	2.473	2.120	2.730	0.265	4

V_{56} = 0V, R_S = 0Ω, V_{CC} = 30V, V_{CM} = 0, V_{OUT} = 1.4V w.r.t. -V_{CC} unless specified otherwise.

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