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.

LM119J/H Total Dose Radiation Test Summary

Summary:

This report presents characteristics of twelve parameters for LM119, high speed dual comparater, in both header and ceramic DIP packages. Data shows that all parameters, with the exception of input offset voltage remained inside the MDS sub group 1 limits throughout the test. Comparison of pre rad and post 200k rad data shows that overall changes in the parameter values were very small and all devices were functional after 200k rad exposure.

Input offset voltage had a wide distribution. One out of four samples in ceramic DIP package failed sub group 1 limits after 50k rad exposure when tested with V_{CM} = -12V. There were no J-package failures at subsequent rad levels. First failure in header package occurred at 5k rad when tested at 3V V_{CM}. At 200k rad exposure, all data read was within sub group 1 limits.

Pre-rad data for samples in header pacage was lost due to a computer failure. Post 5krad data, which is very close to pre-rad data and provides a reasonable approximation, was used in its place.

Following table shows a summary of average changes after 200krad exposure for each of the twelve paramters presented in this report.

Parameter	Avg. Post 200k Rad Change H-Package	J-Package
Positive Supply Current V_{CC} = 15V	-0.339mA	-0.228mA
Negative Supply Current V_{CC} = 15V	0.143mA	0.162mA
Output Leakage Current V_{CC} = 15V	0.054uA	-0.0039uA
Input Offset Voltage V_{CC} = 5V, V_{CM} = 3V, R_S = 5kΩ	-0.205mV	0.968mV
Input Offset Voltage V_{CC} = 5V, V_{CM} = 12V, R_S = 5kΩ	-0.739mV	0.935mV
Input Offset Voltage V_{CC} = 5V, V_{CM} = -12V, R_S = 5kΩ	-0.204mV	0.941mV
Input Offset Current V_{CC} = 5V, V_{CM} = 3V	0.35nA	-0.3nA
Input Offset Current V_{CC} = 5V, V_{CM} = 12V	-1.05nA	0.75nA
Input Offset Current V_{CC} = 5V, V_{CM} = -12V	0.2nA	1.85nA
Gain V_{CC} = 5V	0V/mV	1.25V/mV
Gain V_{CC} = 15V	0.35V/mV	-0.35V/mV
Output Saturation Voltage V_{CC} = 15V, I_L = 25mA	-0.547mV	0.961mV

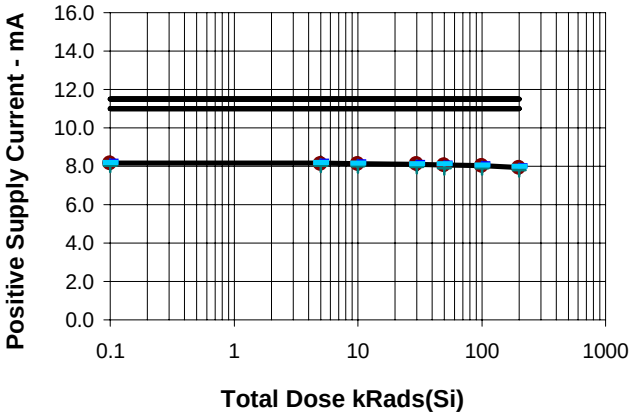
LM119J/H Total Dose Radiation Test Summary

Test Details:

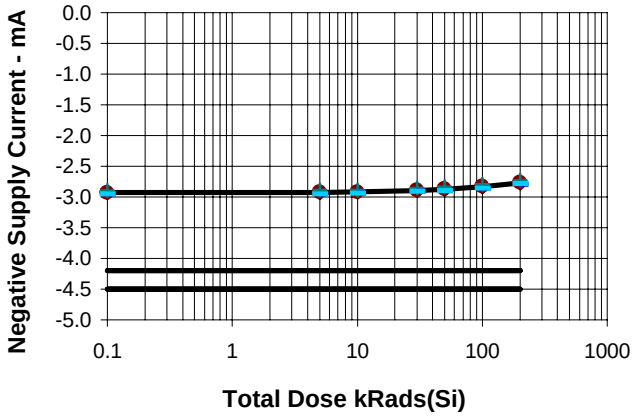
	Ceramic DIP	Header
Samples Size:	4	4
Lot #:	MW4042G019	MU7913H019
Die Run#:	HL065262	HL059A48A
Date Code:	9606	9608
Test Date:	8/16/96	
Dose Rate:	100.44 rads/sec +/- 10%	
MDS #:	MNLM119X-0B0	
Bias Circuit #:	9641HR	8906HR
Test Program Number:	RAD119XXA	

LM119J
Total dose Radiation Test Characteristics (N=4)

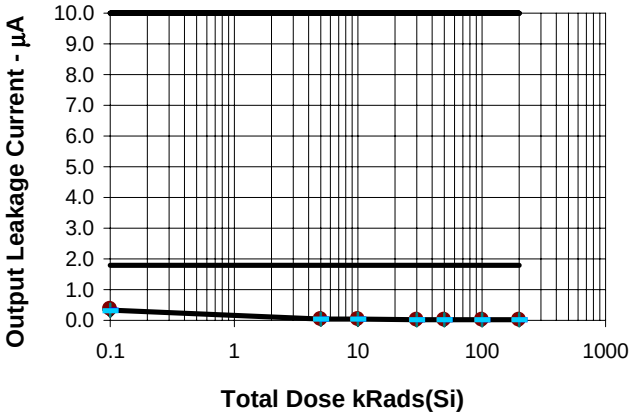
Positive Supply Current vs Total Dose (V_{CC} = 15V)



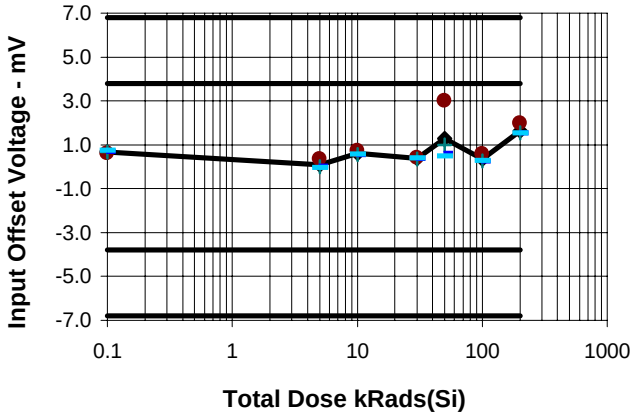
Negative Supply Current vs Total Dose (V_{CC} = 15V)



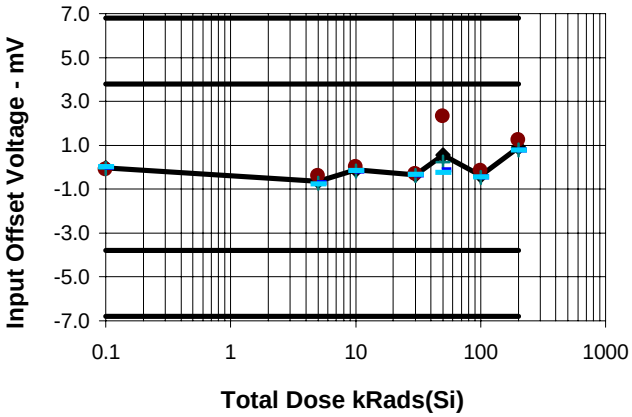
Output Leakage Current vs Total Dose (V_{CC} = +/-15V)



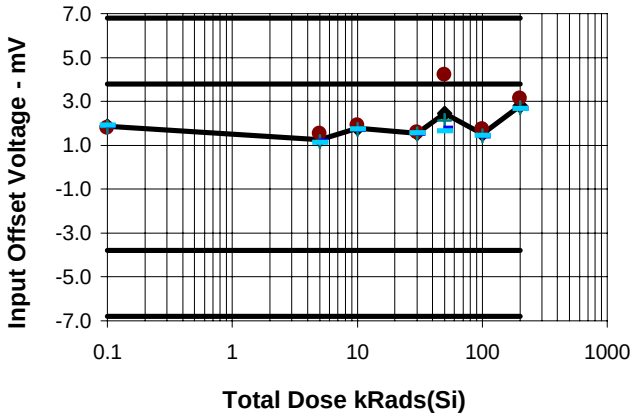
V_{IO} vs Total Dose (V_{CC} = 5V, V_{CM} = 3V, R_S = 5kΩ)



V_{IO} vs Total Dose (V_{CC} = 5V, V_{CM} = 12V, R_S = 5kΩ)



V_{IO} vs Total Dose (V_{CC} = 5V, V_{CM} = -12V, R_S = 5kΩ)



LM119J
Total dose Radiation Test Characteristics (N=4)

Positive Supply Current vs

Total Dose (V_{CC} = +/-15V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	8.175	8.046	8.271	0.095	0
5	8.160	8.031	8.263	0.098	0
10	8.144	8.011	8.246	0.099	0
30	8.112	7.981	8.208	0.095	0
50	8.066	7.916	8.173	0.111	0
100	8.027	7.888	8.123	0.101	0
200	7.947	7.813	8.046	0.099	0

Negative Supply Current vs

Total Dose (V_{CC} = +/-15V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	-2.930	-2.951	-2.894	0.027	0
5	-2.925	-2.944	-2.889	0.026	0
10	-2.918	-2.939	-2.881	0.027	0
30	-2.892	-2.911	-2.856	0.026	0
50	-2.872	-2.891	-2.836	0.026	0
100	-2.831	-2.854	-2.794	0.027	0
200	-2.768	-2.791	-2.731	0.027	0

Output Leakage Current vs

Total Dose (V_{CC} = +/-15V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	0.339	0.318	0.368	0.022	0
5	0.035	0.035	0.035	0.000	0
10	0.039	0.038	0.040	0.001	0
30	0.030	0.030	0.030	0.000	0
50	0.030	0.030	0.030	0.000	0
100	0.030	0.030	0.030	0.000	0
200	0.030	0.030	0.030	0.000	0

V_{IO} vs Total Dose

(V_{CC} = 5V, V_{CM} = 3V, R_S = 5kΩ)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	0.679	0.602	0.747	0.061	0
5	0.088	-0.036	0.354	0.180	0
10	0.611	0.557	0.740	0.087	0
30	0.380	0.337	0.410	0.034	0
50	1.278	0.510	3.000	1.166	0
100	0.355	0.267	0.585	0.154	0
200	1.647	1.532	1.973	0.217	0

V_{IO} vs Total Dose

(V_{CC} = 5V, V_{CM} = 12V, R_S = 5kΩ)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	-0.036	-0.106	0.024	0.056	0
5	-0.649	-0.768	-0.398	0.170	0
10	-0.125	-0.173	-0.008	0.078	0
30	-0.349	-0.386	-0.326	0.028	0
50	0.555	-0.223	2.318	1.192	0
100	-0.375	-0.453	-0.168	0.138	0
200	0.899	0.782	1.227	0.219	0

V_{IO} vs Total Dose

(V_{CC} = 5V, V_{CM} = -12V, R_S = 5kΩ)

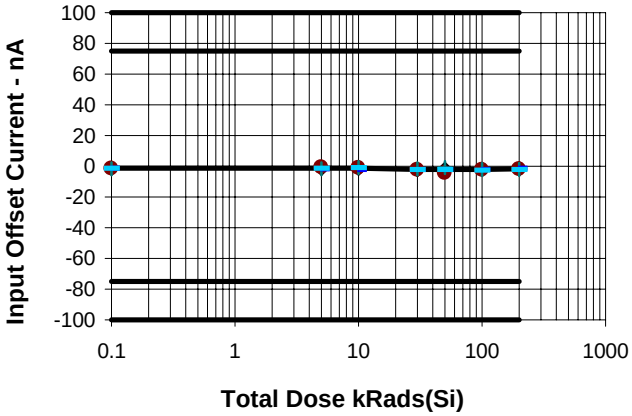
Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	1.860	1.787	1.922	0.058	0
5	1.252	1.130	1.507	0.173	0
10	1.776	1.727	1.897	0.081	0
30	1.548	1.510	1.572	0.029	0
50	2.447	1.672	4.196	1.183	1
100	1.520	1.440	1.735	0.144	0
200	2.801	2.685	3.128	0.218	0

Only amp-1 data is shown, amp-2 data is similar.

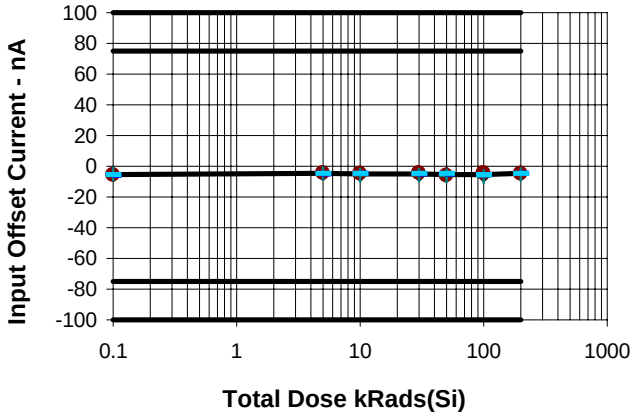
Note 1: Number of devices that were outside MDS sub group 1 limits.

LM119J
Total Dose Radiation Test Characteristics (N=4)

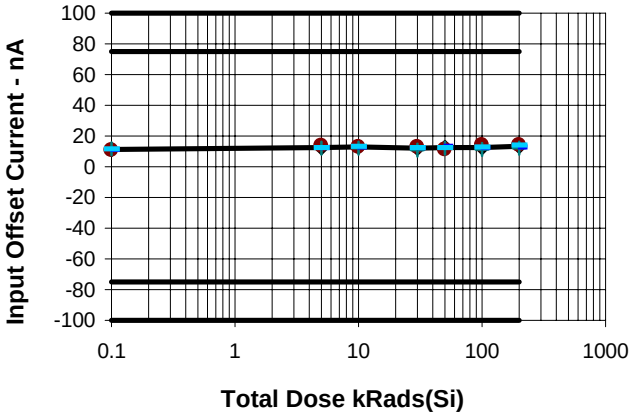
I_{IO} vs Total Dose
(V_{CC} = 5V, V_{CM} = 3V)



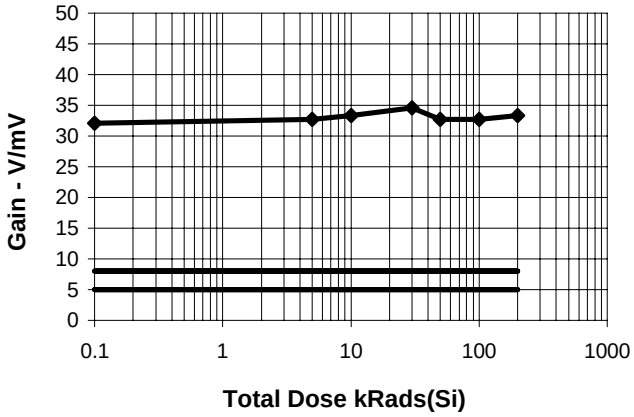
I_{IO} vs Total Dose
(V_{CC} = 5V, V_{CM} = 12V)



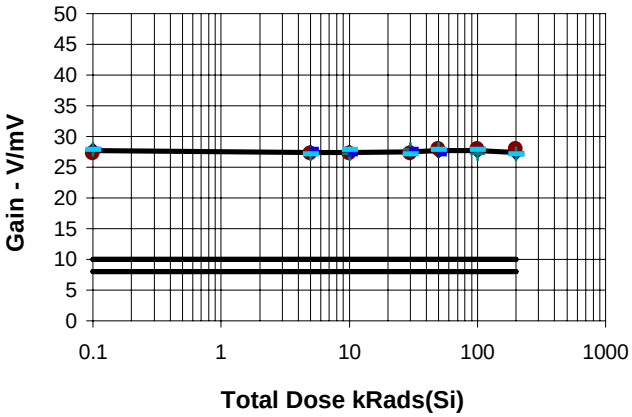
I_{IO} vs Total Dose
(V_{CC} = 5V, V_{CM} = -12V)



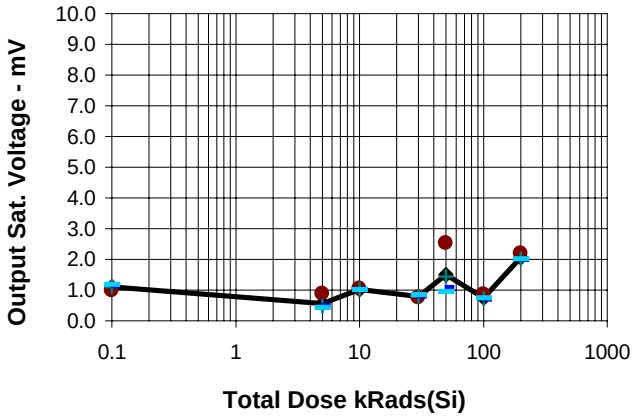
Gain vs Total Dose
(V_{CC} = 5V)



Gain vs Total Dose
(V_{CC} = 15V)



V_{SAT} vs Total Dose
(V_{CC} = 15V, I_L = 25mA)



LM119J
Total Dose Radiation Test Characteristics (N=4)

I_{IO} vs Total Dose

(V_{CC} = 5V, V_{CM} = 3V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	-1.450	-1.600	-1.400	0.100	0
5	-1.250	-1.600	-0.400	0.574	0
10	-1.250	-2.000	-1.000	0.500	0
30	-1.900	-2.000	-1.600	0.200	0
50	-2.250	-4.000	-1.000	1.258	0
100	-2.150	-2.600	-2.000	0.300	0
200	-1.750	-2.000	-1.400	0.300	0

I_{IO} vs Total Dose

(V_{CC} = 5V, V_{CM} = 12V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	-5.450	-6.000	-5.000	0.412	0
5	-4.550	-5.000	-4.000	0.412	0
10	-4.900	-6.000	-4.400	0.739	0
30	-4.850	-6.000	-4.000	0.870	0
50	-5.500	-6.400	-4.600	0.841	0
100	-5.350	-6.600	-4.000	1.063	0
200	-4.700	-5.600	-4.400	0.600	0

I_{IO} vs Total Dose

(V_{CC} = 5V, V_{CM} = -12V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	11.400	11.000	11.600	0.283	0
5	12.650	12.000	13.600	0.681	0
10	12.850	12.000	13.400	0.597	0
30	12.200	11.000	13.000	0.849	0
50	12.350	11.400	13.400	0.854	0
100	12.700	11.400	14.000	1.089	0
200	13.250	12.000	14.000	0.957	0

Gain vs Total Dose

(V_{CC} = 5V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	32.100	32.100	32.100	0.000	0
5	32.725	32.100	34.600	1.250	0
10	33.350	32.100	34.600	1.443	0
30	34.600	34.600	34.600	0.000	0
50	32.725	32.100	34.600	1.250	0
100	32.725	32.100	34.600	1.250	0
200	33.350	32.100	34.600	1.443	0

Gain vs Total Dose

(V_{CC} = 15V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	27.725	27.200	27.900	0.350	0
5	27.375	27.200	27.900	0.350	0
10	27.375	27.200	27.900	0.350	0
30	27.550	27.200	27.900	0.404	0
50	27.725	27.200	27.900	0.350	0
100	27.725	27.200	27.900	0.350	0
200	27.375	27.200	27.900	0.350	0

V_{SAT} vs Total Dose

(V_{CC} = 15V, I_L = 25mA)

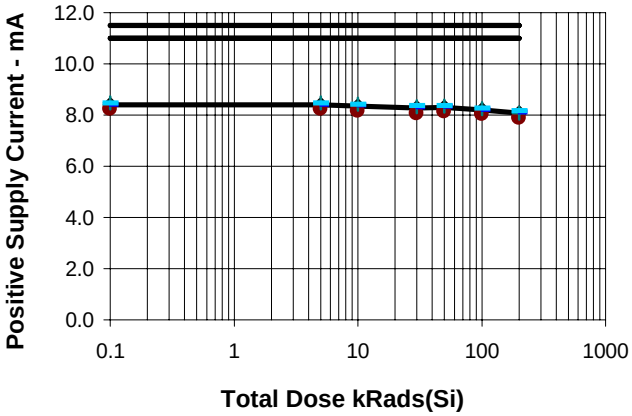
Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	1.100	0.977	1.182	0.088	0
5	0.572	0.435	0.870	0.201	0
10	1.026	1.015	1.040	0.011	0
30	0.798	0.742	0.847	0.045	0
50	1.498	0.957	2.513	0.708	0
100	0.757	0.712	0.855	0.067	0
200	2.061	2.010	2.188	0.085	0

Only amp-1 data is shown, amp-2 data is similar.

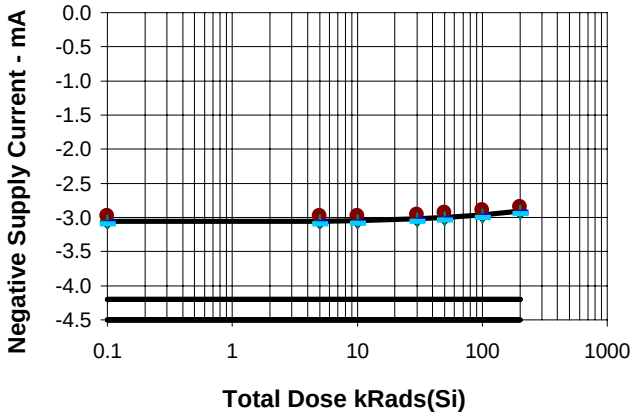
Note 1: Number of devices that were outside MDS sub group 1 limits.

LM119H
Total Dose Radiation Test Characteristics (N=4)

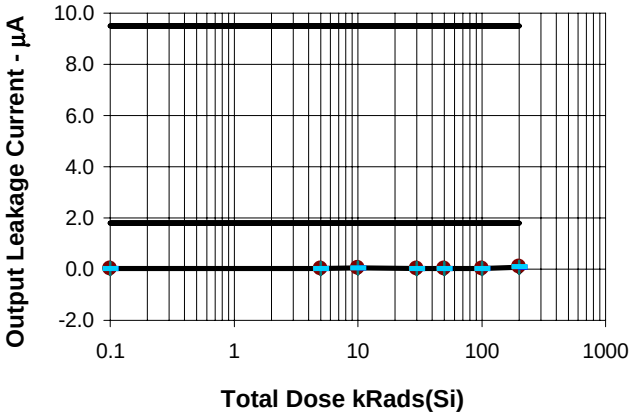
Positive Supply Current vs Total Dose (V_{CC} = +/-15V)



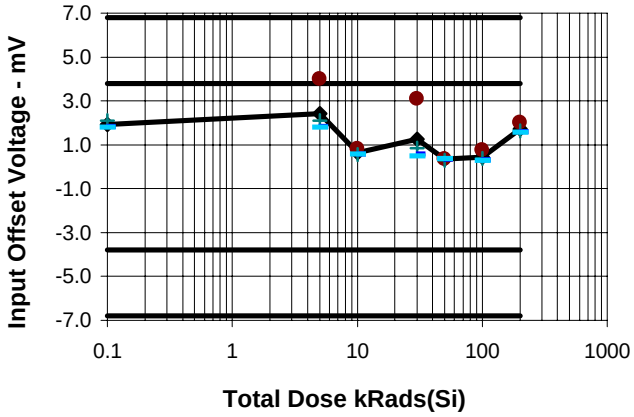
Negative Supply Current vs Total Dose (V_{CC} = +/-15V)



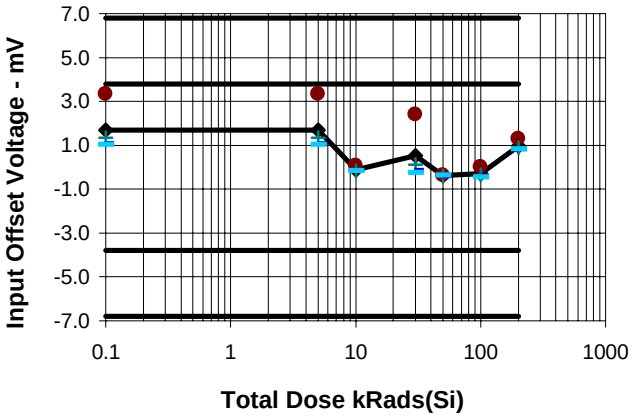
Output Leakage Current vs Total Dose (V_{CC} = +/-15V)



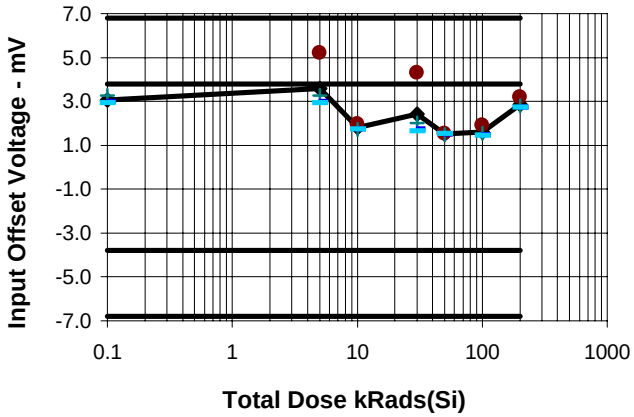
V_{IO} vs Total Dose (V_{CC} = 5V, V_{CM} = 3V, R_S = 5kΩ)



V_{IO} vs Total Dose (V_{CC} = 5V, V_{CM} = 12V, R_S = 5kΩ)



V_{IO} vs Total Dose (V_{CC} = 5V, V_{CM} = -12V, R_S = 5kΩ)



LM119H
Total Dose Radiation Test Characteristics (N=4)

Positive Supply Current vs
Total Dose (V_{CC} = +/-15V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	8.409	8.246	8.486	0.112	0
5	8.409	8.246	8.486	0.112	0
10	8.357	8.186	8.428	0.114	0
30	8.278	8.068	8.381	0.142	0
50	8.301	8.141	8.371	0.107	0
100	8.193	8.038	8.268	0.105	0
200	8.070	7.901	8.168	0.118	0

Negative Supply Current vs
Total Dose (V_{CC} = +/-15V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	-3.052	-3.094	-2.976	0.052	0
5	-3.052	-3.094	-2.976	0.052	0
10	-3.046	-3.086	-2.971	0.051	0
30	-3.023	-3.059	-2.951	0.049	0
50	-2.999	-3.036	-2.929	0.048	0
100	-2.962	-2.996	-2.891	0.048	0
200	-2.909	-2.941	-2.841	0.046	0

Output Leakage Current vs
Total Dose (V_{CC} = +/-15V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	0.033	0.033	0.033	0.000	0
5	0.033	0.033	0.033	0.000	0
10	0.040	0.040	0.040	0.000	0
30	0.032	0.030	0.033	0.002	0
50	0.031	0.030	0.033	0.001	0
100	0.034	0.033	0.035	0.001	0
200	0.087	0.078	0.098	0.008	0

V_{IO} vs Total Dose
(V_{CC} = 5V, V_{CM} = 3V, R_S = 5kΩ)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	1.915	1.807	2.093	0.155	0
5	2.435	1.807	3.996	1.048	1
10	0.634	0.560	0.805	0.115	0
30	1.251	0.487	3.078	1.229	0
50	0.343	0.299	0.374	0.032	0
100	0.434	0.297	0.747	0.212	0
200	1.710	1.587	2.025	0.211	0

V_{IO} vs Total Dose
(V_{CC} = 5V, V_{CM} = 12V, R_S = 5kΩ)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	1.702	1.050	3.315	1.084	0
5	1.702	1.050	3.315	1.084	0
10	-0.105	-0.171	0.057	0.108	0
30	0.528	-0.246	2.400	1.257	0
50	-0.381	-0.413	-0.351	0.025	0
100	-0.297	-0.428	-0.001	0.201	0
200	0.963	0.842	1.277	0.210	0

V_{IO} vs Total Dose
(V_{CC} = 5V, V_{CM} = -12V, R_S = 5kΩ)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	3.070	2.955	3.258	0.164	0
5	3.602	2.955	5.196	1.071	1
10	1.799	1.732	1.962	0.109	0
30	2.424	1.652	4.278	1.246	1
50	1.513	1.477	1.542	0.027	0
100	1.600	1.467	1.900	0.204	0
200	2.866	2.745	3.180	0.210	0

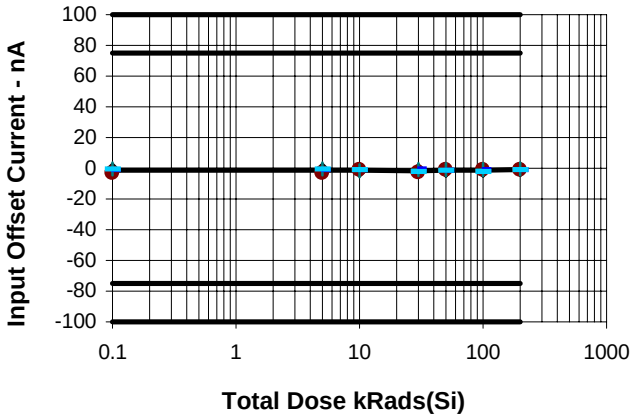
Only amp-1 data is shown, amp-2 data is similar.

Pre-rad data was lost. Post 5k rad data was used in its place.

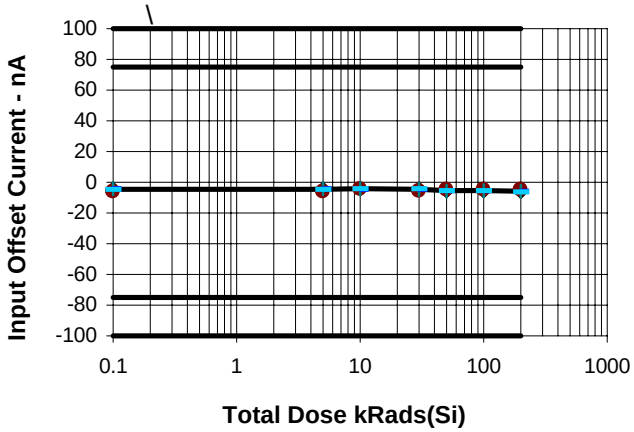
Note 1: Number of devices that were outside MDS sub group 1 limits.

LM119H
Total Dose Radiation Test Characteristics (N=4)

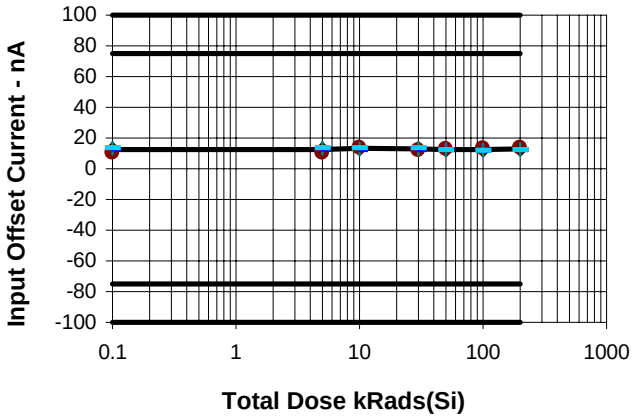
I_{IO} vs Total Dose
(V_{CC} = 5V, V_{CM} = 3V)



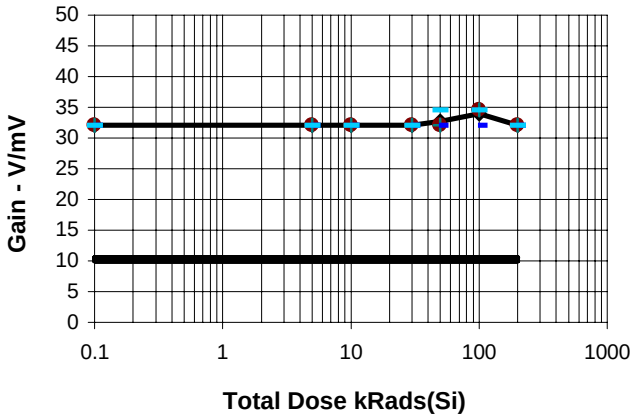
I_{IO} vs Total Dose
(V_{CC} = 5V, V_{CM} = 12V)



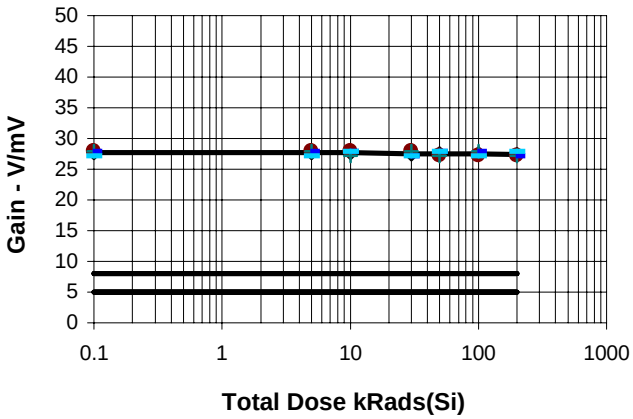
I_{IO} vs Total Dose
(V_{CC} = 5V, V_{CM} = -12V)



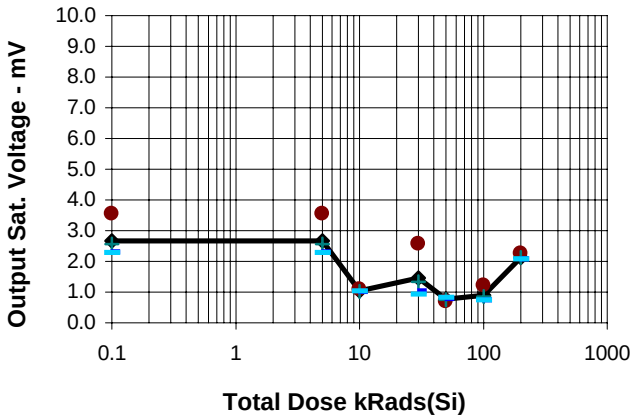
Gain vs Total Dose
(V_{CC} = 5V)



Gain vs Total Dose
(V_{CC} = 15V)



V_{SAT} vs Total Dose
(V_{CC} = 15V, I_L = 25mA)



LM119H
Total Dose Radiation Test Characteristics (N=4)

I_{IO} vs Total Dose
(V_{CC} = 5V, V_{CM} = 3V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	-1.250	-3.000	-0.400	1.193	0
5	-1.250	-3.000	-0.400	1.193	0
10	-1.150	-1.600	-1.000	0.300	0
30	-1.500	-2.600	-0.400	0.987	0
50	-1.200	-1.400	-1.000	0.231	0
100	-1.250	-2.000	-1.000	0.500	0
200	-0.900	-1.000	-0.600	0.200	0

I_{IO} vs Total Dose
(V_{CC} = 5V, V_{CM} = 12V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	-4.650	-6.000	-4.000	0.943	0
5	-4.650	-6.000	-4.000	0.943	0
10	-4.150	-4.600	-4.000	0.300	0
30	-4.650	-5.400	-4.000	0.574	0
50	-5.350	-6.000	-4.600	0.574	0
100	-5.250	-5.600	-4.400	0.574	0
200	-5.700	-6.400	-4.400	0.887	0

I_{IO} vs Total Dose
(V_{CC} = 5V, V_{CM} = -12V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	12.650	10.600	13.600	1.389	0
5	12.650	10.600	13.600	1.389	0
10	13.150	12.400	13.600	0.574	0
30	12.800	12.000	13.600	0.673	0
50	12.700	12.600	13.000	0.200	0
100	12.350	12.000	13.400	0.700	0
200	12.850	12.600	13.600	0.500	0

Gain vs Total Dose
(V_{CC} = 5V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	32.100	32.100	32.100	0.000	0
5	32.100	32.100	32.100	0.000	0
10	32.100	32.100	32.100	0.000	0
30	32.100	32.100	32.100	0.000	0
50	32.725	32.100	34.600	1.250	0
100	33.975	32.100	34.600	1.250	0
200	32.100	32.100	32.100	0.000	0

Gain vs Total Dose
(V_{CC} = 15V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	27.725	27.200	27.900	0.350	0
5	27.725	27.200	27.900	0.350	0
10	27.725	27.200	27.900	0.350	0
30	27.550	27.200	27.900	0.404	0
50	27.550	27.200	27.900	0.404	0
100	27.550	27.200	27.900	0.404	0
200	27.375	27.200	27.900	0.350	0

V_{SAT} vs Total Dose
(V_{CC} = 15V, I_L = 25mA)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	2.676	2.288	3.538	0.588	0
5	2.676	2.288	3.538	0.588	0
10	1.046	1.020	1.080	0.027	0
30	1.467	0.945	2.553	0.743	0
50	0.762	0.680	0.825	0.062	0
100	0.892	0.750	1.212	0.218	0
200	2.129	2.073	2.245	0.080	0

Only amp-1 data is shown, amp-2 data is similar.

Pre-rad data was lost. Post 5k rad data was used in its place.

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