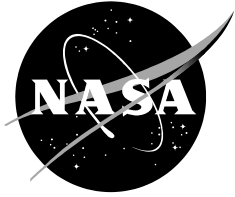


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Total Ionizing Dose Test Report MAX4651 Quad SPST Analog Switch

Jason Osheroff

Ted Wilcox

April 2021

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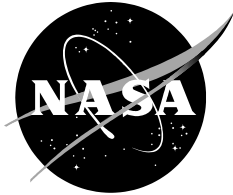
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Jason Osheroff
Goddard Space Flight Center, Greenbelt, MD

Ted Wilcox
Goddard Space Flight Center, Greenbelt, MD

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National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

April 2021

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1. Purpose

The purpose of this testing was to perform a Radiation Lot Acceptance Test (RLAT) for Total Ionizing Dose (TID) of MAX4651 Low-Voltage, 4 Ω , Quad, SPST, CMOS Analog Switches for the Roman Space Telescope (RST).

2. Test Samples

Twelve parts from the flight lot were procured. Ten were used for radiation testing, with five biased and five unbiased during irradiation, and two reserved as controls. The devices were mounted on adapter boards as shown in Fig. 1 to allow for easy insertion and removal into zero insertion force (ZIF) sockets on both the test board and bias board. More information can be found in Table 1.

Table 1: Part Identification Information

Qty	Part Number	LDC	Package	REAG ID #
12	MAX4651EUE+	1831	TSSOP	21-001

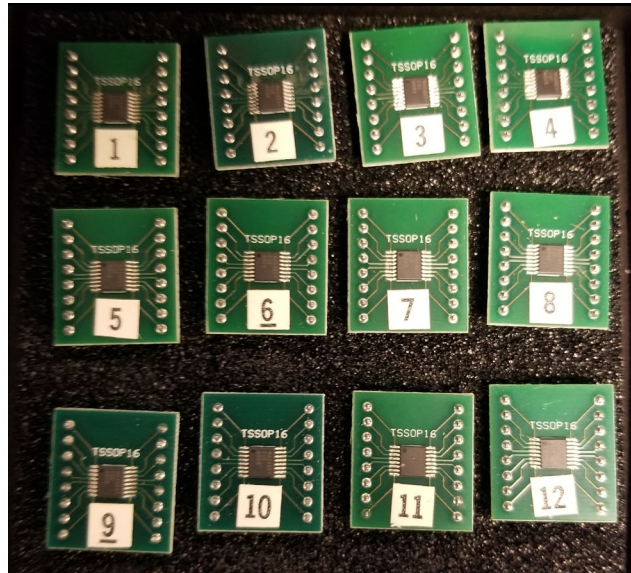
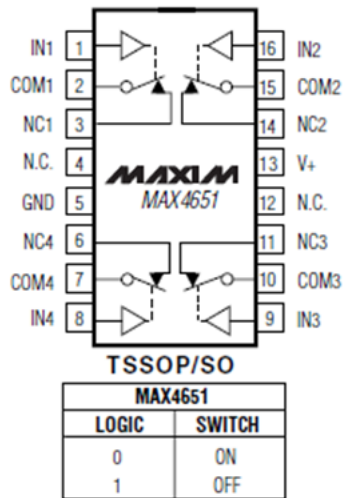


Fig. 1: Pin out for devices (left) and prepared DUTs (Device Under Test)(right)

3. General

The components were exposed to gamma radiation at a dose rate of 7.1 rad(Si)/s and 16.7 rad(Si)/s. After the first dose step of 5 krad at 7.1 rad(Si)/s, the dose rate was increased to 16.7 rad(Si)/s to shorten the irradiation time. Prior to the first irradiation, all parts were electrically tested using Keithley 2400-series sourcemeters for functionality, off-state leakage current (NC and COM pins), on-state resistance, and turn on/off times. After each exposure level, the parts

(including the controls) were re-tested. The dose steps are listed in Table 2. The MAX4651 has 4 identical circuits per device; all 4 were tested separately for each chip by using physical switches on the test board to access or isolate any specific switch circuit. All testing and irradiations were performed at room temperature.

Table 2: Device Grouping and Step-Stress Instructions

Group	Qty	Bias	Dose Rate	Test Levels (krad(Si))
1	5	Biased	7.1-16.7 rad(Si)/s	0, 5, 10, 20, 30, 50
2	5	Unbiased	7.1-16.7 rad(Si)/s	0, 5, 10, 20, 30, 50

4. Electrical Tests

Electrical tests were performed in accordance with the datasheets with the exception of V+. V+ was held at 5 V for all tests. All test conditions listed in Table 3 for the following parameters were tested using the test setup shown in Fig. 2.

Table 3: List of Parameters to be measured

Test	Symbol	MAX4651 Specifications	
		Min	Max
NC OFF Leakage Current	$I_{NC(OFF)}$	-0.1 nA	0.1 nA
COM OFF Leakage Current	$I_{COM(OFF)}$	-0.1 nA	0.1 nA
ON Resistance	R_{ON}		4 Ω
Turn ON Time	T_{ON}		14 ns
Turn OFF Time	T_{OFF}		8 ns



Fig. 2: Picture of electrical test board (top) and test bench (bottom)

5. Failure Criteria

The parametric limits were defined as those listed in the manufacturer's datasheet. Accurate parameter measurements were maintained beyond the specified limits when parameter drift was observed. When functional failure was observed, that result was noted in place of the parameter measurements. For the timing measurements the speed was limited by the electrical characteristics of the test setup so while the "Turn ON times" and "Turn OFF times" are above the specification limit from the beginning, before any radiation was applied, their change with increasing dose is measured and reported.

6. Source Requirements

The total dose source was the GSFC gamma irradiator in the Radiation Effects Facility, which is compliant with MIL-STD-883, Method 1019. Dosimetry is NIST traceable.

7. Bias Conditions and Fixtures

The unbiased parts had all leads grounded during irradiation, while the biased part configuration was as shown in Fig. 3. Fig. 4 is a photograph of the irradiation board.

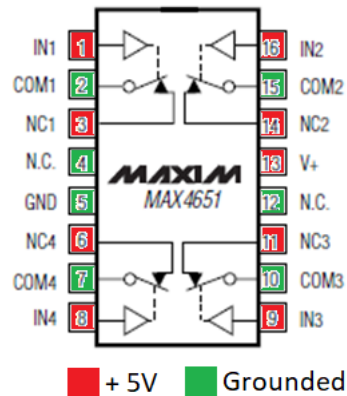


Fig. 3: Applied Voltages for Biased Irradiations

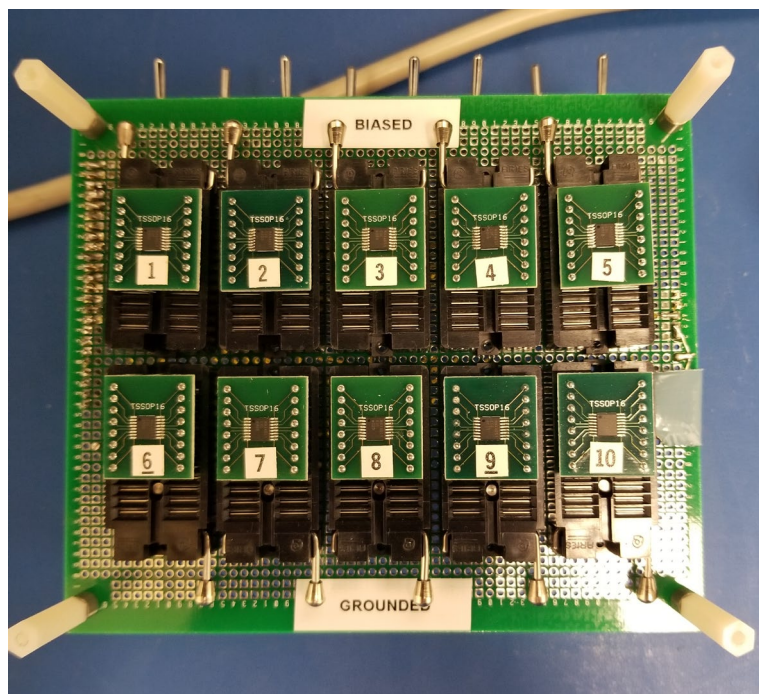


Fig. 4: Picture of DUTs on bias board

8. Procedure

General test procedures were in accordance with MIL-STD-883, Method 1019.9, Condition C. Parts were serialized, with controls marked prominently to distinguish them from test samples. Exposures were performed at ambient laboratory temperature. Approximate cumulative test levels are provided by the values in Table 2.

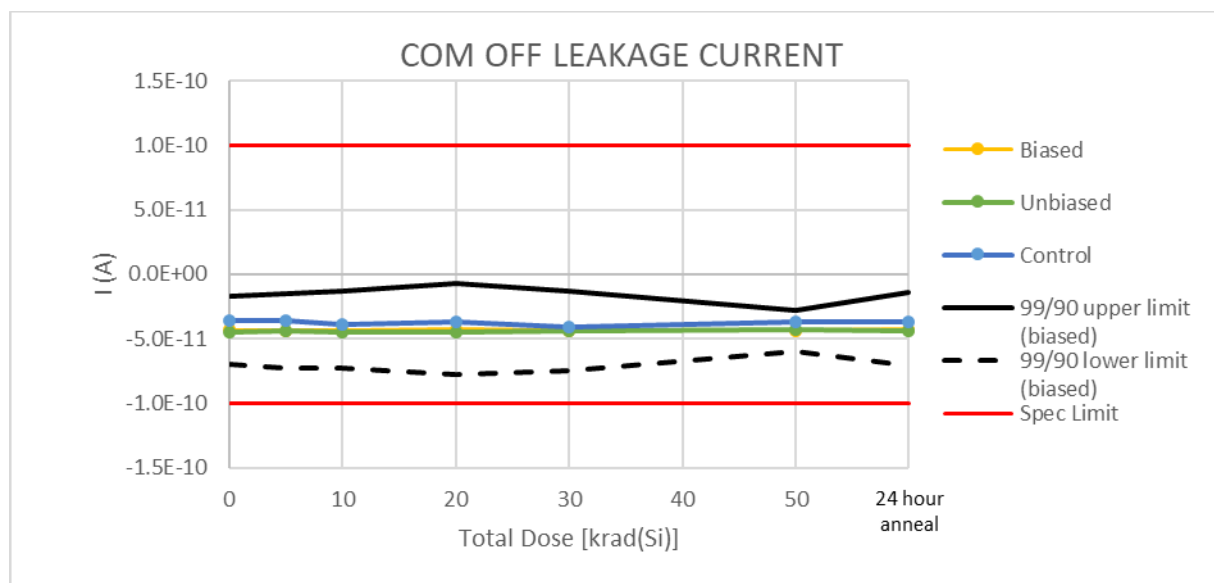
All data from the evaluation of the parameters in Table 3 was logged in Microsoft Excel by the automated LabView testing program. Data for all parts was measured and logged.

9. Results

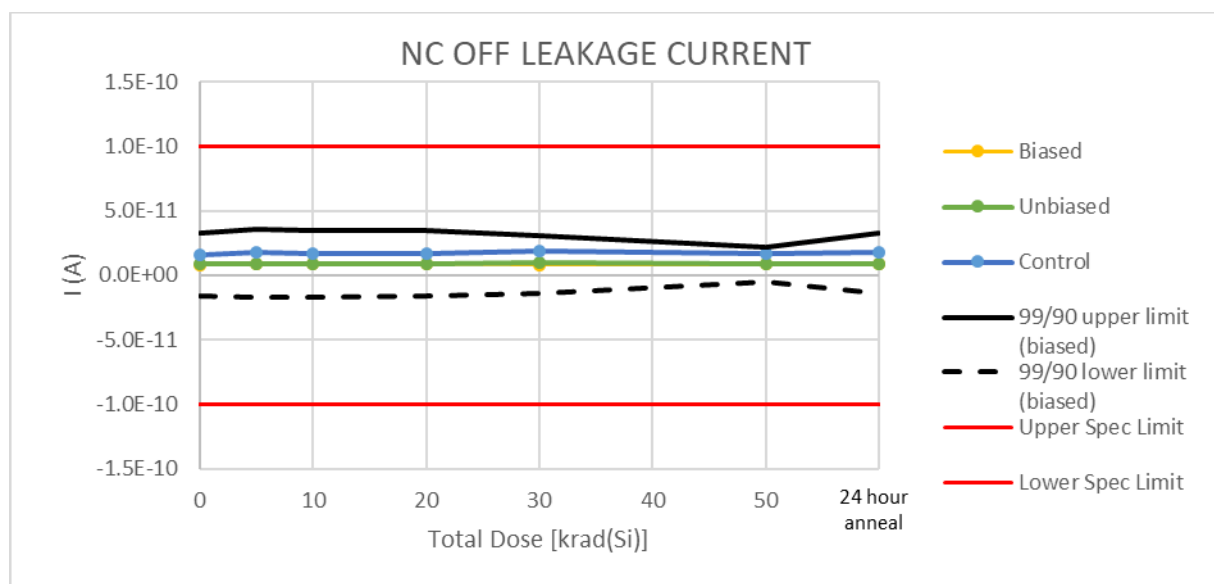
Provided in this section are the raw data collected and graphical representation of the data. In this section, 11 and 12 are the serial numbers assigned to the control parts, while serial numbers 1 through 5 are the parts that were irradiated under biased conditions and serial numbers 6-10 are the parts that were irradiated with all pins grounded.

The figures only show the 99/90 confidence levels for the biased devices, because this group is expected to show the greatest degradation or parameter drift as a function of total ionizing dose. In calculating confidence levels, KTL values of 3.077 (20 samples) and 3.052 (19 samples) were used because there are 5 parts in each bias group each with 4 devices per part for a total of 20 switches per group.

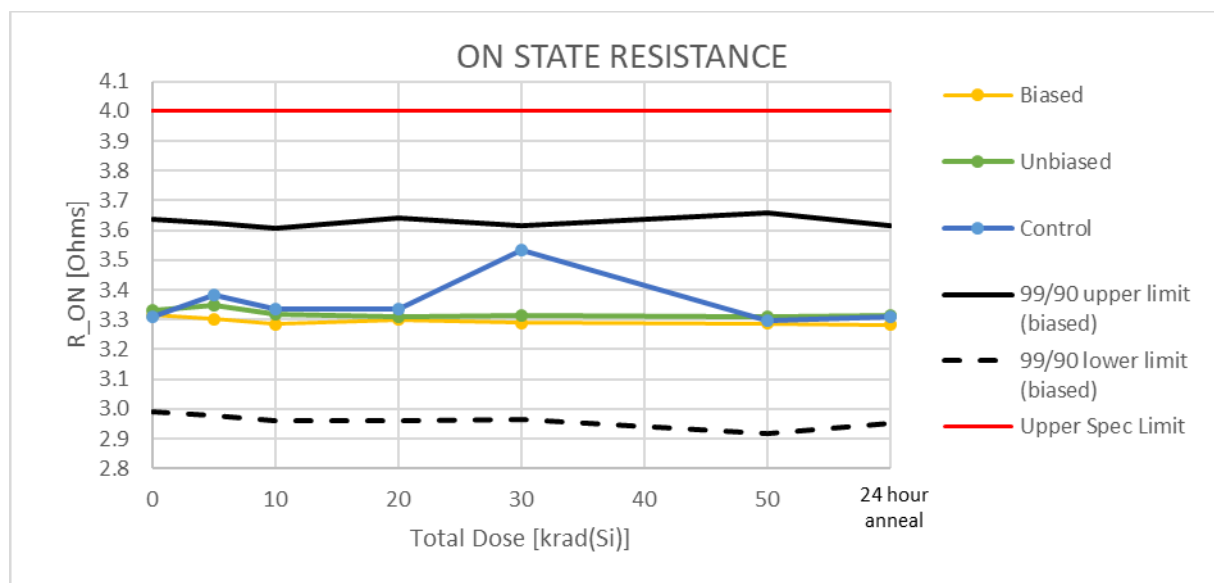
During testing there were a few instances of erroneous measurements. These points are highlighted in red in the raw data tables shown below and omitted in the averages and graphical representation of the data. Appropriate KTL values are used to generate the 99/90 confidence levels where an erroneous data point has been omitted.



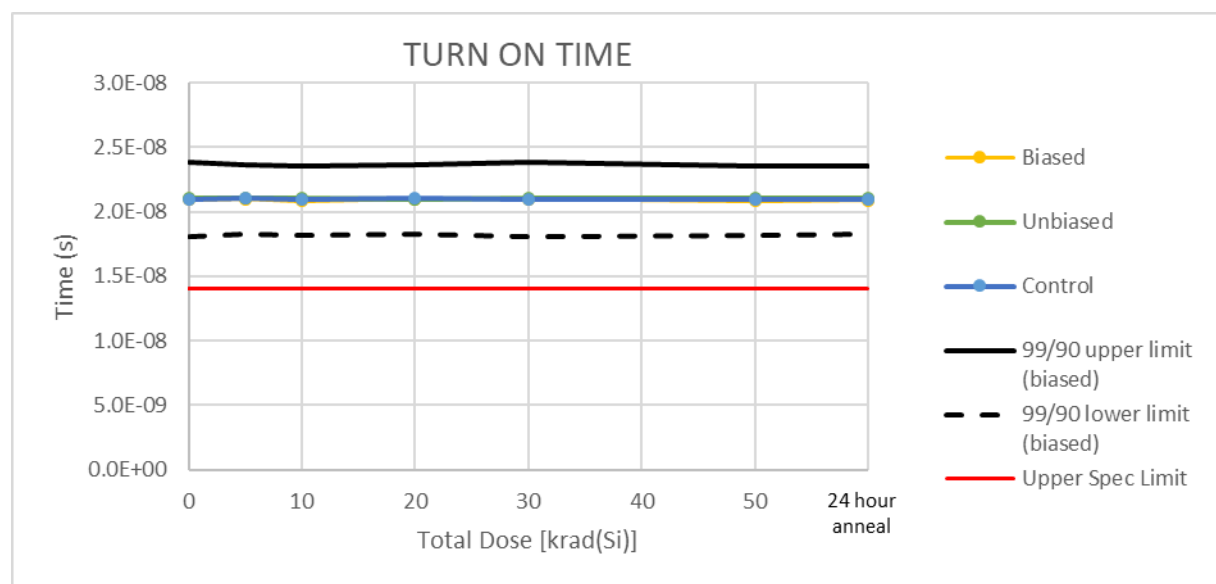
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Switch #	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
0 krad	5.53E-12	9.85E-12	1.97E-11	3.88E-11	1.16E-11	6.63E-12	6.08E-12	8.19E-12	3.47E-12	5.13E-12	-9.61E-14	7.69E-12	3.47E-12	5.88E-12	2.82E-12	5.23E-12	7.14E-12	7.94E-12	5.78E-12	5.78E-12
5 krad	5.93E-12	1.09E-11	2.43E-11	3.82E-11	1.57E-11	1.10E-11	3.32E-12	6.53E-12	7.79E-12	3.77E-12	9.25E-12	6.94E-12	1.76E-12	2.87E-12	2.37E-12	1.11E-12	3.42E-12	6.88E-12	1.00E-11	5.08E-12
10 krad	8.94E-12	8.39E-12	2.28E-11	4.06E-11	1.27E-11	9.60E-12	4.57E-12	6.03E-12	5.88E-12	7.24E-12	6.23E-12	3.47E-12	5.38E-12	5.18E-12	3.67E-12	5.18E-12	6.08E-12	5.23E-12	7.89E-12	3.37E-12
20 krad	3.47E-12	7.19E-12	2.33E-11	3.80E-11	1.63E-11	8.19E-12	6.89E-12	7.44E-12	5.98E-12	6.58E-12	7.24E-12	5.33E-12	8.79E-12	5.78E-12	2.92E-12	8.24E-12	7.64E-12	3.17E-12	1.34E-11	5.13E-12
30 krad	5.23E-12	1.10E-11	1.98E-11	3.30E-11	1.38E-11	1.02E-11	5.08E-12	1.02E-11	4.78E-12	7.74E-12	6.18E-12	8.54E-12	-5.02E-12	4.07E-12	3.32E-12	3.02E-12	5.28E-12	5.83E-12	8.19E-12	5.98E-12
50 krad	5.33E-12	8.04E-12	2.27E-11	4.24E-11	1.32E-11	8.69E-12	7.34E-12	1.00E-11	4.27E-12	6.73E-12	8.84E-12	4.88E-12	5.73E-12	6.43E-12	7.79E-12	1.38E-11	6.13E-12	8.14E-12	9.10E-12	2.77E-12
24 hour anneal	4.32E-12	1.03E-11	1.90E-11	3.96E-11	1.15E-11	9.14E-12	3.47E-12	8.79E-12	7.59E-12	3.02E-12	8.69E-12	6.38E-12	4.98E-12	6.99E-12	6.94E-12	7.89E-12	5.18E-12	8.44E-12	1.12E-11	3.57E-12
DUT #	6	6	6	6	7	7	7	7	8	8	8	8	9	9	9	9	10	10	10	10
Switch #	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
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5 krad	5.83E-12	4.93E-12	5.38E-12	4.93E-12	6.28E-11	6.18E-12	4.73E-12	3.17E-12	9.30E-12	7.69E-12	1.04E-11	7.19E-12	6.63E-12	6.58E-12	5.88E-12	1.05E-11	5.38E-12	8.59E-12	5.38E-12	4.68E-12
10 krad	5.53E-12	5.28E-12	5.13E-12	4.22E-12	6.33E-11	5.23E-12	2.77E-12	6.89E-12	6.03E-12	8.39E-12	1.71E-11	3.97E-12	8.59E-12	4.27E-12	1.81E-12	8.19E-12	7.09E-12	-2.15E-12	7.99E-12	1.04E-11
20 krad	6.28E-12	8.69E-12	6.53E-12	4.93E-12	6.08E-11	3.07E-12	4.83E-12	5.43E-12	7.94E-12	6.53E-12	1.03E-11	6.89E-12	1.03E-11	3.77E-12	1.11E-12	9.30E-12	6.13E-12	1.71E-12	5.73E-12	5.38E-12
30 krad	9.45E-12	4.17E-12	6.33E-12	6.18E-12	6.56E-11	6.84E-12	4.42E-12	4.22E-12	8.29E-12	1.03E-11	1.33E-11	1.41E-11	-2.96E-13	4.98E-12	-3.66E-12	9.60E-12	1.36E-11	7.19E-12	5.08E-12	-2.20E-12
50 krad	5.13E-12	4.98E-12	5.33E-12	3.32E-12	6.90E-11	4.88E-12	4.88E-12	8.54E-12	6.38E-12	6.58E-12	8.79E-12	5.53E-12	5.53E-12	4.32E-12	2.52E-12	1.06E-11	3.37E-12	4.98E-12	3.07E-12	6.38E-12
24 hour anneal	4.98E-12	3.32E-12	4.22E-12	5.88E-12	5.86E-11	6.28E-12	6.28E-12	4.98E-12	5.58E-12	7.99E-12	8.79E-12	4.12E-12	4.17E-12	4.68E-12	6.03E-12	1.10E-11	3.82E-12	3.37E-12	5.78E-12	9.80E-12
DUT #	11	11	11	11	12	12	12	12												
Switch #	1	2	3	4	1	2	3	4												
0 krad	4.73E-12	5.43E-12	6.33E-12	1.01E-11	6.23E-12	1.13E-11	7.83E-11	7.74E-12												
5 krad	7.19E-12	4.02E-12	6.03E-12	6.28E-12	1.18E-11	1.38E-11	7.52E-11	1.24E-11												
10 krad	9.25E-12	-2.36E-12	5.38E-12	5.93E-12	1.57E-11	1.18E-11	7.56E-11	1.04E-11												
20 krad	3.72E-12	4.22E-12	5.68E-12	6.43E-12	6.38E-12	1.60E-11	7.75E-11	1.29E-11												
30 krad	7.44E-12	1.67E-11	1.69E-11	3.87E-12	1.18E-11	-1.10E-12	8.26E-11	1.19E-11												
50 krad	3.82E-12	3.57E-12	4.27E-12	5.53E-12	7.44E-12	1.41E-11	8.35E-11	1.23E-11												
24 hour anneal	6.18E-12	3.97E-12	3.87E-12	5.58E-12	8.29E-12	2.10E-11	7.92E-11	1.50E-11												



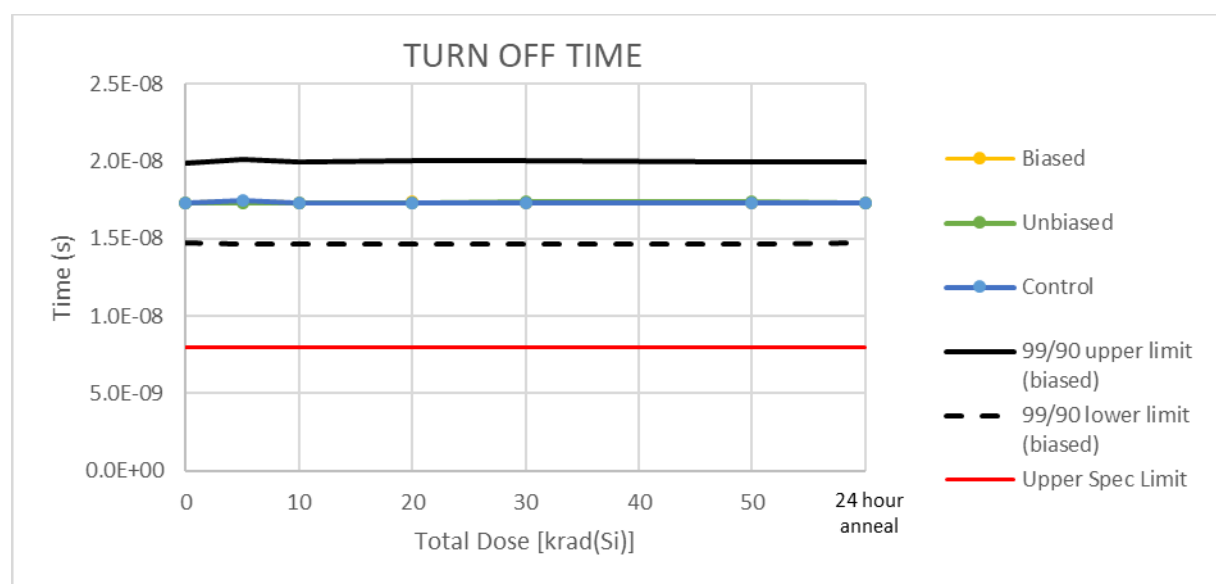
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5 krad	-4.88E-11	-4.90E-11	-3.41E-11	-9.47E-12	-4.31E-11	-4.89E-11	-4.15E-11	-3.77E-11	-3.91E-11	-5.10E-11	-5.26E-11	-5.06E-11	-4.42E-11	-4.34E-11	-4.41E-11	-4.48E-11	-4.20E-11	-5.15E-11	-5.00E-11	-4.92E-11
10 krad	-4.71E-11	-4.35E-11	-3.41E-11	-6.75E-12	-3.22E-11	-4.63E-11	-4.88E-11	-4.04E-11	-4.34E-11	-4.89E-11	-4.12E-11	-4.29E-11	-4.29E-11	-4.97E-11	-5.02E-11	-5.12E-11	-4.42E-11	-5.11E-11	-4.22E-11	-5.07E-11
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30 krad	-4.94E-11	-4.99E-11	-2.62E-11	-9.42E-12	-3.41E-11	-4.32E-11	-4.25E-11	-4.34E-11	-4.34E-11	-4.62E-11	-4.95E-11	-5.28E-11	-4.74E-11	-4.62E-11	-5.23E-11	-4.25E-11	-5.26E-11	-4.99E-11	-4.14E-11	-5.40E-11
50 krad	-4.74E-11	-4.33E-11	-2.92E-11	-4.28E-12	-4.28E-11	-4.31E-11	-4.78E-11	-4.36E-11	-5.28E-11	-5.19E-11	-4.33E-11	-4.24E-11	-4.73E-11	-4.67E-11	-4.06E-11	-3.37E-11	-4.19E-11	-4.47E-11	-4.32E-11	-4.31E-11
24 hour anneal	-4.78E-11	-4.05E-11	-3.42E-11	-8.11E-12	-4.21E-11	-4.24E-11	-4.38E-11	-4.25E-11	-4.87E-11	-4.32E-11	-4.89E-11	-4.88E-11	-5.15E-11	-4.23E-11	-4.65E-11	-3.20E-11	-5.16E-11	-4.22E-11	-4.99E-11	-4.55E-11
DUT #	6	6	6	6	7	7	7	7	8	8	8	8	9	9	9	9	10	10	10	10
Switch #	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
0 krad	-5.06E-11	-4.33E-11	-4.61E-11	-5.32E-11	7.65E-12	-4.21E-11	-4.63E-11	-4.56E-11	-5.14E-11	-4.83E-11	-4.70E-11	-4.45E-11	-4.94E-11	-4.50E-11	-5.38E-11	-4.51E-11	-4.92E-11	-5.20E-11	-4.76E-11	-5.26E-11
5 krad	-5.32E-11	-4.33E-11	-4.13E-11	-4.39E-11	1.24E-11	-5.16E-11	-4.41E-11	-4.20E-11	-4.59E-11	-4.73E-11	-4.08E-11	-5.21E-11	-5.01E-11	-4.34E-11	-4.21E-11	-4.42E-11	-5.23E-11	-5.28E-11	-5.21E-11	-4.32E-11
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20 krad	-5.22E-11	-5.10E-11	-5.30E-11	-5.33E-11	8.70E-12	-4.19E-11	-4.44E-11	-4.51E-11	-5.02E-11	-4.47E-11	-5.03E-11	-5.09E-11	-5.09E-11	-4.57E-11	-4.31E-11	-4.00E-11	-5.01E-11	-4.36E-11	-5.02E-11	-4.38E-11
30 krad	-4.25E-11	-4.48E-11	-5.10E-11	-4.29E-11	6.54E-12	-5.16E-11	-4.61E-11	-4.36E-11	-4.28E-11	-4.15E-11	-4.53E-11	-4.38E-11	-5.13E-11	-5.01E-11	-4.47E-11	-4.48E-11	-5.25E-11	-4.51E-11	-4.35E-11	-5.16E-11
50 krad	-4.28E-11	-4.82E-11	-4.15E-11	-4.42E-11	9.05E-12	-4.61E-11	-3.90E-11	-4.53E-11	-4.88E-11	-4.78E-11	-3.75E-11	-4.12E-11	-4.26E-11	-5.01E-11	-5.15E-11	-4.39E-11	-4.91E-11	-4.61E-11	-5.11E-11	-4.37E-11
24 hour anneal	-4.90E-11	-4.30E-11	-4.84E-11	-5.14E-11	1.04E-11	-5.06E-11	-4.84E-11	-4.14E-11	-4.57E-11	-4.86E-11	-4.27E-11	-5.29E-11	-4.36E-11	-5.20E-11	-5.23E-11	-4.26E-11	-4.54E-11	-4.51E-11	-5.01E-11	-4.43E-11
DUT #	11	11	11	11	12	12	12	12												
Switch #	1	2	3	4	1	2	3	4												
0 krad	-4.46E-11	-4.17E-11	-4.86E-11	-5.16E-11	-3.74E-11	-4.03E-11	1.15E-11	-3.60E-11												
5 krad	-4.12E-11	-4.14E-11	-4.97E-11	-5.25E-11	-4.72E-11	-4.75E-11	2.04E-11	-3.84E-11												
10 krad	-4.96E-11	-5.09E-11	-4.33E-11	-5.30E-11	-4.96E-11	-4.67E-11	1.75E-11	-3.79E-11												
20 krad	-4.92E-11	-4.41E-11	-4.65E-11	-4.39E-11	-4.24E-11	-4.74E-11	1.50E-11	-3.75E-11												
30 krad	-5.15E-11	-4.91E-11	-5.13E-11	-5.22E-11	-4.65E-11	-4.44E-11	1.37E-11	-4.48E-11												
50 krad	-4.77E-11	-5.30E-11	-4.46E-11	-5.23E-11	-4.12E-11	-4.36E-11	2.30E-11	-3.95E-11												
24 hour anneal	-4.70E-11	-4.73E-11	-4.04E-11	-4.34E-11	-5.02E-11	-4.16E-11	1.07E-11	-3.89E-11												



DUT #	1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4	5	5	5	5
Switch #	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
0 krad	3.46	3.24	3.24	3.43	3.42	3.22	3.21	3.41	3.42	3.23	3.21	3.39	3.41	3.18	3.21	3.41	3.42	3.16	3.20	3.41
5 krad	3.42	3.20	3.21	3.40	3.40	3.18	3.20	3.40	3.41	3.18	3.20	3.38	3.39	31.11	3.20	3.40	3.41	3.15	3.19	3.40
10 krad	3.42	3.19	3.21	3.39	3.39	3.17	3.19	3.39	3.40	3.18	3.19	3.38	3.36	3.16	3.20	3.39	3.40	3.14	3.18	3.39
20 krad	3.48	3.21	3.21	3.40	3.40	3.18	3.19	3.39	3.41	3.19	3.19	3.37	3.39	3.16	3.20	3.40	3.40	3.14	15771270.00	3.39
30 krad	3.41	3.19	3.20	3.39	3.39	3.17	3.19	3.38	3.40	3.18	3.19	3.37	3.40	3.16	3.20	3.40	3.41	3.17	3.18	3.39
50 krad	3.53	3.19	3.20	31.24	3.38	3.16	3.18	3.37	3.40	3.17	3.18	3.36	3.46	3.17	3.19	3.40	3.39	3.15	3.17	3.39
24 hour anneal	3.42	3.19	3.20	3.39	3.40	3.18	3.19	3.39	3.40	3.17	3.19	3.37	3.40	3.14	3.18	3.38	3.39	3.14	3.18	3.38
DUT #	6	6	6	6	7	7	7	7	8	8	8	8	9	9	9	9	10	10	10	10
Switch #	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
0 krad	3.46	3.26	3.25	3.43	3.44	3.21	3.22	3.43	3.45	3.22	3.26	3.44	3.43	3.23	3.22	3.43	3.42	3.18	3.21	3.42
5 krad	3.45	3.22	3.24	3.43	3.44	3.19	3.21	3.42	3.45	3.22	3.25	3.44	3.43	3.50	3.21	3.42	3.42	3.43	3.21	3.41
10 krad	3.44	3.22	3.23	3.42	3.44	3.19	3.20	3.41	3.45	3.19	3.25	3.43	3.41	3.19	3.20	3.40	3.44	3.20	3.20	3.41
20 krad	3.44	3.20	3.23	3.42	3.43	3.19	3.20	3.41	3.44	3.19	3.24	3.43	3.41	3.19	3.20	3.40	3.41	3.17	3.20	3.41
30 krad	3.44	3.20	3.23	3.42	3.43	3.19	3.20	3.41	3.43	3.19	3.24	3.42	3.43	3.24	3.20	3.40	3.42	3.21	3.19	3.40
50 krad	3.46	3.19	3.22	3.41	3.44	3.23	3.20	3.40	3.43	3.18	3.24	3.42	3.40	3.18	3.19	3.39	3.43	3.18	3.19	3.39
24 hour anneal	3.43	3.19	3.22	3.41	3.42	3.18	3.19	3.40	3.44	3.19	3.24	3.42	3.43	3.28	3.20	3.40	3.43	3.17	3.19	3.41
DUT #	11	11	11	11	12	12	12	12												
Switch #	1	2	3	4	1	2	3	4												
0 krad	3.41	3.21	3.21	3.40	3.43	3.19	3.22	3.40												
5 krad	3.41	3.19	3.20	3.40	3.86	28.17	3.22	3.40												
10 krad	3.40	3.18	3.20	3.39	3.45	3.31	3.21	3.55												
20 krad	3.41	3.19	3.21	3.39	3.47	3.36	3.21	3.44												
30 krad	3.41	3.19	3.20	3.39	3.56	4.81	3.21	3.48												
50 krad	3.40	3.18	3.20	3.39	3.42	3.19	3.20	3.40												
24 hour anneal	3.41	3.19	3.21	3.40	3.49	3.18	3.20	3.41												



DUT #	1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4	5	5	5	5
Switch #	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
0 krad	2.19E-08	2.03E-08	2.01E-08	2.17E-08	2.19E-08	1.99E-08	1.99E-08	2.18E-08	2.20E-08	2.03E-08	1.99E-08	2.19E-08	2.18E-08	1.99E-08	2.00E-08	2.12E-08	2.20E-08	2.01E-08	2.00E-08	2.25E-08
5 krad	2.21E-08	2.04E-08	2.01E-08	2.23E-08	2.18E-08	2.00E-08	1.99E-08	2.14E-08	2.23E-08	2.03E-08	2.01E-08	2.14E-08	2.19E-08	2.00E-08	1.99E-08	2.13E-08	2.20E-08	2.01E-08	2.01E-08	2.15E-08
10 krad	2.21E-08	2.02E-08	2.01E-08	2.13E-08	2.17E-08	1.98E-08	2.00E-08	2.17E-08	2.22E-08	2.03E-08	2.01E-08	2.14E-08	2.18E-08	1.99E-08	2.00E-08	2.12E-08	2.19E-08	2.00E-08	1.98E-08	2.16E-08
20 krad	2.21E-08	2.02E-08	2.01E-08	2.19E-08	2.18E-08	2.00E-08	1.99E-08	2.19E-08	2.22E-08	2.04E-08	2.01E-08	2.14E-08	2.18E-08	1.99E-08	2.00E-08	2.13E-08	2.19E-08	2.01E-08	2.01E-08	2.17E-08
30 krad	2.21E-08	2.03E-08	1.99E-08	2.17E-08	2.19E-08	2.01E-08	2.01E-08	2.18E-08	2.21E-08	2.03E-08	1.99E-08	2.20E-08	2.18E-08	1.99E-08	2.00E-08	2.23E-08	2.19E-08	2.03E-08	2.00E-08	2.15E-08
50 krad	2.20E-08	2.04E-08	2.01E-08	2.16E-08	2.17E-08	1.99E-08	1.97E-08	2.13E-08	2.22E-08	2.03E-08	2.01E-08	2.17E-08	2.18E-08	1.99E-08	2.01E-08	2.18E-08	2.15E-08	2.01E-08	1.99E-08	2.18E-08
24 hour anneal	2.20E-08	2.03E-08	2.01E-08	2.14E-08	2.19E-08	1.99E-08	2.05E-08	2.12E-08	2.20E-08	2.03E-08	2.00E-08	2.14E-08	2.18E-08	1.99E-08	1.97E-08	2.18E-08	2.19E-08	2.01E-08	2.00E-08	2.16E-08
DUT #	6	6	6	6	7	7	7	7	8	8	8	8	9	9	9	9	10	10	10	10
Switch #	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
0 krad	2.19E-08	2.05E-08	2.02E-08	2.16E-08	2.19E-08	2.00E-08	2.01E-08	2.19E-08	2.25E-08	2.06E-08	2.03E-08	2.26E-08	2.17E-08	1.99E-08	1.99E-08	2.14E-08	2.15E-08	1.99E-08	2.00E-08	2.19E-08
5 krad	2.23E-08	2.06E-08	2.02E-08	2.20E-08	2.19E-08	2.01E-08	2.02E-08	2.20E-08	2.25E-08	2.08E-08	2.03E-08	2.21E-08	2.17E-08	1.99E-08	1.99E-08	2.18E-08	2.18E-08	1.98E-08	2.00E-08	2.13E-08
10 krad	2.23E-08	2.06E-08	2.03E-08	2.15E-08	2.20E-08	2.01E-08	2.01E-08	2.19E-08	2.24E-08	2.06E-08	2.02E-08	2.20E-08	2.17E-08	2.00E-08	1.96E-08	2.18E-08	2.18E-08	1.98E-08	2.00E-08	2.25E-08
20 krad	2.23E-08	2.05E-08	2.01E-08	2.17E-08	2.19E-08	2.01E-08	2.01E-08	2.19E-08	2.22E-08	2.06E-08	2.03E-08	2.22E-08	2.17E-08	1.99E-08	1.99E-08	2.17E-08	2.18E-08	2.01E-08	2.00E-08	2.12E-08
30 krad	2.22E-08	2.04E-08	2.01E-08	2.18E-08	2.19E-08	2.01E-08	2.00E-08	2.19E-08	2.25E-08	2.06E-08	2.03E-08	2.27E-08	2.18E-08	2.01E-08	1.99E-08	2.11E-08	2.19E-08	2.00E-08	2.00E-08	2.23E-08
50 krad	2.23E-08	2.05E-08	2.02E-08	2.18E-08	2.19E-08	2.00E-08	1.99E-08	2.23E-08	2.24E-08	2.07E-08	2.04E-08	2.21E-08	2.15E-08	1.99E-08	1.99E-08	2.14E-08	2.18E-08	2.00E-08	2.00E-08	2.19E-08
24 hour anneal	2.22E-08	2.05E-08	2.02E-08	2.14E-08	2.20E-08	2.00E-08	2.00E-08	2.19E-08	2.24E-08	2.06E-08	2.03E-08	2.26E-08	2.18E-08	1.99E-08	1.99E-08	2.15E-08	2.18E-08	1.99E-08	2.00E-08	2.16E-08
DUT #	11	11	11	11	12	12	12	12												
Switch #	1	2	3	4	1	2	3	4												
0 krad	2.19E-08	2.01E-08	2.01E-08	2.16E-08	2.18E-08	2.04E-08	2.01E-08	2.17E-08												
5 krad	2.17E-08	2.01E-08	2.01E-08	2.19E-08	2.19E-08	2.04E-08	2.00E-08	2.19E-08												
10 krad	2.20E-08	2.01E-08	2.01E-08	2.16E-08	2.20E-08	2.02E-08	1.99E-08	2.17E-08												
20 krad	2.20E-08	2.03E-08	2.01E-08	2.14E-08	2.21E-08	2.03E-08	2.01E-08	2.20E-08												
30 krad	2.19E-08	2.01E-08	1.99E-08	2.16E-08	2.21E-08	2.02E-08	2.00E-08	2.14E-08												
50 krad	2.20E-08	2.03E-08	1.98E-08	2.14E-08	2.20E-08	2.00E-08	2.00E-08	2.24E-08												
24 hour anneal	2.17E-08	2.02E-08	2.01E-08	2.19E-08	2.21E-08	2.01E-08	2.01E-08	2.14E-08												



DUT #	1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4	5	5	5	5
Switch #	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
0 krad	1.82E-08	1.66E-08	1.65E-08	1.83E-08	1.81E-08	1.65E-08	1.64E-08	1.81E-08	1.81E-08	1.65E-08	1.65E-08	1.82E-08	1.81E-08	1.65E-08	1.64E-08	1.81E-08	1.82E-08	1.64E-08	1.64E-08	1.82E-08
5 krad	1.83E-08	1.65E-08	1.65E-08	1.84E-08	1.80E-08	1.65E-08	1.63E-08	1.83E-08	1.82E-08	1.65E-08	1.64E-08	1.83E-08	1.81E-08	1.65E-08	1.64E-08	1.83E-08	1.82E-08	1.65E-08	1.64E-08	1.82E-08
10 krad	1.82E-08	1.65E-08	1.65E-08	1.83E-08	1.81E-08	1.63E-08	1.64E-08	1.82E-08	1.82E-08	1.65E-08	1.65E-08	1.85E-08	1.81E-08	1.65E-08	1.64E-08	1.81E-08	1.81E-08	1.65E-08	1.64E-08	1.81E-08
20 krad	1.82E-08	1.65E-08	1.65E-08	1.84E-08	1.81E-08	1.64E-08	1.64E-08	1.81E-08	1.82E-08	1.65E-08	1.65E-08	1.82E-08	1.81E-08	1.64E-08	1.64E-08	1.82E-08	1.82E-08	1.64E-08	1.64E-08	1.82E-08
30 krad	1.83E-08	1.66E-08	1.64E-08	1.82E-08	1.81E-08	1.62E-08	1.63E-08	1.82E-08	1.82E-08	1.64E-08	9.90E+37	1.81E-08	1.81E-08	1.65E-08	1.64E-08	1.81E-08	1.81E-08	1.65E-08	1.64E-08	1.82E-08
50 krad	1.82E-08	1.66E-08	1.65E-08	1.82E-08	1.81E-08	1.64E-08	1.65E-08	1.80E-08	1.82E-08	1.66E-08	1.64E-08	1.83E-08	1.82E-08	1.65E-08	1.64E-08	1.83E-08	1.81E-08	1.65E-08	1.64E-08	1.83E-08
24 hour anneal	1.82E-08	1.65E-08	1.65E-08	1.82E-08	1.80E-08	1.64E-08	1.68E-08	1.82E-08	1.82E-08	1.65E-08	1.65E-08	1.82E-08	1.82E-08	1.64E-08	1.64E-08	1.81E-08	1.82E-08	1.65E-08	1.63E-08	1.82E-08
DUT #	6	6	6	6	7	7	7	7	8	8	8	8	9	9	9	9	10	10	10	10
Switch #	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
0 krad	1.82E-08	1.65E-08	1.65E-08	1.83E-08	1.81E-08	1.64E-08	1.65E-08	1.83E-08	1.83E-08	1.65E-08	1.64E-08	1.83E-08	1.80E-08	1.65E-08	1.63E-08	1.81E-08	1.81E-08	1.64E-08	1.64E-08	1.82E-08
5 krad	1.83E-08	1.66E-08	1.65E-08	1.83E-08	1.81E-08	1.64E-08	1.64E-08	1.82E-08	1.83E-08	1.66E-08	1.66E-08	1.83E-08	1.81E-08	1.64E-08	1.64E-08	1.81E-08	1.81E-08	1.65E-08	1.64E-08	1.82E-08
10 krad	1.82E-08	1.65E-08	1.64E-08	1.83E-08	1.81E-08	1.64E-08	1.64E-08	1.82E-08	1.82E-08	1.65E-08	1.65E-08	1.82E-08	1.81E-08	1.64E-08	1.64E-08	1.81E-08	1.81E-08	1.65E-08	1.64E-08	1.82E-08
20 krad	1.83E-08	1.66E-08	1.65E-08	1.84E-08	1.82E-08	1.64E-08	1.64E-08	1.82E-08	1.83E-08	1.66E-08	1.65E-08	1.83E-08	1.80E-08	1.64E-08	1.64E-08	1.81E-08	1.81E-08	1.65E-08	1.63E-08	1.82E-08
30 krad	1.83E-08	1.66E-08	1.66E-08	1.84E-08	1.82E-08	1.65E-08	1.64E-08	1.83E-08	1.83E-08	1.66E-08	1.66E-08	1.83E-08	1.81E-08	1.65E-08	1.63E-08	1.82E-08	1.81E-08	1.64E-08	1.64E-08	1.82E-08
50 krad	1.83E-08	1.66E-08	1.65E-08	1.83E-08	1.82E-08	1.65E-08	1.63E-08	1.82E-08	1.83E-08	1.66E-08	1.66E-08	1.84E-08	1.82E-08	1.64E-08	1.64E-08	1.81E-08	1.81E-08	1.64E-08	1.64E-08	1.84E-08
24 hour anneal	1.82E-08	1.66E-08	1.65E-08	1.84E-08	1.82E-08	1.64E-08	1.65E-08	1.81E-08	1.83E-08	1.65E-08	1.66E-08	1.84E-08	1.82E-08	1.64E-08	1.64E-08	1.82E-08	1.81E-08	1.64E-08	1.64E-08	1.83E-08
DUT #	11	11	11	11	12	12	12	12												
Switch #	1	2	3	4	1	2	3	4												
0 krad	1.82E-08	1.64E-08	1.63E-08	1.83E-08	1.80E-08	1.64E-08	1.64E-08	1.82E-08												
5 krad	1.83E-08	1.65E-08	1.65E-08	1.83E-08	1.81E-08	1.64E-08	1.64E-08	1.83E-08												
10 krad	1.82E-08	1.65E-08	1.64E-08	1.81E-08	1.81E-08	1.64E-08	1.63E-08	1.83E-08												
20 krad	1.82E-08	1.64E-08	1.64E-08	1.81E-08	1.81E-08	1.64E-08	1.64E-08	1.82E-08												
30 krad	1.82E-08	1.65E-08	1.64E-08	1.83E-08	1.80E-08	1.64E-08	1.63E-08	1.82E-08												
50 krad	1.81E-08	1.64E-08	1.64E-08	1.83E-08	1.81E-08	1.64E-08	1.64E-08	1.82E-08												
24 hour anneal	1.82E-08	1.64E-08	1.64E-08	1.83E-08	1.80E-08	1.64E-08	1.64E-08	1.82E-08												

10. Conclusions

The devices did not experience any significant parameter drift after exposure to 50 krad(Si) of gamma radiation.

11. References

- 1) Department of Defense “Test Method Standard Microcircuits,” MIL-STD-883 Test Method 1019.9 Ionizing radiation (total dose) test procedure, June 7, 2013,
<https://landandmaritimeapps.dla.mil/Downloads/MilSpec/Docs/MIL-STD-883/std883.pdf>.
- 2) MAX4651 DATASHEET: <https://datasheets.maximintegrated.com/en/ds/MAX4651-MAX4653.pdf>
- 3) KTL values: <https://landandmaritimeapps.dla.mil/Downloads/MilSpec/Docs/MIL-HDBK-814/hb814.pdf>

