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.

LM124J Total Dose Radiation Test Summary

Summary:

This report includes data for ten parameters specified in the RETS for the LM124. Data shows that the samples remained inside the room temperature limits up to 200 kRads(Si). Post 200 kRads(Si) variation in the parameter value is very small.

Input bias current data is not included in this report due to potential errors in the data acuisition. Input offset current, however, was measured accurately and is a part of this report.

Following table presents a summary of changes in the parameters value after 200 kRads(Si) exposure.

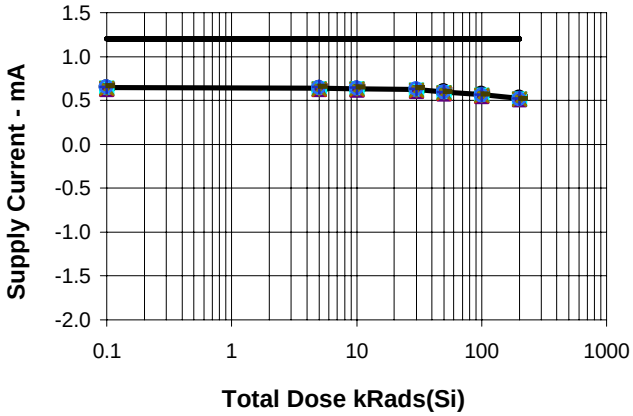
Parameter	Average Change Pre-rad to post 200k rad
Supply Current V_S = 5V	-0.127 mA
Supply Current V_S = 32V	-0.079 mA
Output Sink Current V_S = 15V, V_{OUT} = 200mV	-10.62µA
Output Source Current V_S = 15V, V_{OUT} = 2V	1.097µA
Short Circuit Current V_S = 5V	1.082 mA
Input Offset Voltage V_S = 30V, V_{CM} = 0V	-0.802 mV
CMRR V_S = 30V, V_{CM} = 0 - 28.5V	3.2 dB
PSRR V_S = 5- 30V, V_{CM} = 0V	2.4 dB
Large Signal Gain V_S = 15V	-37.7 V/mV
Input Offset Current V_S = 5V, V_{CM} = 0V	-4.881 nA

Test Details:

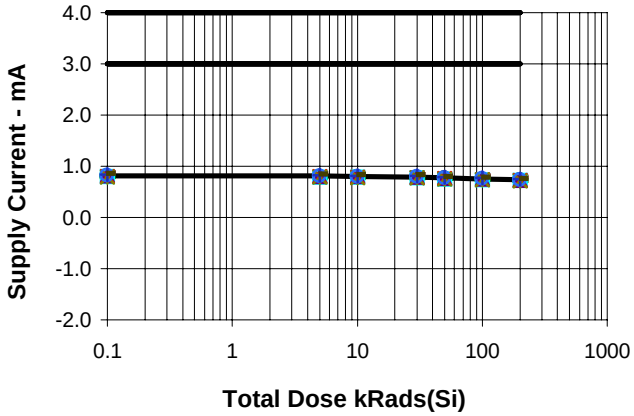
Sample Size:	12		
Lot #:	M69591L019, M66688L019, M66683K019		
Die Run#:	HL05A478	RETS:	RETS124X
Date Code:	9625	Bias Circuit:	5441HR
Test Date:	8/15/96	Test Program:	RAD124XXA
Dose Rate:	100.48 rads/sec +/- 10%		

LM124J
Total Dose Radiation Test Characteristics (N=12)

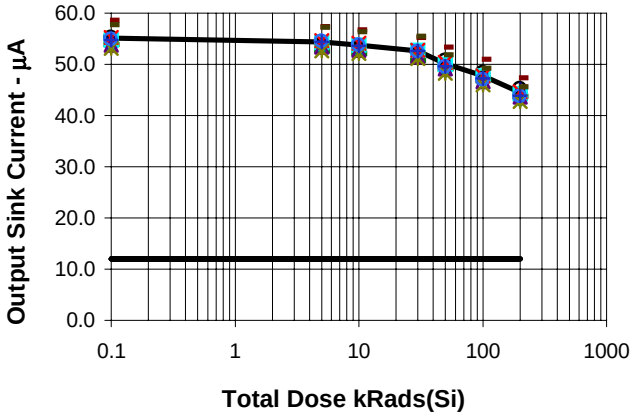
Supply Current vs Total Dose (V_S = 5V)



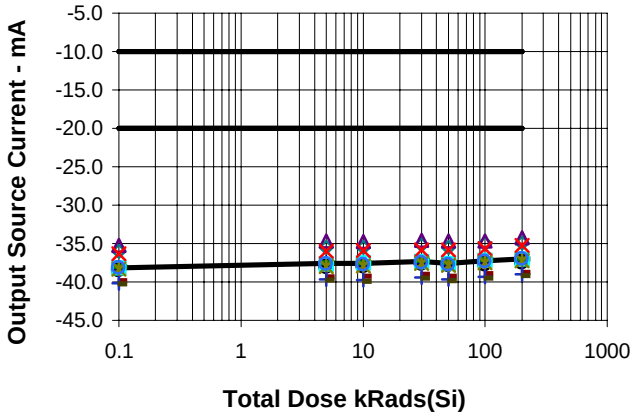
Supply Current vs Total Dose (V_S = 32V)



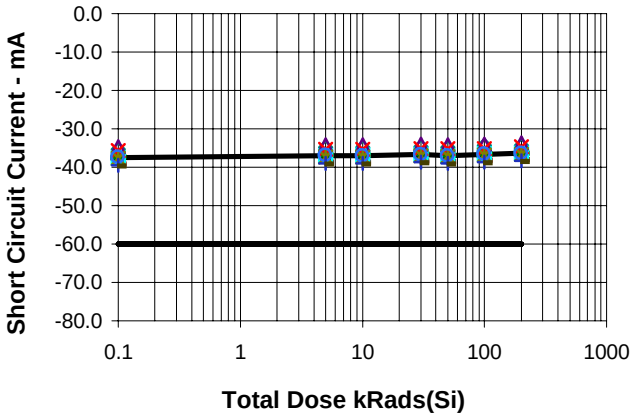
Output Sink Current vs Total Dose (V_S = 15V, V_{OUT} = 200mV)



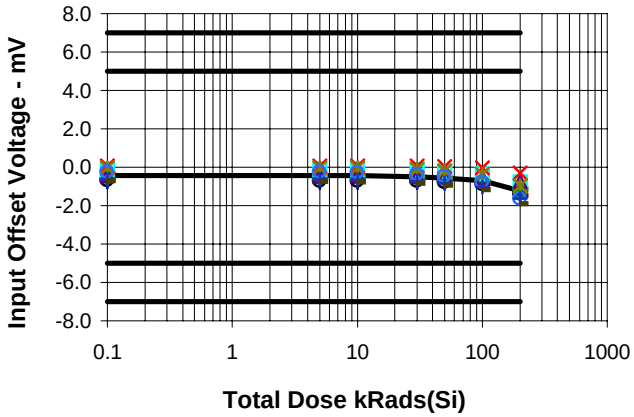
Output Source Current vs Total Dose (V_S = 15V, V_{OUT} = 2V)



Short Circuit Current vs Total Dose (V_S = 5V)



V_{IO} vs Total Dose (V_S = 30V, V_{CM} = 0V)



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Total Dose Radiation Test Characteristics (N=12)

Supply Current vs Total Dose (V_S = 5V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	0.648	0.625	0.683	0.017	0
5	0.641	0.622	0.670	0.015	0
10	0.635	0.616	0.664	0.015	0
30	0.623	0.604	0.649	0.015	0
50	0.595	0.576	0.628	0.015	0
100	0.566	0.547	0.597	0.014	0
200	0.521	0.505	0.548	0.013	0

Supply Current vs Total Dose (V_S = 32V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	0.816	0.790	0.875	0.026	0
5	0.808	0.782	0.862	0.025	0
10	0.801	0.777	0.855	0.024	0
30	0.791	0.770	0.840	0.024	0
50	0.772	0.747	0.825	0.023	0
100	0.755	0.732	0.810	0.023	0
200	0.737	0.715	0.790	0.022	0

Output Sink Current vs Total Dose (V_S = 15V, V_{OUT} = 200mV)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	55.064	53.140	58.610	1.630	0
5	54.425	52.610	57.390	1.521	0
10	53.756	52.090	56.740	1.465	0
30	52.563	50.740	55.490	1.467	0
50	50.103	48.240	53.360	1.426	0
100	47.756	45.940	50.940	1.349	0
200	44.444	42.730	47.390	1.279	0

Output Source Current vs Total Dose (V_S = 15V, V_{OUT} = 2V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	-38.130	-40.290	-35.270	1.597	0
5	-37.616	-39.790	-34.690	1.590	0
10	-37.622	-39.890	-34.740	1.612	0
30	-37.353	-39.470	-34.590	1.547	0
50	-37.593	-39.870	-34.690	1.606	0
100	-37.288	-39.520	-34.640	1.564	0
200	-37.033	-39.170	-34.220	1.566	0

Short Circuit Current vs Total Dose (V_S = 5V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	-37.478	-39.590	-34.690	1.561	0
5	-36.969	-39.090	-34.120	1.557	0
10	-36.978	-39.190	-34.170	1.573	0
30	-36.702	-38.790	-34.020	1.511	0
50	-36.951	-39.170	-34.140	1.570	0
100	-36.648	-38.820	-34.070	1.525	0
200	-36.396	-38.490	-33.670	1.526	0

V_{IO} vs Total Dose (V_S = 30V, V_{CM} = 0V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	-0.429	-0.780	0.060	0.288	0
5	-0.442	-0.793	0.070	0.291	0
10	-0.446	-0.793	0.075	0.293	0
30	-0.493	-0.833	0.058	0.294	0
50	-0.553	-0.938	0.025	0.297	0
100	-0.703	-1.176	-0.025	0.327	0
200	-1.231	-1.907	-0.285	0.460	0

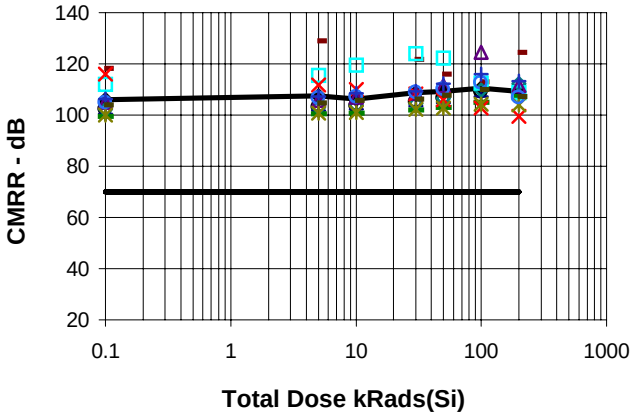
Output source and sink current, short circuit current and input offset voltage test data show only amplifier #1's data.

Other three amplifiers performed similarly.

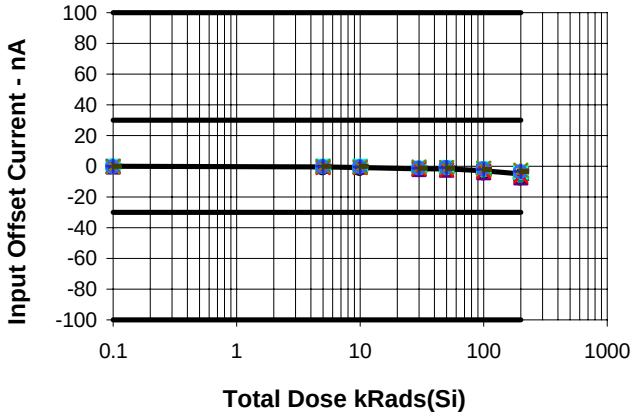
Note 1: Number of devices that were outside RETS sub group 1 limits.

LM124J
Total Dose Radiation Test Characteristics (N=12)

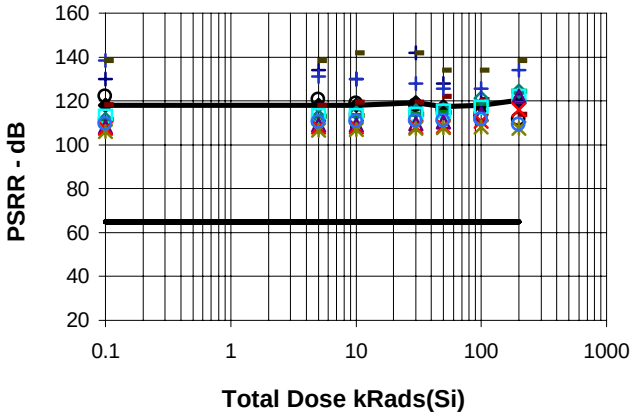
CMRR vs Total Dose (V_S = 30V, V_{CM} = 0 to 28.5V)



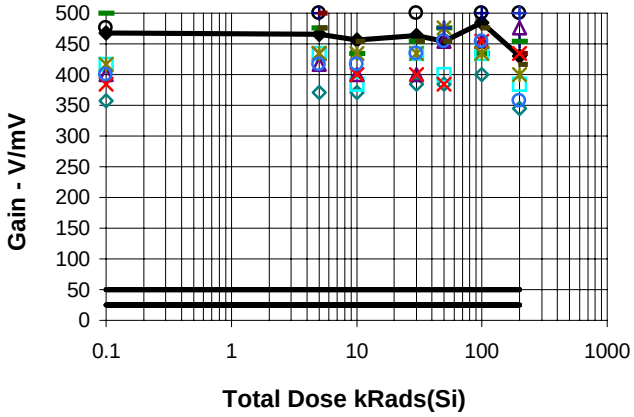
Input Offset Current vs Total Dose (V_S = 5V, V_{CM} = 0V)



PSRR vs Total Dose (V_S = 5 - 30V, V_{CM} = 0V)



Large Signal Gain vs Total Dose (V_S = 15V)



LM124J
Total Dose Radiation Test Characteristics (N=12)

CMRR vs Total Dose

(V_S = 30V, V_{CM} = 0 to 28.5V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	106.0	99.5	118.2	6.2	0
5	107.5	100.4	129.1	8.1	0
10	106.3	100.9	119.6	5.3	0
30	108.7	101.9	124.0	7.1	0
50	109.2	102.9	122.2	5.7	0
100	110.6	102.7	124.5	5.9	0
200	109.2	99.6	124.5	6.0	0

Input Offset Current vs Total Dose (V_S = 5V, V_{CM} = 0V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	-0.139	-0.600	0.530	0.301	0
5	-0.404	-1.260	0.150	0.514	0
10	-0.683	-1.750	-0.070	0.508	0
30	-1.494	-2.380	-0.480	0.617	0
50	-1.691	-2.850	-0.750	0.792	0
100	-2.763	-5.080	-1.100	1.344	0
200	-5.020	-8.010	-2.100	2.222	0

PSRR vs Total Dose

(V_S = 5 - 30V, V_{CM} = 0V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	117.9	106.2	138.4	11.7	0
5	118.0	106.7	138.4	10.8	0
10	118.0	107.0	141.9	10.7	0
30	119.0	107.4	141.9	12.1	0
50	117.4	107.8	134.0	8.3	0
100	117.9	108.0	134.0	7.2	0
200	120.3	107.5	138.4	9.4	0

Large Signal Gain vs Total Dose (V_S = 15V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	467.5	357.1	588.2	82.5	0
5	465.5	370.4	625.0	64.6	0
10	455.8	370.4	625.0	81.2	0
30	464.0	384.6	588.2	64.8	0
50	454.0	384.6	555.6	47.5	0
100	484.5	400.0	714.3	82.9	0
200	429.8	344.8	500.0	51.2	0

PSRR, CMRR, I_{IO} and voltage gain data show only amplifier 1's data.

Other three amplifiers performed similarly.

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