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.

LP2956J Total Dose Radiation Test Report

November 9, 1996

Eight samples of LP2956J were exposed to 200k Rads(Si) total dose and electrical data was collected after 5k, 10k, 30k, 50k and 100k Rads(Si) exposure. Since none of the devices were functional at 200k Rads(Si), this report includes data that only goes up to 100k Rads(Si).

Main output voltage started to fall between 30k and 50k Rads(Si). Due to narrow MDS limits, first fall out occurred at 10k Rads(Si). Feedback pin voltage also followed a similar trend and started to deteriorate at 50k Rads(Si). Since its limits are not as narrow as V_{OUT}, first fall out occurred 100k Rads(Si).

Dropout voltage started to shift at 30k Rads(Si) and the first MDS failure occurred at 100k Rads(Si).

Line regulation data for the main regulator shows six catastrophic failures at 50k Rads(Si). Since three of these devices recovered at 100k Rads(Si), data at 50k Rads(Si) is questionable. This is potentially due to the method used to measure this parameter. Load regulation started to shift at 50k Rads(Si) and did not have any MDS failures.

Ground current data for active mode and dropout mode shows five catastrophic failures at 50k Rads(Si). Current appeared to be going into the ground pin. All of the failed devices recover at 100k Rads(Si) and there are no failures at 100k Rads(Si). Same five devices failed both tests. Ground current in the shutdown mode also had four catastrophic failures at 50k Rads(Si) and all four devices recovered at 100k Rads(Si). It should be noted that the four devices failing the ground current in shut down test have no correlation with the devices that failed the other two ground current tests. All four of these devices also show a sudden change in the current limit at 50k Rads(Si) which also recovered at 100k Rads(Si).

Data for shutdown input threshold voltages shows actual voltages at which the transition from device ON to device OFF or vice versa occurred. In the case of high threshold, on average transition occurred at 0.8V. A minimum input of 0.9V at room temperature guarantees the transition from ON to OFF. These threshold voltages did not have any significant change.

Performance of the dropout detection output and auxiliary output closely matched the performance of the main regulator. Several parameters show catastrophic failures at 50k Rads(Si). All the failing devices recovered at 100k Rads(Si).

Experiment Details:

Sample Size:	8		
Lot No:	STM58589R (1 - 4), STM39920R (5 - 8)		
Wafer Run No:	AA0039E41 (1 - 4), AA0039E41 (5 - 8)		
Date Code:	9442 (1 - 4), 9420 (5 - 8)		
Test Date:	18 October 1996		
Dose Rate:	123.88 Rads(Si)/sec	Bias Circuit:	6261HR
MDS:	MNLP2956A-X Rev 0A0	Test Program:	RAD2956RA

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Total Dose Radiation Test Characteristics

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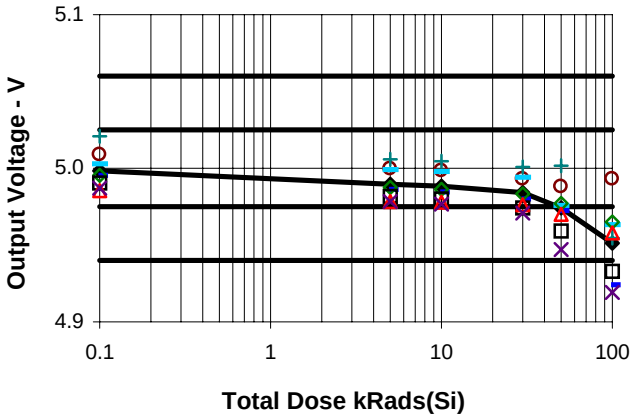
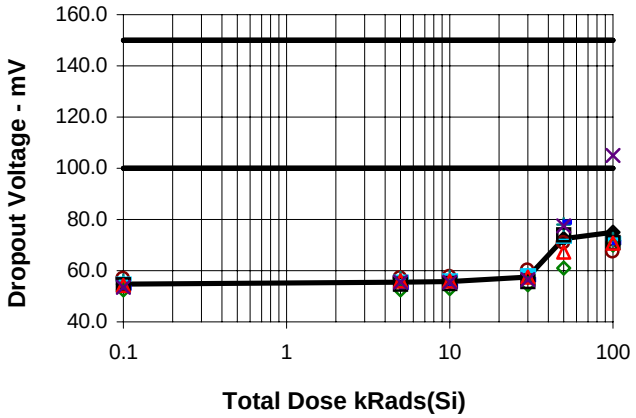
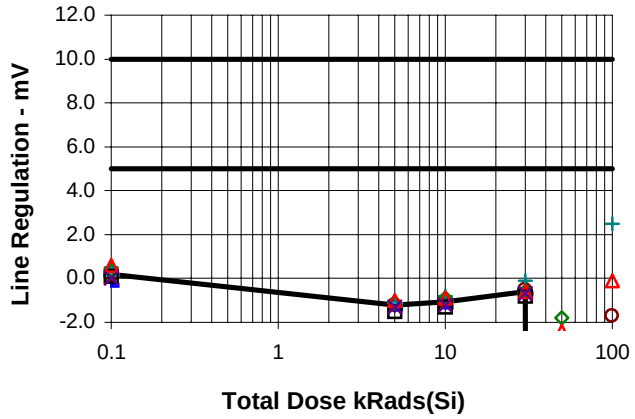
Output Voltage vs Total Dose
(V_{IN} = 6V, I_L = 1mA)



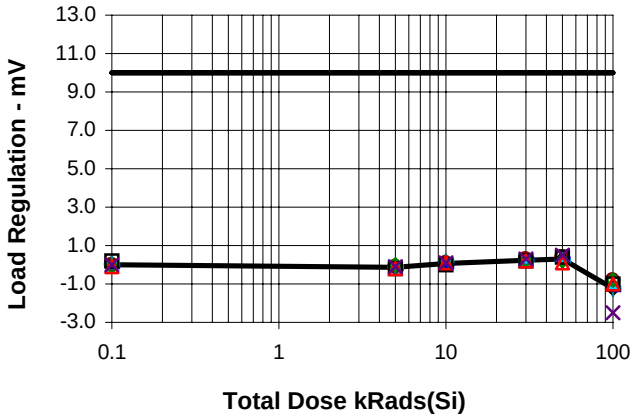
Dropout Voltage vs Total Dose
(I_{OUT} = 1mA)



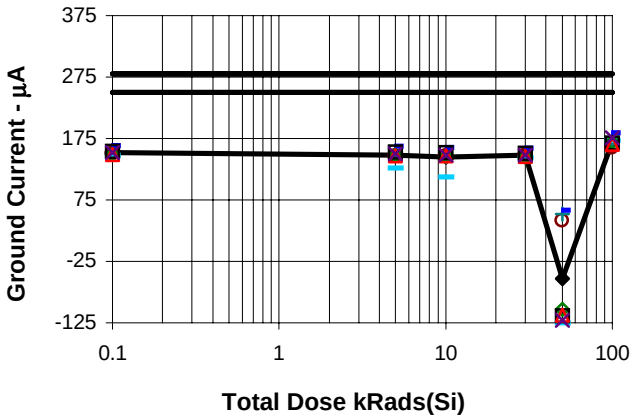
Line Regulation vs Total Dose
(V_{IN} = 6 - 30V)



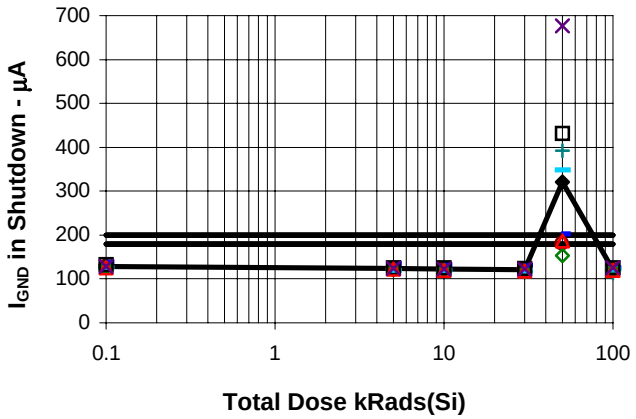
Load Regulation vs Total Dose
(I_L = 1 - 0.1mA)



Ground Current vs Total
Dose (IL_{MAIN} = 1mA, IL_{AUX} = 100uA)



Ground Current in Shutdown vs Total
Dose (I_{SHD} = 1µA, No Load)



Dose Rate :123.88 Rads(Si)/sec, see table page for standard conditions.

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Total Dose Radiation Test Characteristics

November 9, 1996

Output Voltage vs Total Dose

(V_{IN} = 6V, I_L = 1mA)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	4.998	4.986	5.021	0.012	0
5	4.990	4.978	5.006	0.011	0
10	4.988	4.977	5.005	0.011	1
30	4.984	4.971	5.001	0.011	2
50	4.974	4.947	5.002	0.017	3
100	4.951	4.919	4.993	0.025	6

Dropout Voltage vs Total Dose

(I_{OUT} = 1mA)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	54.738	52.50	57.10	1.699	0
5	55.550	52.60	57.60	1.817	0
10	55.850	52.90	57.90	1.803	0
30	57.438	54.60	60.20	1.967	0
50	72.400	61.00	78.90	6.119	0
100	74.963	67.40	104.90	12.197	1

Line Regulation vs Total Dose

(V_{IN} = 6 - 30V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	0.200	-0.3	0.6	0.293	0
5	-1.225	-1.5	-1.0	0.167	0
10	-1.075	-1.3	-0.8	0.191	0
30	-0.588	-0.8	-0.1	0.217	0
50	-1710.2	-5503.7	81.2	2086.2	6
100	-122.5	-480.3	2.5	182.8	3

Load Regulation vs Total Dose

(I_L = 1 - .1mA)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	0.000	-0.1	0.2	0.107	0
5	-0.138	-0.2	0.0	0.074	0
10	0.075	-0.1	0.2	0.104	0
30	0.238	0.2	0.3	0.052	0
50	0.300	0.1	0.5	0.131	0
100	-1.238	-2.5	-0.8	0.548	0

Ground Pin Current vs Total

Dose (IL_{MAIN} = 1mA, IL_{AUX} = 100uA)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	151.88	148	164	5.276	0
5	147.50	127	162	9.783	0
10	144.75	113	160	13.698	0
30	148.38	144	159	4.779	0
50	-53.000	-125	58	85.934	5
100	170.13	159	184	7.434	0

Ground Current in Shutdown vs Total

Dose (I_{SHD} = 1uA, No Load)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	128.63	125	139	4.809	0
5	124.13	120	135	4.764	0
10	122.63	119	133	4.868	0
30	121.13	116	131	4.734	0
50	321.13	153	676	179.07	5
100	121.25	114	126	4.062	0

Dose Rate :123.88 Rads(Si)/sec.

Standard Conditions :V_{IN} = 6V, C_L = 2.2µF (Main Out.) and 10µF (Aux. Out.) ,Feedback pin is tied to 5V Tap pin, C_{IN} = 1µF, V_{SD} = 0V, Main Out. Pin is tied to Out. Sense pin, Aux. Out. is programmed for 5V. The main regulator output has a 1mA load, aux. regulator output has a 100uA load.

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

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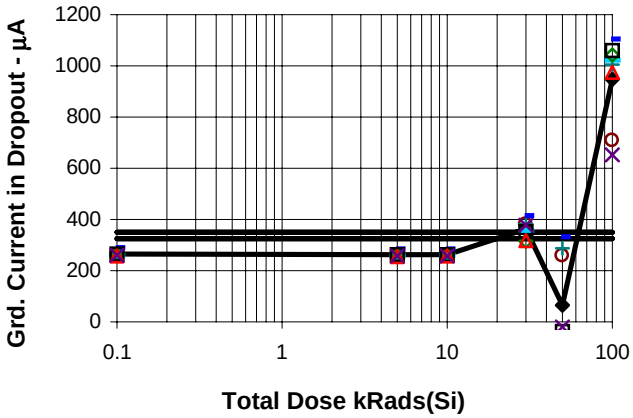
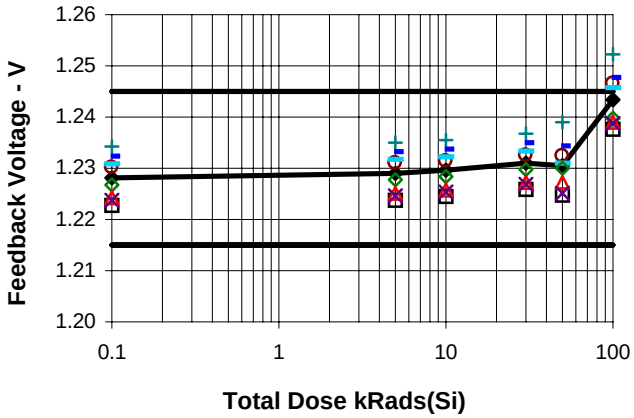
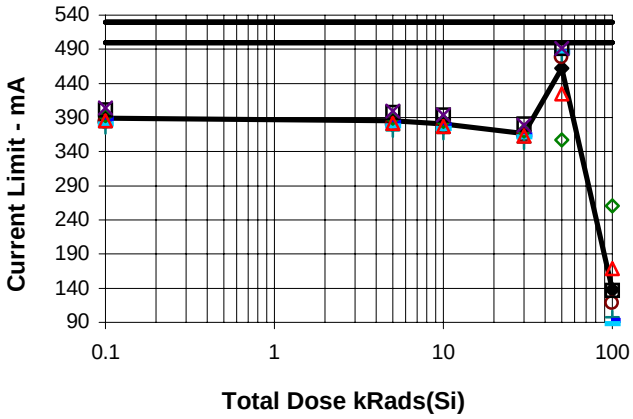
Ground Current in Dropout vs Total Dose (V_{IN} = 4.5V, I_L = 100µA)



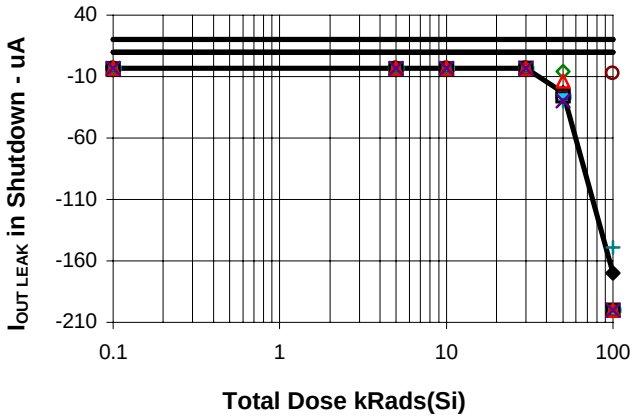
Feedback Voltage vs Total Dose



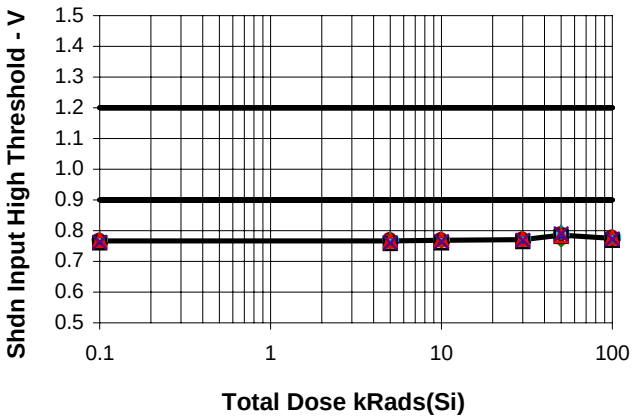
Current Limit vs Total Dose



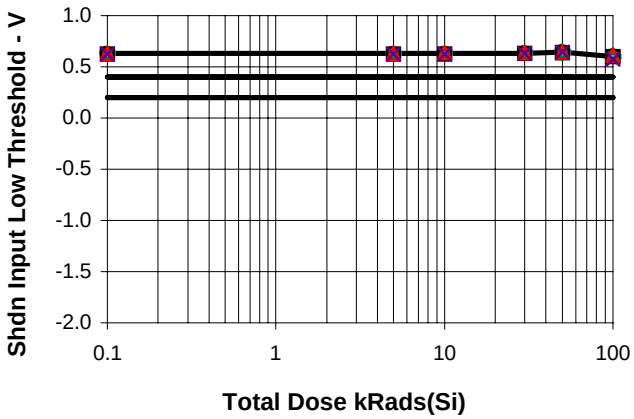
$I_{OUT\ LEAK}$ in Shutdown vs Total Dose (I_{SD} = 1µA, V_{IN} = 30V, V_{OUT} = 0V)



Shutdown Input High Threshold vs Total Dose



Shutdown Input Low Threshold vs Total Dose



Dose Rate :123.88 Rads(Si)/Sec

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Ground Current in Dropout vs Total Dose (V_{IN} = 4.5V, I_L = 100µA)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	264.63	258.0	289.0	10.099	0
5	262.50	256.0	286.0	9.754	0
10	263.00	257.0	286.0	9.472	0
30	362.25	314.0	414.0	34.217	6
50	64.875	-122.0	333.0	192.71	1
100	946.88	652.0	1105.0	169.43	8

Feedback Voltage vs Total Dose

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	1.228	1.223	1.234	0.004	0
5	1.229	1.224	1.235	0.004	0
10	1.230	1.225	1.236	0.004	0
30	1.231	1.226	1.237	0.004	0
50	1.231	1.225	1.239	0.005	0
100	1.243	1.238	1.252	0.005	4

Current Limit vs Total Dose

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	389.01	376.0	403.9	9.752	0
5	385.08	371.6	399.8	9.777	0
10	380.78	367.6	394.2	9.360	0
30	366.99	353.5	380.5	9.169	0
50	462.19	357.2	491.4	47.751	0
100	137.57	87.8	260.8	61.385	0

$I_{OUT\ LEAK}$ in Shutdown vs Total Dose (I_{SD} = 1υA, V_{IN} = 30V, V_{OUT} = 0V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	-3.466	-3.74	-3.36	0.124	0
5	-3.433	-3.71	-3.34	0.124	0
10	-3.416	-3.69	-3.31	0.124	0
30	-3.364	-3.61	-3.29	0.111	0
50	-22.964	-29.77	-5.71	8.620	0
100	-169.71	-200.18	-7.62	67.901	0

Shutdown Input High Threshold vs Total Dose

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	0.766	0.760	0.773	0.004	0
5	0.766	0.759	0.773	0.005	0
10	0.768	0.761	0.774	0.004	0
30	0.770	0.764	0.776	0.004	0
50	0.785	0.771	0.795	0.007	0
100	0.776	0.768	0.782	0.005	0

Shutdown Input Low Threshold vs Total Dose

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	0.629	0.626	0.633	0.003	0
5	0.629	0.623	0.634	0.004	0
10	0.631	0.627	0.635	0.003	0
30	0.633	0.630	0.638	0.003	0
50	0.643	0.634	0.654	0.007	0
100	0.599	0.572	0.616	0.013	0

Dose Rate :123.88 Rads(Si)/sec.

Standard Conditions :V_{IN} = 6V, C_L = 2.2µF (Main Out.) and 10µF (Aux. Out.) ,Feedback pin is tied to 5V Tap pin, C_{IN} = 1µF, V_{SD} = 0V, Main Out. Pin is tied to Out. Sense pin, Aux. Out. is programmed for 5V. The main regulator output has a 1mA load, aux. regulator output has a 100uA load.

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

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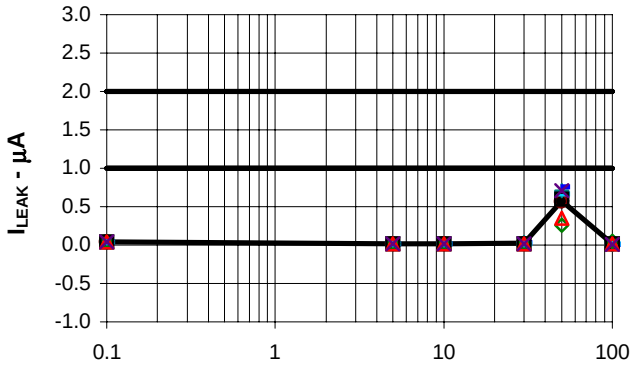
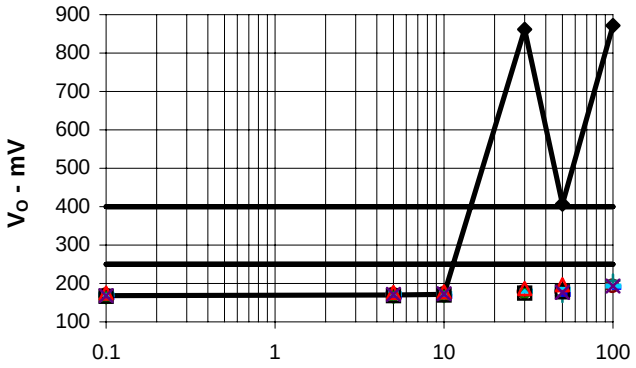
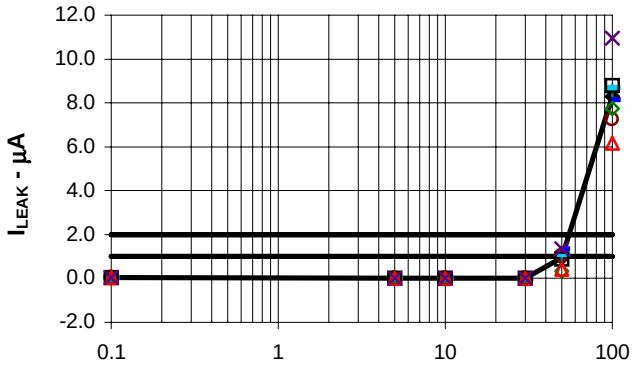
Dropout Detection I_{LEAK} vs Total Dose (V_{OH} = 30V)



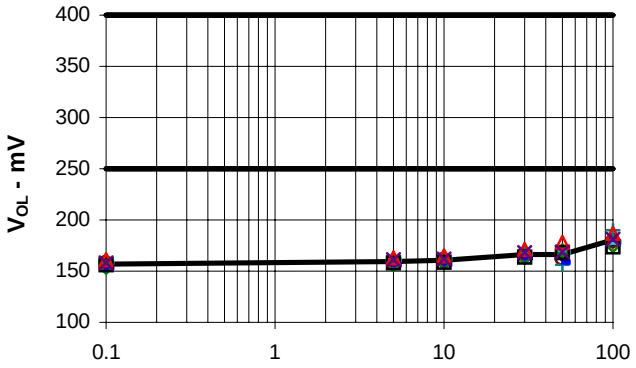
Dropout Detection V_{OL} vs Total Dose (V_{IN} = 4V, $I_{O(COMP)}$ = 400µA)



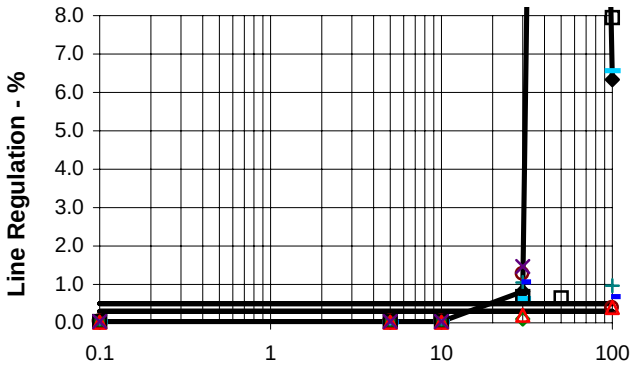
Auxiliary Output I_{LEAK} vs Total Dose (V_{OH} = 30V, $V_{IN(COMP)}$ = 1.3V)



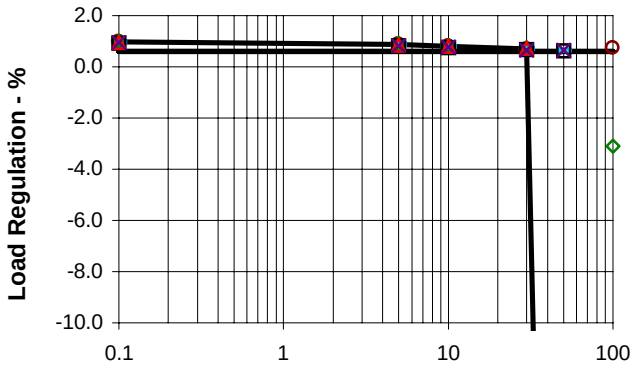
Auxiliary Comparator V_{OL} vs Total Dose ($V_{IN(COMP)}$ = 1.1V, $I_{O(COMP)}$ = 400µA)



Auxiliray Comparator Line Reg. vs Total Dose (V_{IN} = 6V to 30V)



Auxiliary Comparator Load Reg. vs Total Dose (I_L = 1mA to 75mA)



Dose Rate :123.88 Rads(Si)/Sec

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Dropout Detection I_{LEAK} vs
Total Dose (V_{OH} = 30V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	0.040	0.040	0.040	N/A	0
5	0.020	0.020	0.020	N/A	0
10	0.020	0.020	0.020	N/A	0
30	0.023	0.020	0.030	N/A	0
50	0.579	0.260	0.760	0.181	0
100	0.019	0.010	0.050	0.014	0

Dropout Detection V_{OL} vs
Total Dose (V_{IN} = 4V, $I_{O(COMP)}$) = 400µA)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	168.6	163.0	175.0	3.7	0
5	170.6	165.0	177.0	3.9	0
10	172.1	167.0	179.0	3.8	0
30	861.6	175.0	1999.0	941.8	2
50	406.9	169.0	1999.0	643.4	1
100	871.6	190.0	1999.0	933.6	3

Auxiliary Output I_{LEAK} vs Total
Dose (V_{OH} = 30V, $V_{IN(COMP)}$ = 1.3V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	0.030	0.030	0.030	N/A	0
5	0.010	0.010	0.010	N/A	0
10	0.010	0.010	0.010	N/A	0
30	0.020	0.020	0.020	N/A	0
50	0.951	0.340	1.360	0.387	4
100	8.294	6.170	10.950	1.387	8

Auxiliary Comparator V_{OL} vs Total
Dose ($V_{IN(COMP)}$ = 1.1V, $I_{O(COMP)}$ = 400µA)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	157.13	154.00	161.00	2.42	0
5	159.13	156.00	163.00	2.47	0
10	160.63	157.00	165.00	2.56	0
30	166.13	163.00	171.00	2.75	0
50	166.38	156.00	178.00	7.03	0
100	180.38	174.00	190.00	5.55	0

Auxiliray Comparator Line Reg.
vs Total Dose (V_{IN} = 6V to 30V)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	0.03	0.02	0.03	0.00	0
5	0.03	0.02	0.03	0.00	0
10	0.03	0.02	0.03	0.00	0
30	0.81	0.11	1.47	0.49	5
50	71.50	0.64	136.93	56.22	8
100	6.33	0.38	19.40	7.24	8

Auxiliary Comparator Load Reg.
vs Total Dose (I_L = 1mA to 75mA)

Dose	Avg.	Min.	Max.	S. Dev.	Fail[1]
0.1	0.97	0.92	1.01	0.03	8
5	0.87	0.83	0.91	0.03	8
10	0.79	0.76	0.82	0.02	8
30	0.70	0.65	0.75	0.03	8
50	-60.46	-157.33	0.65	66.79	8
100	-82.05	-110.66	0.73	49.93	8

Dose Rate :123.88 Rads(Si)/sec.

Standard Conditions :V_{IN} = 6V, C_L = 2.2µF (Main Out.) and 10µF (Aux. Out.) ,Feedback pin is tied to 5V Tap pin, C_{IN} = 1µF, V_{SD} = 0V, Main Out. Pin is tied to Out. Sense pin, Aux. Out. is programmed for 5V. The main regulator output has a 1mA load, aux. regulator output has a 100uA load.

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