

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. Dosimetry

Thermoluminescence Dosimetry is performed according to MIL-STD-883 method 1019. Actual dose rate for individual test is calculated from the exponential decay approximation of the dosimetry data.

III. TEST SETUP AND PROCEDURE

A. Pre-radiation Electrical Test

All test samples are verified to be functionally and parametrically 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°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

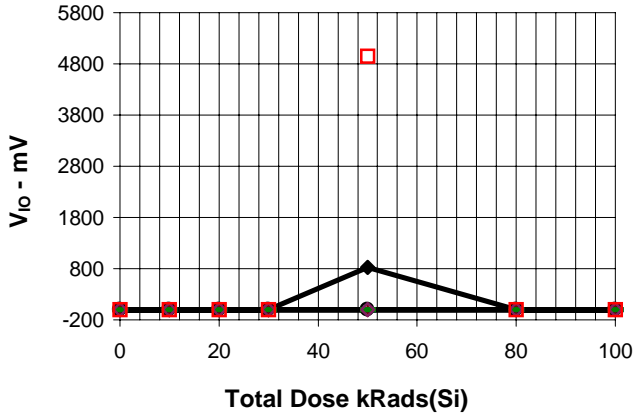
A Test Summary sheet provides details on the origins of test samples, dose rate, list of parameters tested and total variation in those parameters. Details of the test consists of select device parameter plotted and tabulated as a function of total dose. Test conditions for each parameter are also specified. 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.

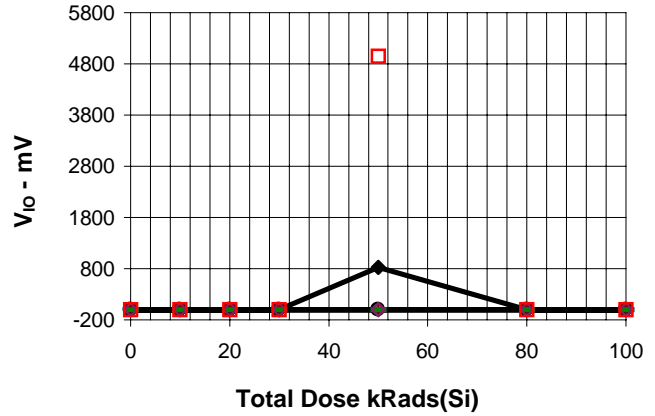


LM158AH-MLS Total Dose Radiation Test Characteristics

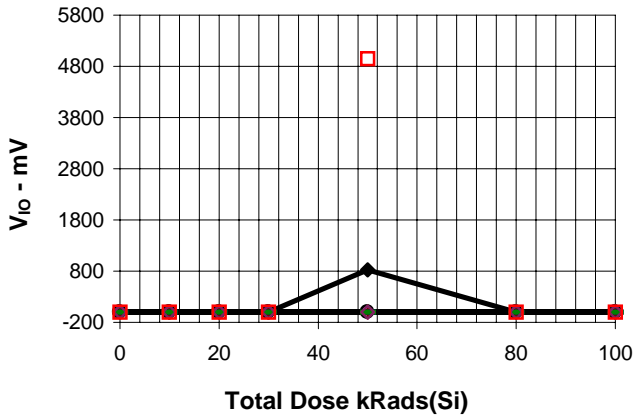
**V_{IO} ; $V_+=30V$, $V_{CM}=0V$, AMP 1
vs Total Dose**



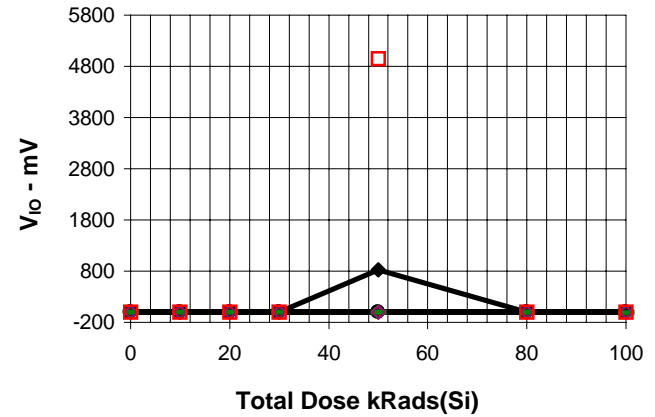
**V_{IO} ; $V_+=30V$, $V_{CM}=0V$, AMP 2
vs Total Dose**



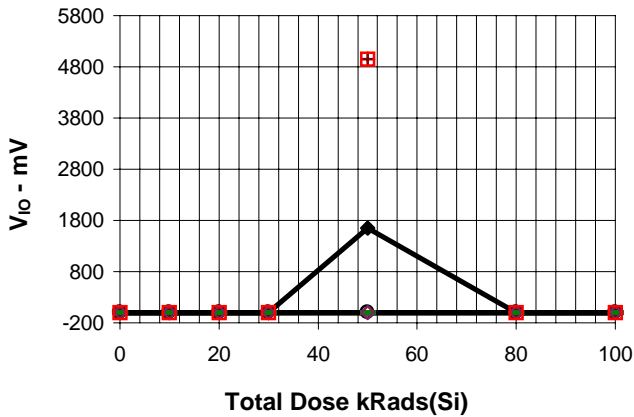
**V_{IO} ; $V_+=30V$, $V_{CM}=28V$, AMP 1
vs Total Dose**



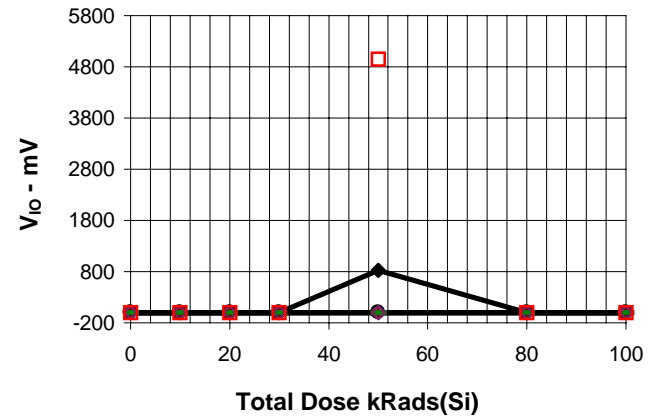
**V_{IO} ; $V_+=30V$, $V_{CM}=28V$, AMP 2
vs Total Dose**



**V_{IO} ; $V_+=5V$, $V_{CM}=0V$, AMP 1
vs Total Dose**



**V_{IO} ; $V_+=5V$, $V_{CM}=0V$, AMP 2
vs Total Dose**



Dose Rate: 62.646 Rads(Si)/sec, $V_+=5V$, $V_{CM}=0$ unless specified otherwise.



LM158AH-MLS Total Dose Radiation Test Characteristics

VIO; V+=30V, VCM=0V, AMP 1

vs Total Dose

Dose	Avg.	Min.	Max.	S. Dev.	Fail ¹
0	1.075	0.790	1.270	0.174	0
10	0.705	0.410	0.890	0.171	0
20	0.285	0.010	0.450	0.162	0
30	-0.127	-0.400	0.040	0.169	0
50	824.86	-1.220	4954.1	2022.9	1
80	-2.315	-2.620	-2.090	0.218	6
100	-3.332	-3.710	-3.080	0.247	6

VIO; V+=30V, VCM=0V, AMP 2

vs Total Dose

Dose	Avg.	Min.	Max.	S. Dev.	Fail ¹
0	0.833	0.500	1.300	0.316	0
10	0.487	0.120	0.980	0.343	0
20	0.060	-0.310	0.570	0.365	0
30	-0.348	-0.770	0.190	0.405	0
50	824.29	-1.590	4951.2	2021.8	1
80	-2.502	-3.000	-1.810	0.546	4
100	-3.517	-4.080	-2.660	0.626	6

VIO; V+=30V, VCM=28V, AMP 1

vs Total Dose

Dose	Avg.	Min.	Max.	S. Dev.	Fail ¹
0	-0.402	-0.730	-0.200	0.220	0
10	-0.782	-1.140	-0.540	0.247	0
20	-1.235	-1.570	-0.990	0.248	0
30	-1.698	-2.060	-1.400	0.281	2
50	823.51	-3.090	4954.4	2023.7	6
80	-4.178	-4.790	-3.750	0.399	6
100	-5.342	-6.040	-4.890	0.448	6

VIO; V+=30V, VCM=28V, AMP 2

vs Total Dose

Dose	Avg.	Min.	Max.	S. Dev.	Fail ¹
0	-0.747	-1.000	-0.410	0.260	0
10	-1.112	-1.410	-0.750	0.294	0
20	-1.568	-1.920	-1.180	0.331	0
30	-2.040	-2.420	-1.590	0.373	3
50	822.76	-3.450	4951.2	2022.5	6
80	-4.500	-5.080	-3.740	0.542	6
100	-5.665	-6.320	-4.730	0.631	6

VIO; V+=5V, VCM=0V, AMP 1

vs Total Dose

Dose	Avg.	Min.	Max.	S. Dev.	Fail ¹
0	1.105	0.890	1.330	0.158	0
10	0.680	0.490	0.830	0.130	0
20	0.260	0.060	0.460	0.158	0
30	-0.182	-0.400	0.010	0.174	0
50	1650.1	-1.400	4954.1	2558.1	2
80	-2.590	-3.030	-2.330	0.250	6
100	-3.735	-4.260	-3.450	0.292	6

VIO; V+=5V, VCM=0V, AMP 2

vs Total Dose

Dose	Avg.	Min.	Max.	S. Dev.	Fail ¹
0	0.840	0.530	1.230	0.289	0
10	0.453	0.110	0.870	0.321	0
20	0.003	-0.340	0.430	0.342	0
30	-0.433	-0.820	0.020	0.384	0
50	824.15	-1.740	4951.2	2021.8	1
80	-2.810	-3.320	-2.060	0.534	6
100	-3.950	-4.530	-3.020	0.626	6

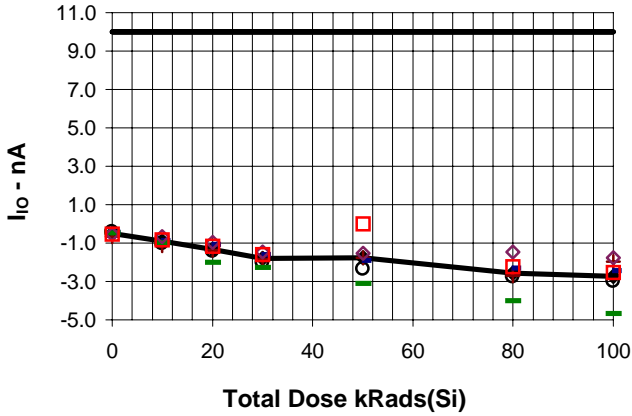
Dose Rate: 62.646 Rads(Si)/sec, V+=5V, V_{CM}=0 unless specified otherwise.

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

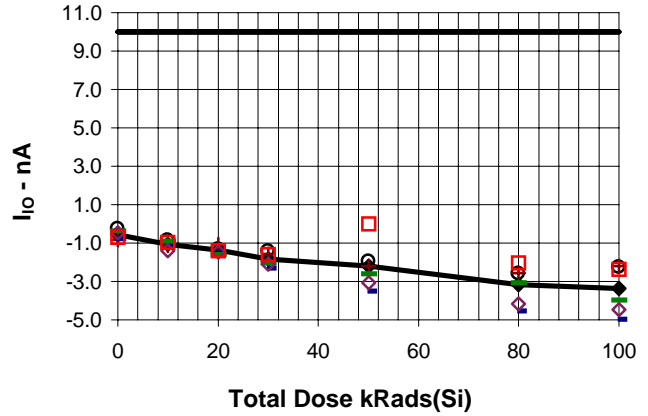


LM158AH-MLS Total Dose Radiation Test Characteristics

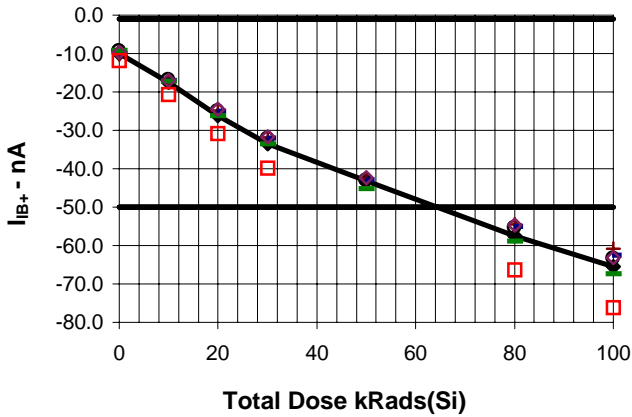
I_{IO} ; $V_+=5V, V_{CM}=0V$, AMP 1 vs
Total Dose



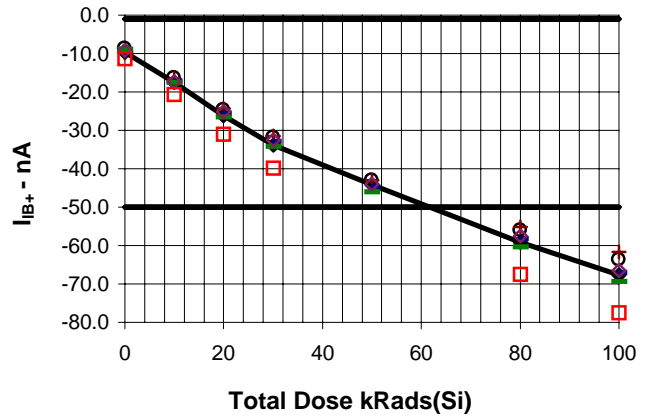
I_{IO} ; $V_+=5V, V_{CM}=0V$, AMP 2 vs
Total Dose



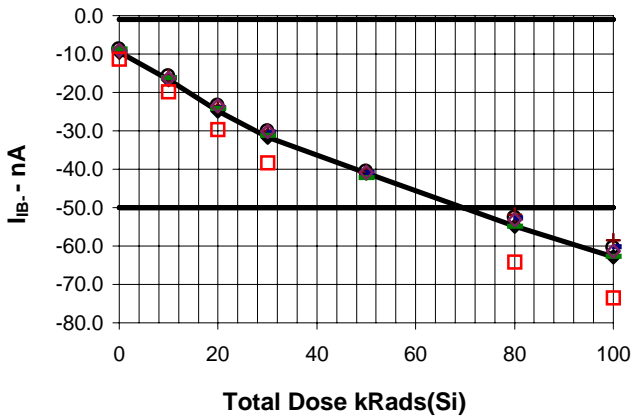
I_{IB+} ; $V_+=5V, V_{CM}=0V$, AMP 1 vs
Total Dose



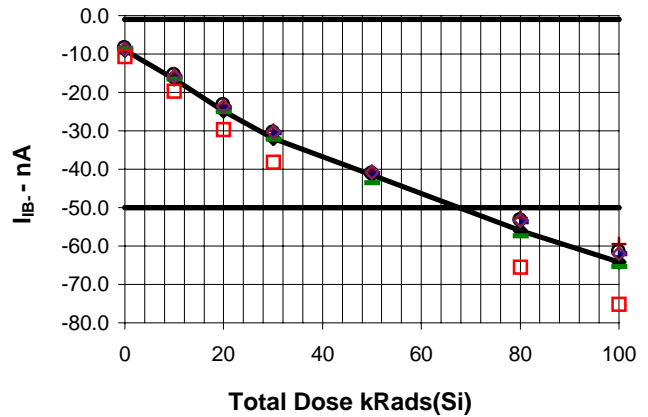
I_{IB+} ; $V_+=5V, V_{CM}=0V$, AMP 2 vs
Total Dose



I_{IB-} ; $V_+=5V, V_{CM}=0V$, AMP 1 vs
Total Dose



I_{IB-} ; $V_+=5V, V_{CM}=0V$, AMP 2 vs
Total Dose



Dose Rate: 62.646 Rads(Si)/sec, $V_+=5V, V_{CM}=0$ unless specified otherwise.



LM158AH-MLS Total Dose Radiation Test Characteristics

I_{IO} ; $V_{+}=5V, V_{CM}=0V$, AMP 1 vs

Total Dose

Dose	Avg.	Min.	Max.	S. Dev.	Fail ¹
0	-0.503	-0.660	-0.400	0.094	0
10	-0.913	-1.140	-0.650	0.167	0
20	-1.332	-2.000	-0.970	0.367	0
30	-1.795	-2.280	-1.450	0.307	0
50	-1.768	-3.090	0.000	1.025	0
80	-2.580	-4.010	-1.480	0.835	0
100	-2.718	-4.670	-1.750	1.047	0

I_{IO} ; $V_{+}=5V, V_{CM}=0V$, AMP 2 vs

Total Dose

Dose	Avg.	Min.	Max.	S. Dev.	Fail ¹
0	-0.557	-0.820	-0.220	0.239	0
10	-1.052	-1.390	-0.830	0.201	0
20	-1.382	-1.600	-1.050	0.189	0
30	-1.832	-2.290	-1.390	0.357	0
50	-2.215	-3.490	0.000	1.223	0
80	-3.157	-4.540	-2.020	0.992	0
100	-3.362	-4.980	-2.190	1.251	0

I_{IB+} ; $V_{+}=5V, V_{CM}=0V$, AMP 1 vs

Total Dose

Dose	Avg.	Min.	Max.	S. Dev.	Fail ¹
0	-10.012	-11.850	-9.200	0.976	0
10	-17.573	-20.670	-16.760	1.522	0
20	-26.088	-30.880	-24.550	2.416	0
30	-33.490	-39.880	-31.630	3.199	0
50	-43.134	-45.230	-42.280	1.199	0
80	-57.465	-66.400	-54.540	4.659	6
100	-65.547	-76.100	-60.750	5.604	6

I_{IB+} ; $V_{+}=5V, V_{CM}=0V$, AMP 2 vs

Total Dose

Dose	Avg.	Min.	Max.	S. Dev.	Fail ¹
0	-9.632	-11.390	-8.730	0.992	0
10	-17.530	-20.630	-16.290	1.584	0
20	-26.230	-31.040	-24.410	2.473	0
30	-33.775	-39.830	-31.580	3.107	0
50	-44.124	-46.030	-42.930	1.279	0
80	-59.112	-67.480	-55.190	4.486	6
100	-67.590	-77.490	-61.640	5.538	6

I_{IB-} ; $V_{+}=5V, V_{CM}=0V$, AMP 1 vs

Total Dose

Dose	Avg.	Min.	Max.	S. Dev.	Fail ¹
0	-9.510	-11.330	-8.740	0.948	0
10	-16.658	-19.810	-15.750	1.557	0
20	-24.755	-29.710	-23.500	2.444	0
30	-31.700	-38.280	-29.950	3.252	0
50	-41.008	-42.130	-40.620	0.633	0
80	-54.883	-64.160	-51.840	4.651	6
100	-62.792	-73.580	-58.550	5.459	6

I_{IB-} ; $V_{+}=5V, V_{CM}=0V$, AMP 2 vs

Total Dose

Dose	Avg.	Min.	Max.	S. Dev.	Fail ¹
0	-9.075	-10.690	-8.470	0.835	0
10	-16.473	-19.670	-15.340	1.622	0
20	-24.848	-29.650	-23.360	2.425	0
30	-31.945	-38.220	-30.010	3.168	0
50	-41.468	-43.420	-40.740	1.105	0
80	-55.955	-65.460	-52.600	4.949	6
100	-64.230	-75.120	-59.450	5.663	6

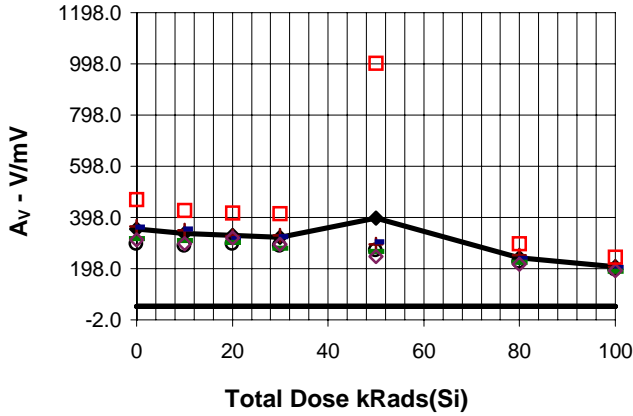
Dose Rate: 62.646 Rads(Si)/sec, $V_{+}=5V, V_{CM}=0$ unless specified otherwise.

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

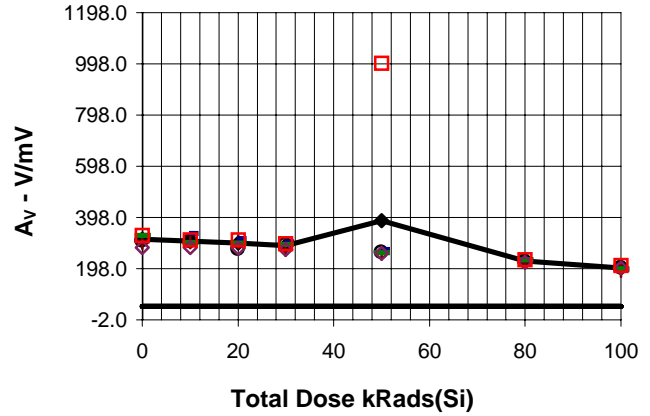


LM158AH-MLS Total Dose Radiation Test Characteristics

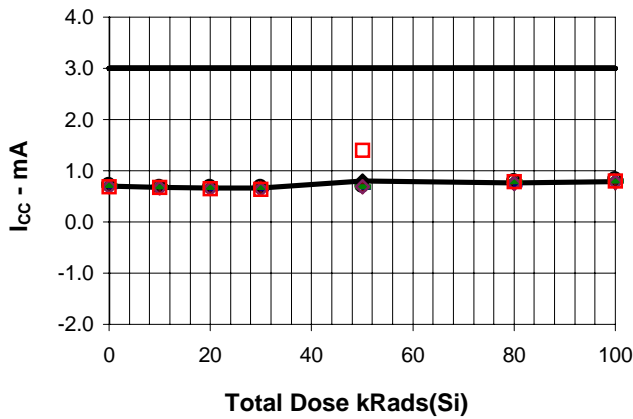
Large Signal Voltage Gain vs
Total Dose



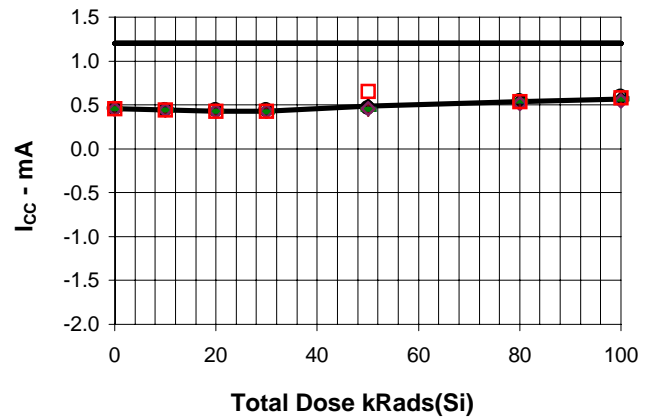
Large Signal Voltage Gain vs
Total Dose



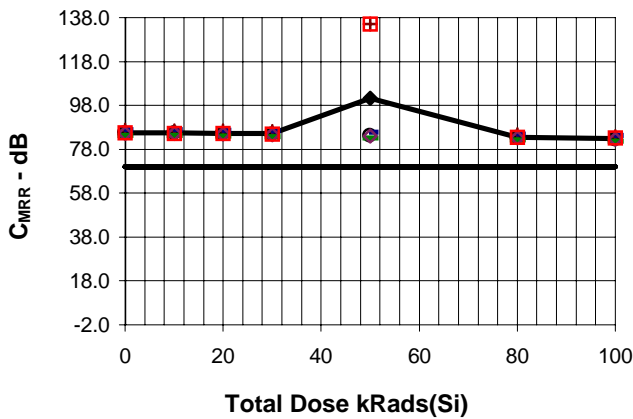
I_{CC} ; $V_+=30V$, $R_L=100K$, $V_O=1.4V$ vs
Total Dose



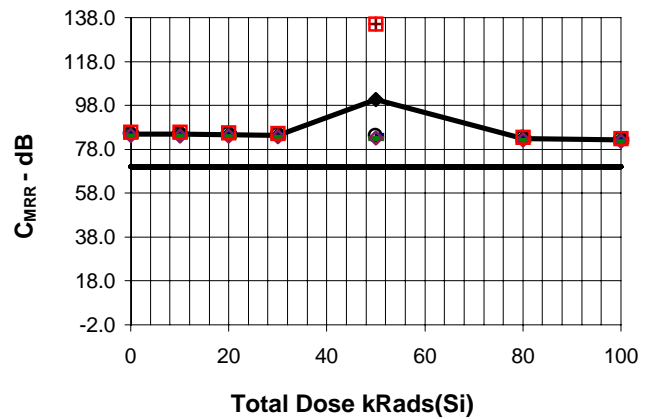
I_{CC} ; $V_+=5V$, $R_L=100K$, $V_O=1.4V$ vs
Total Dose



C_{MRR} ; $V_+=30V$, $V_I=0-28V$, AMP 1
vs Total Dose



C_{MRR} ; $V_+=30V$, $V_I=0-28V$, AMP 2
vs Total Dose



Dose Rate: 62.646 Rads(Si)/sec, $V_+=5V$, $V_{CM}=0$ unless specified otherwise.



LM158AH-MLS Total Dose Radiation Test Characteristics

Large Signal Voltage Gain vs

Total Dose

Dose	Avg.	Min.	Max.	S. Dev.	Fail ¹
0	352.43	295.02	468.89	63.631	0
10	336.39	287.22	425.33	51.493	0
20	328.79	295.75	415.64	44.009	0
30	320.55	277.12	413.20	49.814	0
50	396.17	245.49	1000.0	296.5	0
80	240.69	214.70	294.94	29.444	0
100	204.60	188.91	243.28	20.090	0

Large Signal Voltage Gain vs

Total Dose

Dose	Avg.	Min.	Max.	S. Dev.	Fail ¹
0	312.08	280.14	328.65	19.627	0
10	306.12	280.50	335.79	17.814	0
20	297.06	276.64	315.92	16.329	0
30	288.26	273.67	302.3	11.8	0
50	385.46	256.95	1000.0	301.1	0
80	228.92	222.60	233.48	5.202	0
100	199.27	189.48	209.35	6.694	0

I_{CC}: V₊=30V, R_L=100K, V_O=1.4V vs

Total Dose

Dose	Avg.	Min.	Max.	S. Dev.	Fail ¹
0	0.697	0.684	0.726	0.016	0
10	0.677	0.659	0.692	0.013	0
20	0.661	0.651	0.690	0.016	0
30	0.657	0.632	0.688	0.020	0
50	0.805	0.670	1.404	0.293	0
80	0.764	0.731	0.794	0.026	0
100	0.794	0.766	0.832	0.024	0

I_{CC}: V₊=5V, R_L=100K, V_O=1.4V vs

Total Dose

Dose	Avg.	Min.	Max.	S. Dev.	Fail ¹
0	0.457	0.451	0.460	0.004	0
10	0.443	0.441	0.451	0.004	0
20	0.431	0.426	0.441	0.006	0
30	0.428	0.420	0.441	0.007	0
50	0.489	0.451	0.651	0.080	0
80	0.536	0.517	0.545	0.011	0
100	0.570	0.545	0.593	0.016	0

C_{MRR}: V₊=30V, V_i=0-28V, AMP 1

vs Total Dose

Dose	Avg.	Min.	Max.	S. Dev.	Fail ¹
0	85.607	84.300	87.040	1.007	0
10	85.547	84.280	86.970	1.001	0
20	85.352	84.120	86.730	0.973	0
30	85.068	83.760	86.430	1.000	0
50	101.18	83.190	134.96	26.177	0
80	83.570	82.230	84.790	0.953	0
100	82.927	81.580	84.190	0.966	0

C_{MRR}: V₊=30V, V_i=0-28V, AMP 2

vs Total Dose

Dose	Avg.	Min.	Max.	S. Dev.	Fail ¹
0	84.993	84.050	85.890	0.694	0
10	84.902	83.980	85.730	0.684	0
20	84.710	83.760	85.450	0.659	0
30	84.403	83.460	85.200	0.657	0
50	100.73	82.910	134.96	26.519	0
80	82.938	82.020	83.600	0.597	0
100	82.308	81.410	82.980	0.576	0

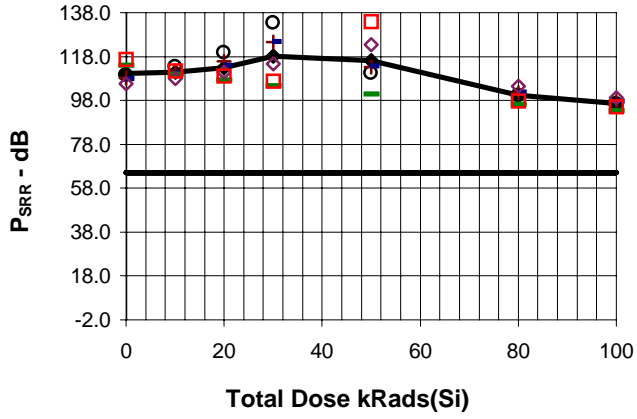
Dose Rate: 62.646 Rads(Si)/sec, V₊=5V, V_{CM}=0 unless specified otherwise.

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

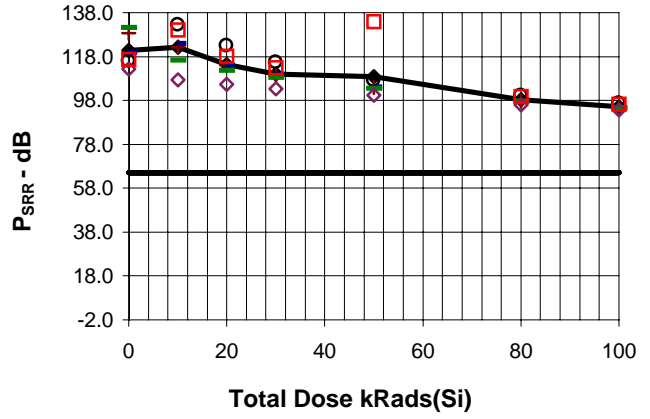


LM158AH-MLS Total Dose Radiation Test Characteristics

P_{SRR} ; $V_+ = 5-30V$, $V_{CM} = 0V$, AMP 1
vs Total Dose



P_{SRR} ; $V_+ = 5-30V$, $V_{CM} = 0V$, AMP 2
vs Total Dose



Dose Rate: 62.646 Rads(Si)/sec, $V_+ = 5V$, $V_{CM} = 0$ unless specified otherwise.



LM158AH-MLS Total Dose Radiation Test Characteristics

P_{SRR}: V₊=5-30V, V_{CM}=0V, AMP 1

vs Total Dose

Dose	Avg.	Min.	Max.	S. Dev.	Fail ¹
0	110.35	105.59	116.57	4.180	0
10	110.81	108.01	113.52	1.820	0
20	112.87	107.41	119.88	4.622	0
30	118.21	104.82	133.34	11.255	0
50	116.01	101.00	133.98	11.372	0
80	100.34	96.15	104.35	2.966	0
100	96.552	93.470	99.290	2.056	0

P_{SRR}: V₊=5-30V, V_{CM}=0V, AMP 2

vs Total Dose

Dose	Avg.	Min.	Max.	S. Dev.	Fail ¹
0	120.87	112.22	131.42	7.552	0
10	122.12	107.48	132.39	9.171	0
20	114.43	105.23	123.23	6.037	0
30	109.92	103.26	115.64	4.198	0
50	108.89	100.39	133.98	12.495	0
80	98.25	96.12	100.44	1.579	0
100	95.097	93.660	96.840	1.172	0

Dose Rate: 62.646 Rads(Si)/sec, V₊=5V, V_{CM}=0 unless specified otherwise.

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