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.

LM108AW (Rad Hard Die)
Total Dose Radiation Test

Summary:

LM108 comes in a standard and a rad hard version. This test was carried out on the rad hard die and overall, parts were functional even after 100k Rad exposure. Some parameters drifted from their pre rad values but not by much. At 100k Rad exposure, all parameters were inside room temperature spec limits.

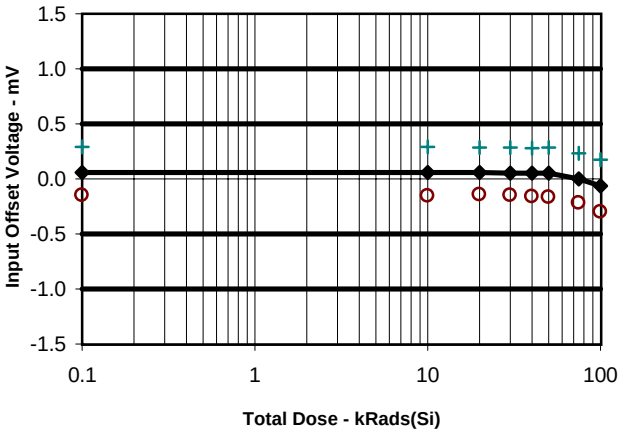
General Test Information:

Bias Circuit:	1R7114
Dose Rate:	86.524 Rads(Si)/sec
Wafer Run No.:	AA0282365A
Wafer No.:	06
Package Type:	Flat Pack
Standard Test Condition[1]:	V_{CC}=+/- 20V, V_{CM}=0V

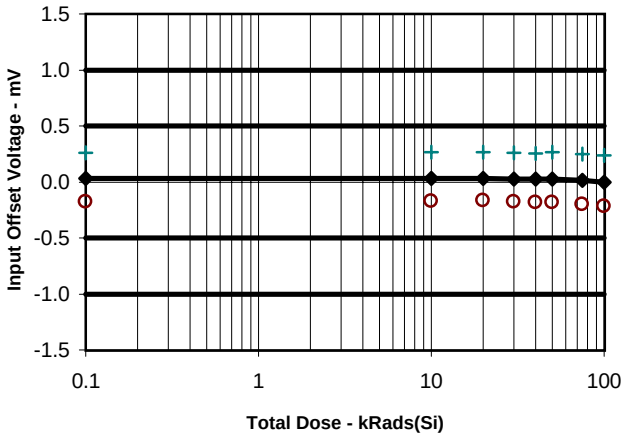
[1] These conditions apply to the automated electrical tester used to collect parameter data.

LM108AW (Rad Hard Die)
Performance Characteristics

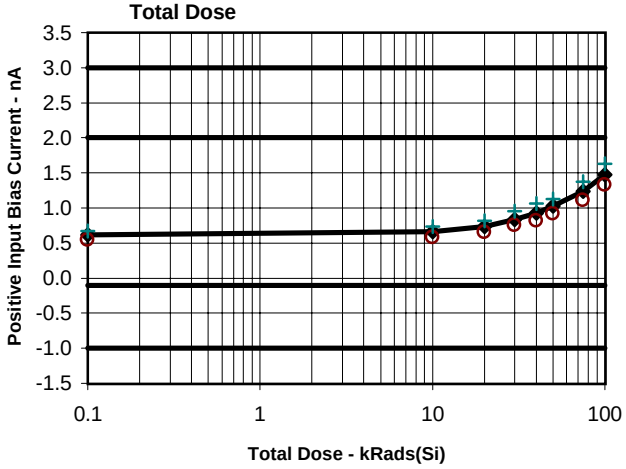
Input Offset Voltage vs
Total Dose (V_+=+5V, V_-=-35V, V_{CM} = 15V)



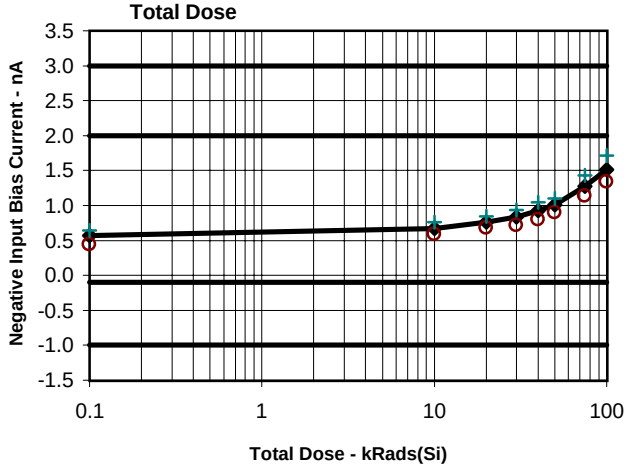
Input Offset Voltage vs
Total Dose (V_{CC}=+/-5V)



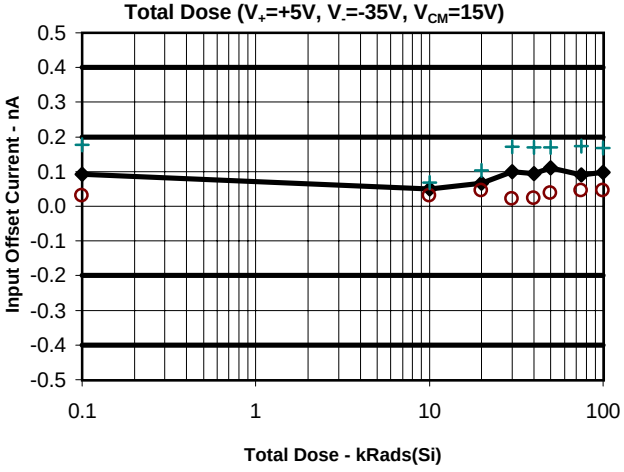
Positive Input Bias Current vs
Total Dose



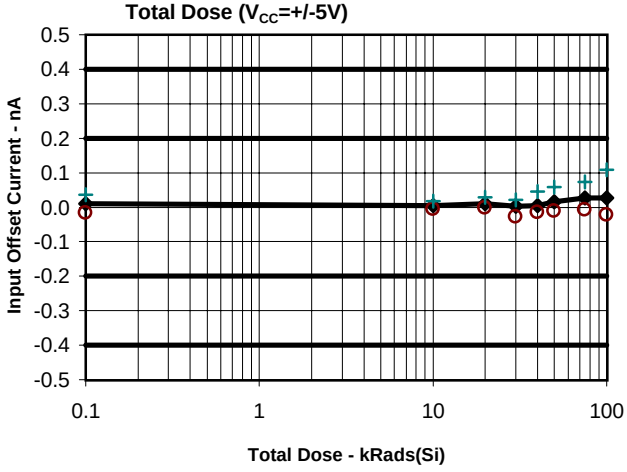
Negative Input Bias Current vs
Total Dose



Input Offset Current vs
Total Dose (V_+=+5V, V_-=-35V, V_{CM}=15V)



Input Offset Current vs
Total Dose (V_{CC}=+/-5V)



Note: + = Max, o = Min, solid lines show RETS limits, see cover page for standard conditions.

LM108AW (Rad Hard Die)
Performance Characteristics

Input Offset Voltage - mV (V+=+5V, V-=-35V, V_{CM}=15V)

Limits: -.5mV - .5mV (SG1), -1.0mV-1.0mV (SG2)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	0.061	-0.144	0.289	0.148	0
10	0.057	-0.149	0.289	0.149	0
20	0.059	-0.138	0.286	0.146	0
30	0.054	-0.145	0.282	0.147	0
40	0.050	-0.155	0.279	0.148	0
50	0.052	-0.160	0.285	0.151	0
75	0.000	-0.214	0.230	0.150	0
100	-0.065	-0.298	0.172	0.157	0

Input Offset Voltage - mV (V_{CC}=+/-5V)

Limits: -.5mV - .5mV (SG1), -1.0mV-1.0mV (SG2)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	0.029	-0.172	0.260	0.146	0
10	0.032	-0.171	0.265	0.147	0
20	0.033	-0.165	0.263	0.145	0
30	0.026	-0.174	0.259	0.147	0
40	0.026	-0.180	0.255	0.146	0
50	0.024	-0.181	0.263	0.149	0
75	0.013	-0.198	0.248	0.150	0
100	-0.001	-0.213	0.236	0.149	0

Positive Input Bias Current - nA

Limits: -.1nA - .2nA (SG1), -1.0nA - 3.0nA (SG3)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	0.613	0.546	0.671	0.052	0
10	0.659	0.584	0.738	0.060	0
20	0.737	0.653	0.822	0.063	0
30	0.838	0.754	0.950	0.076	0
40	0.923	0.821	1.064	0.089	0
50	1.023	0.916	1.132	0.086	0
75	1.236	1.107	1.374	0.106	0
100	1.471	1.324	1.632	0.124	0

Negative Input Bias Current - nA

Limits: -.1nA - .2nA (SG1), -1.0nA - 3.0nA (SG3)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	0.567	0.440	0.644	0.075	0
10	0.671	0.584	0.766	0.067	0
20	0.762	0.682	0.848	0.069	0
30	0.833	0.720	0.938	0.086	0
40	0.931	0.801	1.044	0.093	0
50	1.012	0.895	1.099	0.076	0
75	1.271	1.133	1.431	0.104	0
100	1.514	1.338	1.712	0.130	0

Input Offset Current - nA (V+=+5V, V-=-35V, V_{CM}=15V)

Limits: -.2nA - .2nA (SG1), -.4nA - .4nA (SG2,3)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	0.093	0.029	0.177	0.056	0
10	0.049	0.029	0.069	0.015	0
20	0.067	0.044	0.104	0.019	0
30	0.099	0.020	0.172	0.056	0
40	0.094	0.023	0.169	0.055	0
50	0.110	0.037	0.169	0.057	0
75	0.090	0.045	0.173	0.045	0
100	0.097	0.045	0.167	0.052	0

Input Offset Current - nA (V_{cc}=+/-5V)

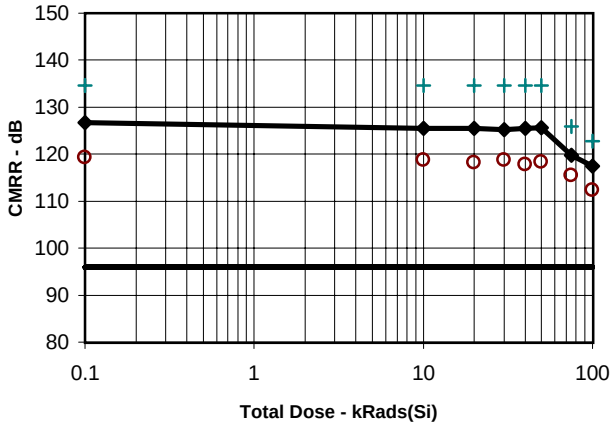
Limits: -.2nA - .2nA (SG1), -.4nA - .4nA (SG2,3)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	0.010	-0.017	0.037	0.019	0
10	0.005	-0.006	0.017	0.007	0
20	0.011	-0.002	0.029	0.010	0
30	0.002	-0.028	0.022	0.018	0
40	0.004	-0.016	0.046	0.022	0
50	0.015	-0.012	0.059	0.026	0
75	0.026	-0.008	0.074	0.029	0
100	0.026	-0.024	0.108	0.047	0

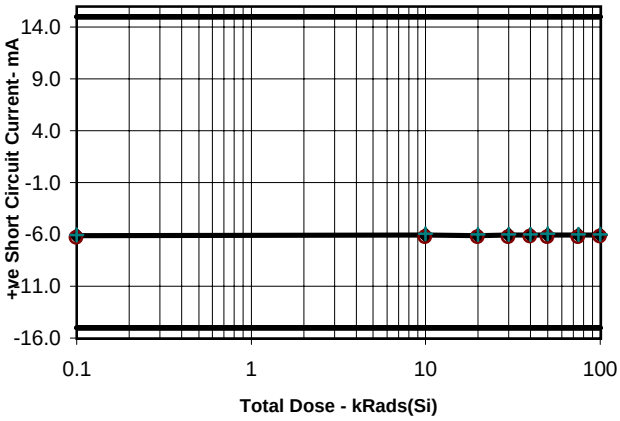
Note 1: Number of devices that were outside sub group 1 limits.

LM108AW (Rad Hard Die)
Performance Characteristics

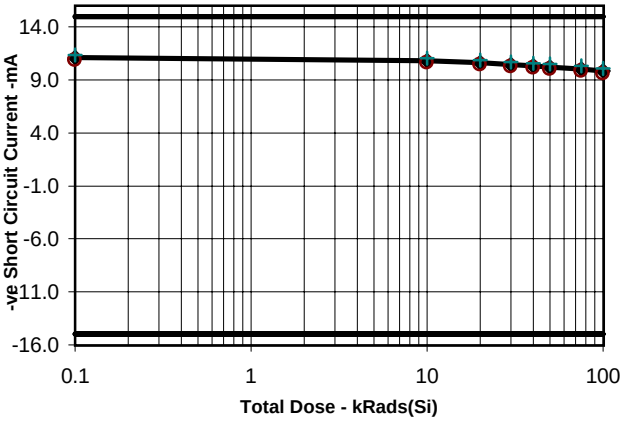
Common Mode Rejection Ratio vs
Total Dose (V_{CM} = +/-15V)



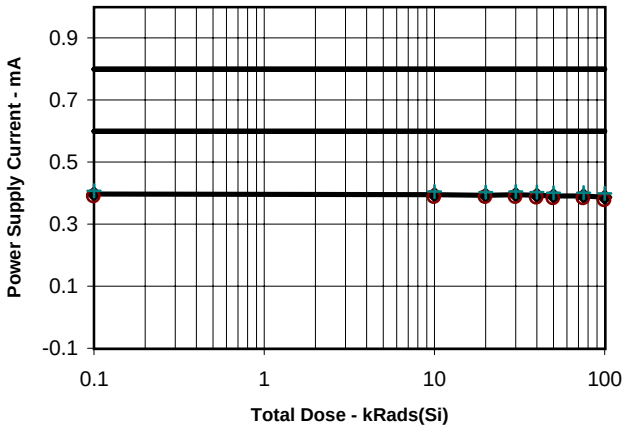
Positive Short Circuit Current vs
Total Dose (V_{CC} = +/- 15V, t<=25mS)



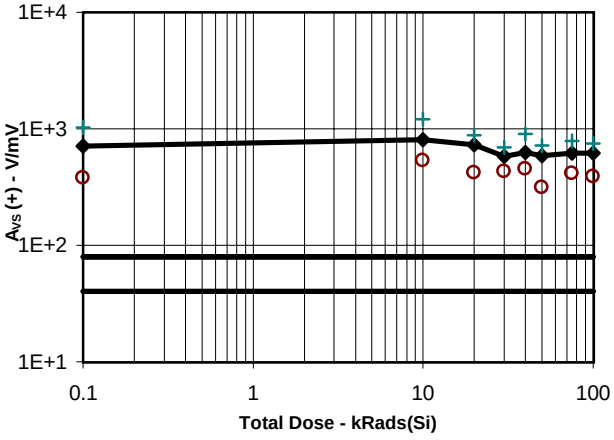
Negative Short Circuit Current vs
Total Dose (V_{CC} = +/- 15V, t<=25mS)



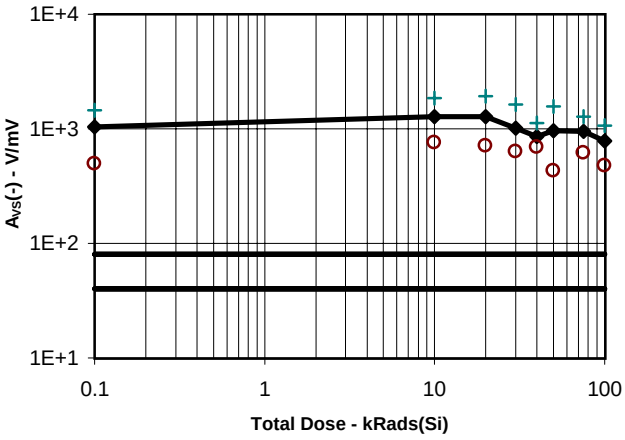
Power Supply Current vs
Total Dose (V_{CC}=+/-15V)



Positive Open Loop Voltage Gain vs
Total Dose (R_L=10k Ω , V_{OUT} =15V)



Negative Open Loop Voltage Gain vs
Total Dose (R_i=10kΩ, V_{OUT} = -15V)



Note: + = Max, o = Min, solid lines show RETS limits, see cover page for standard conditions.

LM108AW (Rad Hard Die)
Performance Characteristics

Common Mode Rejection Ratio - dB (VCM=+/-15V)

Limits: Min 96dB (SG1, SG2)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	126.767	119.387	134.647	6.735	0
10	125.437	118.875	134.647	7.385	0
20	125.433	118.278	134.647	7.278	0
30	125.260	118.752	134.647	5.980	0
40	125.433	117.885	134.647	6.847	0
50	125.684	118.371	134.647	7.299	0
75	119.757	115.509	125.904	3.665	0
100	117.490	112.372	122.792	3.656	0

+ve Short Circuit Current - mA (V_{cc}=+/-15V, t<=25mS)

Limits: -15 to 15mA (SG1, SG2)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	-6.134	-6.282	-6.035	0.095	0
10	-6.076	-6.215	-5.952	0.091	0
20	-6.088	-6.233	-5.986	0.088	0
30	-6.079	-6.210	-5.996	0.082	0
40	-6.084	-6.203	-5.986	0.081	0
50	-6.047	-6.214	-5.927	0.102	0
75	-6.081	-6.223	-5.982	0.088	0
100	-6.057	-6.182	-5.962	0.083	0

-ve Short Circuit Current - mA (V_{cc}=+/-15V, t<=25mS)

Limits: -15 to 15mA (SG1, SG2)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	11.098	10.892	11.380	0.206	0
10	10.781	10.600	11.032	0.186	0
20	10.606	10.436	10.884	0.196	0
30	10.450	10.283	10.708	0.185	0
40	10.333	10.170	10.587	0.191	0
50	10.199	10.007	10.503	0.212	0
75	10.017	9.826	10.303	0.204	0
100	9.829	9.630	10.095	0.202	0

Power Supply Current - mA

Limits: Max .6mA (SG1,2), Max .8mA (SG3)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	0.398	0.390	0.408	0.006	0
10	0.395	0.387	0.405	0.007	0
20	0.394	0.387	0.403	0.007	0
30	0.395	0.387	0.405	0.006	0
40	0.393	0.384	0.404	0.007	0
50	0.392	0.383	0.401	0.007	0
75	0.391	0.383	0.402	0.007	0
100	0.388	0.376	0.399	0.008	0

Positive Open Loop Voltage Gain - V/mV

(R_L=10K Ohms, V_{out} = 15V)

Limits: Min 80V/mV (SG4), Min 40V/mV (SG5,6)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	712.4	377.1	1032.0	222.5	0
10	803.0	529.5	1202.6	249.3	0
20	729.1	419.6	883.7	194.8	0
30	582.9	428.0	691.3	104.8	0
40	626.7	452.0	904.5	161.9	0
50	590.1	314.2	718.6	149.9	0
75	622.2	411.2	791.0	128.8	0
100	619.4	386.1	748.4	140.4	0

Negative Open Loop Voltage Gain - V/mV

(R_L=10K Ohms, V_{out} = -15V)

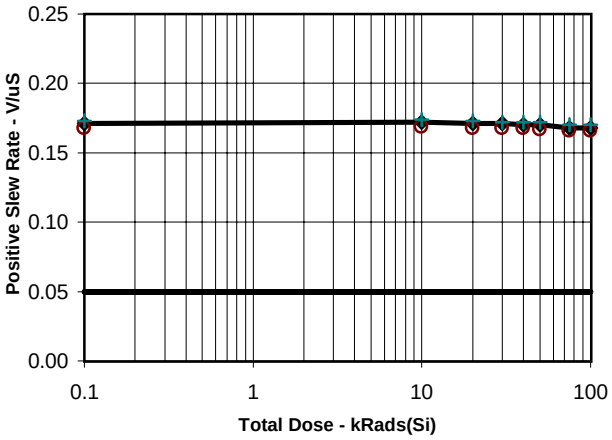
Limits: Min 80V/mV (SG4), Min 40V/mV (SG5,6)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	1043.3	491.2	1448.7	352.5	0
10	1281.1	749.3	1844.7	353.7	0
20	1284.7	710.8	1921.4	519.2	0
30	1010.9	629.3	1623.6	361.8	0
40	858.8	686.0	1122.9	161.7	0
50	957.2	425.8	1570.8	413.4	0
75	944.1	617.1	1271.3	247.5	0
100	783.7	475.1	1072.3	208.9	0

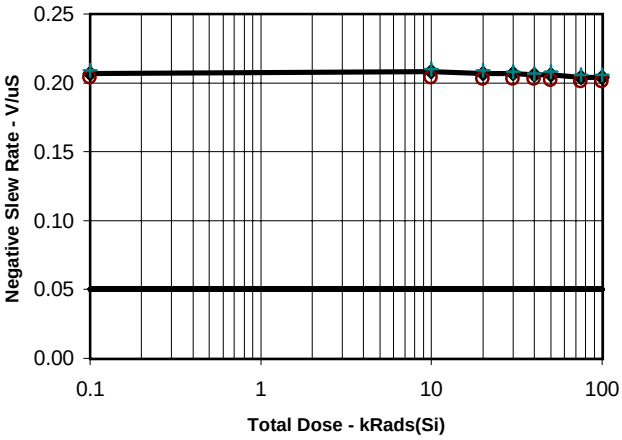
Note 1: Number of devices that were outside sub group 1 limits.

LM108AW (Rad Hard Die)
Performance Characteristics

Positive Slew Rate vs
Total Dose (A_V=1, V_{IN}=-5V to +5V)



Negative Slew Rate vs
Total Dose (A_V=1, V_{in} = +5V to -5V)



Note: + = Max, o = Min, solid lines show RETS limits, see cover page for standard conditions.

LM108AW (Rad Hard Die)
Performance Characteristics

Positive Slew Rate - V/uS, (A_V=1, V_{IN}=-5V to +5V)

Limits: Min .05 V/uS (SG1, SG2)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	0.171	0.168	0.173	0.001	0
10	0.172	0.169	0.174	0.001	0
20	0.171	0.168	0.173	0.001	0
30	0.171	0.168	0.172	0.001	0
40	0.170	0.168	0.172	0.001	0
50	0.170	0.167	0.172	0.001	0
75	0.168	0.166	0.170	0.001	0
100	0.168	0.166	0.170	0.001	0

Negative Slew Rate - V/uS, (A_V=1, V_{IN}=+5V to -5V)

Limits: Min .05 V/uS (SG1, SG2)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	0.207	0.204	0.209	0.002	0
10	0.208	0.204	0.210	0.002	0
20	0.207	0.203	0.209	0.002	0
30	0.207	0.203	0.208	0.002	0
40	0.206	0.203	0.207	0.001	0
50	0.206	0.202	0.208	0.002	0
75	0.204	0.201	0.206	0.002	0
100	0.204	0.201	0.206	0.001	0

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