Total Dose Radiation Test Report

MSK4304RH

3 - Phase Motor Drive Hybrid

June 14, 2007 (1st test)

November 6, 2013 (2nd Test: IC Wafer Lot: DJA6ENC
Transistor Wafer Lot: BA1016MFA #16)

June 27, 2018 (3rd Test: IC Wafer Lot: G3W8EDA Wf#3
Transistor Wafer Lot: DA03104MSA Wf#5)

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J. Joy

Anaren, Inc - MSK Products

I. Introduction:

The Total Ionizing Dose radiation test plan for the MSK4304RH was developed to qualify the devices as RAD Hard to 300Krad(Si). The testing was performed beyond 300Krad(Si) to show trends in the device performance as a function of total dose. The test does not classify maximum radiation tolerance of the device, but simply offers designers insight to the critical parameter-shifts up to the specified total dose level.

MIL-STD-883 Method 1019.7 and ASTM F1892-06 were used as guidelines in the development and implementation of the total dose test plan for the MSK4304RH.

II. Radiation Source:

Total ionizing dose testing was performed at the University of Massachusetts, Lowell, using a cobalt 60 radiation source. The dose rate was determined to be 119.2Rad(Si)/sec. The total dose schedule can be found in Table I.

III. Test Setup:

All test samples were subjected to Group A Electrical Test in accordance with the device data sheet. In addition, all devices received a minimum of 160 hours of burn-in per MIL-STD-883 Method 1015 and were fully screened IAW MIL-PRF-38535 Class H. For test platform verification, one control device was tested at 25°C. Eight devices were then tested at 25°C, prior to irradiation, and were found to be within acceptable test limits.

The devices were vertically aligned with the radiation source and enclosed in a lead/aluminum container during irradiation. Four devices were kept under bias during irradiation. Four devices had all leads grounded during irradiation for the unbiased condition.

After each irradiation, the device leads were shorted together and the devices were transported to the electrical test platform. Testing was performed in accordance with the MSK device data sheet. Testing was performed on irradiated devices, as well as the control devices, at each total dose level. Electrical tests were completed within one hour of irradiation. Devices were subjected to subsequent radiation doses within two hours of removal from the radiation field.

IV. Data:

All performance curves are averaged from the test results of the biased and unbiased devices respectively. Post 300Krad(Si) limits have also been plotted for reference. If required, full test data can be obtained by contacting Anaren, Inc – MSK Products.

V. Summary:

Based on the test data recorded during radiation testing and statistical analysis, the MSK4304RH qualifies as a 300Krad(Si) radiation hardened device. All performance curves stayed well within specifications up to the maximum test dose, 450Krad(Si) TID.

MSK4304RH Biased/Unbiased Dose Rate Schedule

Dosimetry Equipment
Bruker Biospin # 0162

Irradiation Date
6/27/18

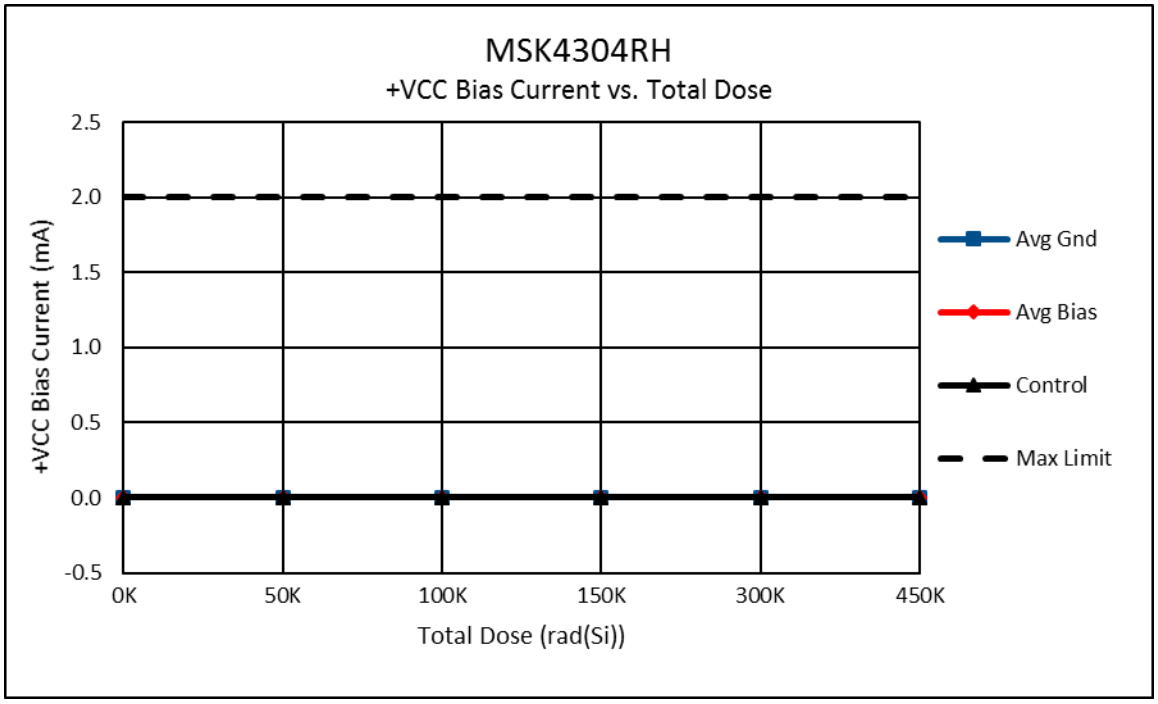
Exposure Length (min:sec)	Incremental Dose rad(Si)	Cumulative Dose rad(Si)
7:12	51,500	51,500
7:12	51,500	103,000
7:12	51,500	154,500
21:36	154,500	309,000
21:36	154,500	463,500

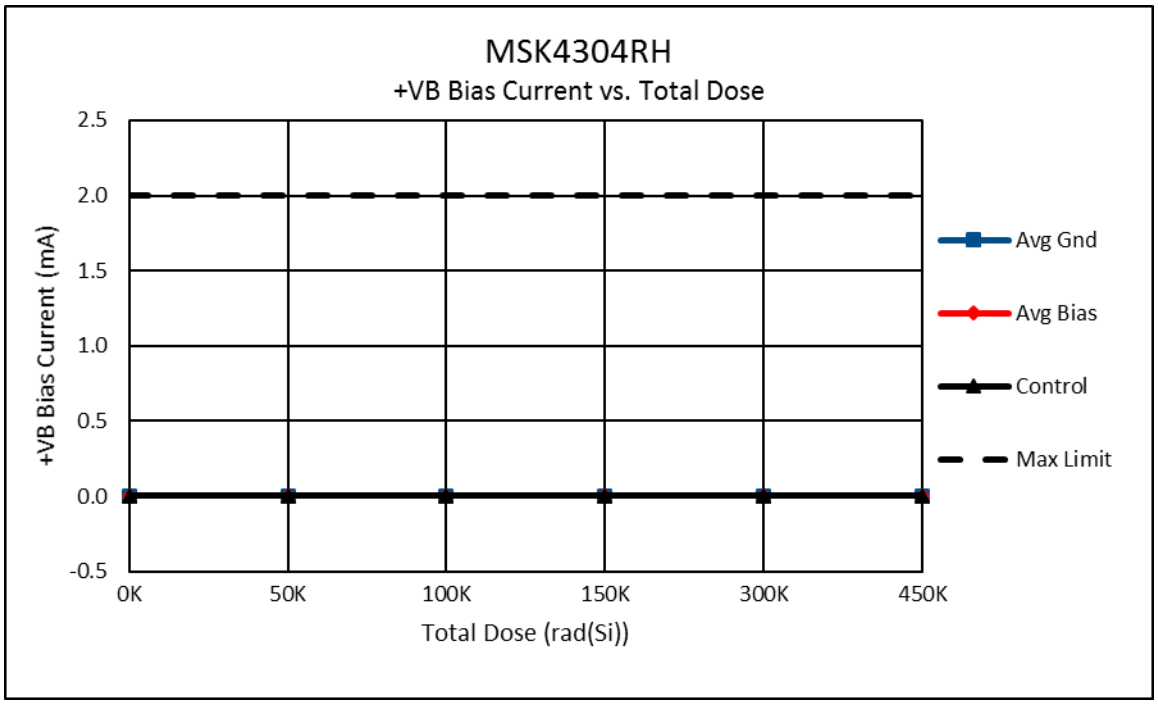
Biased S/N – 0254, 0255, 0256, 0260

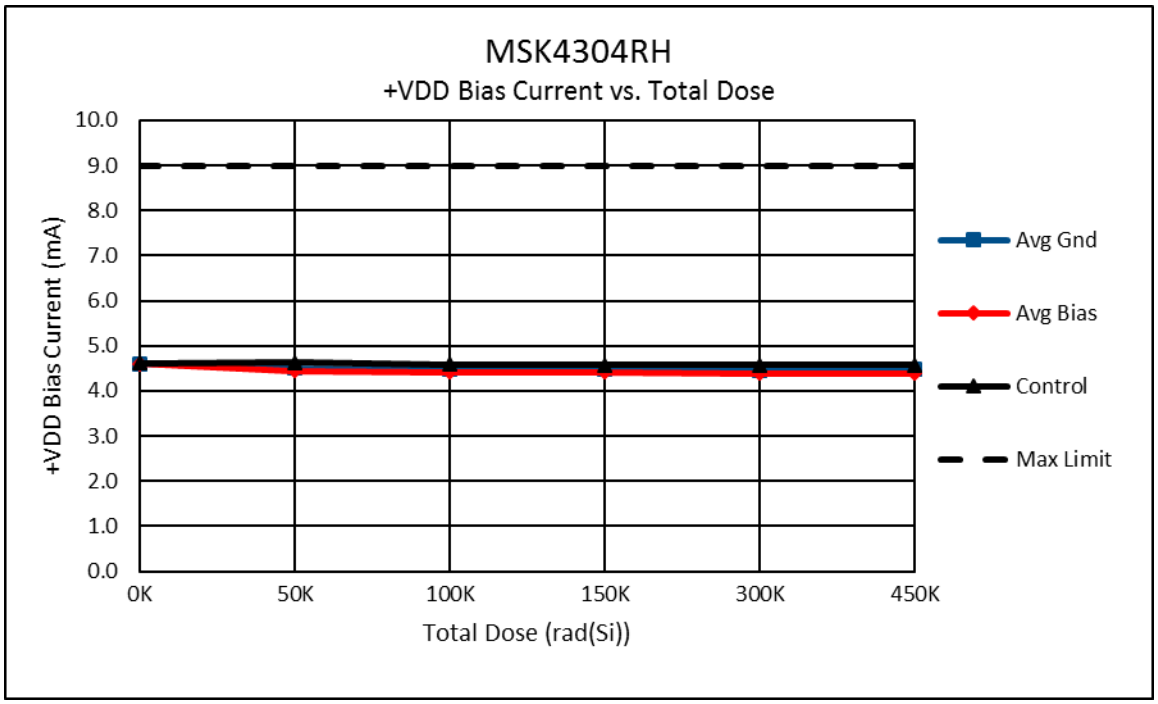
Unbiased S/N – 0261, 0262, 0263, 0264

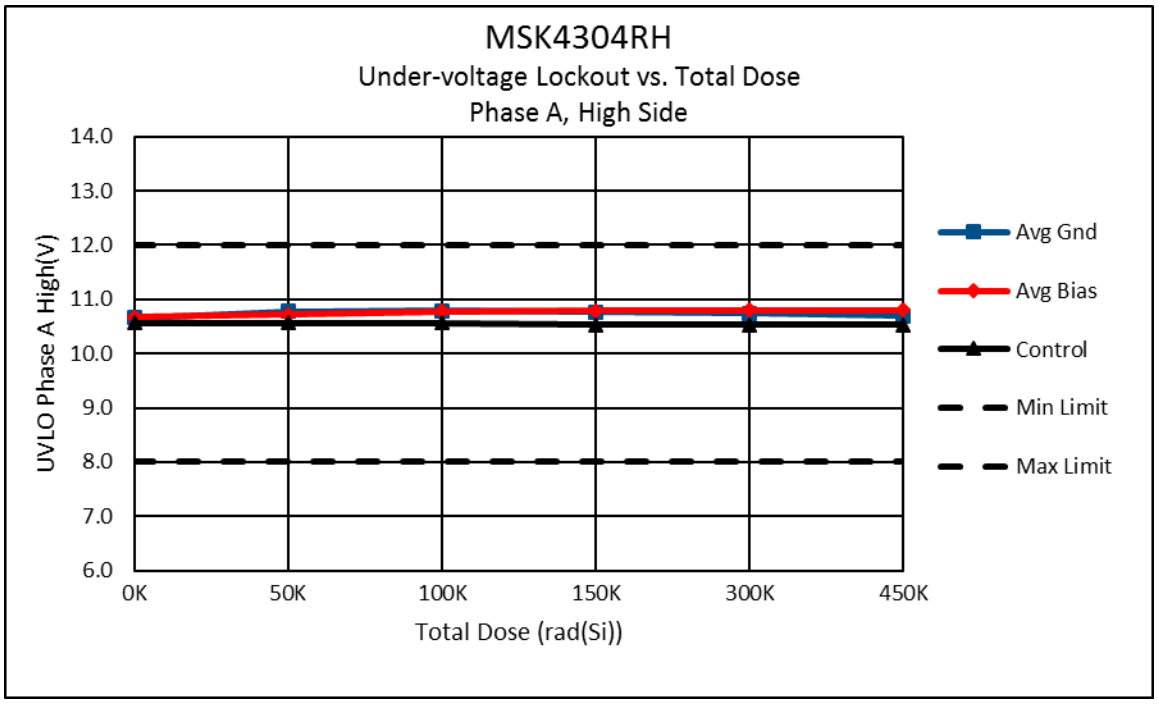
Table 1

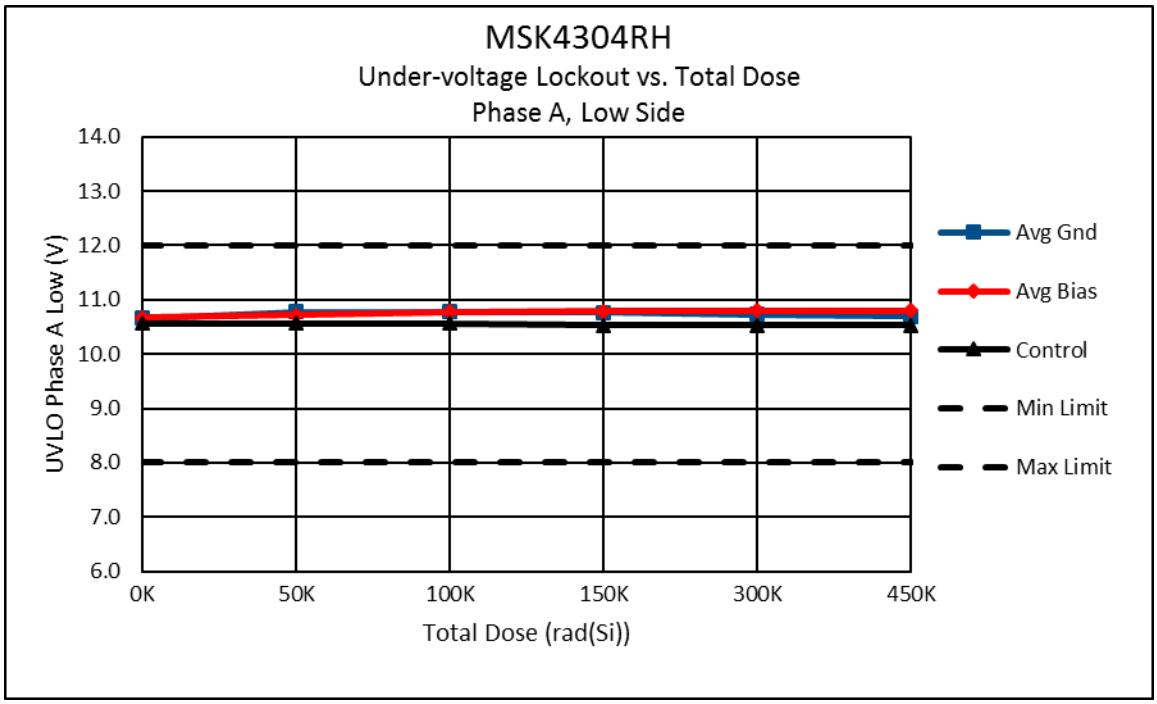
Dose Time, Incremental Dose and Total Cumulative Dose

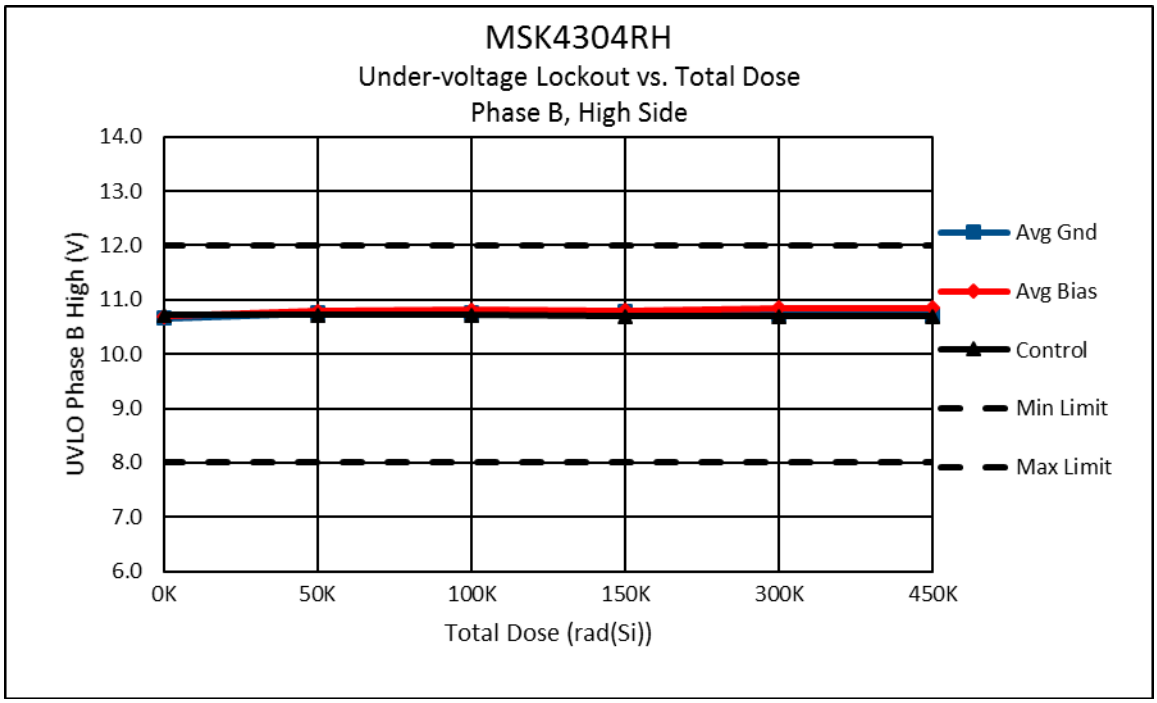

MSK4304RH
+VCC Bias Current vs. Total Dose
+VCC Bias Current (mA)
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit

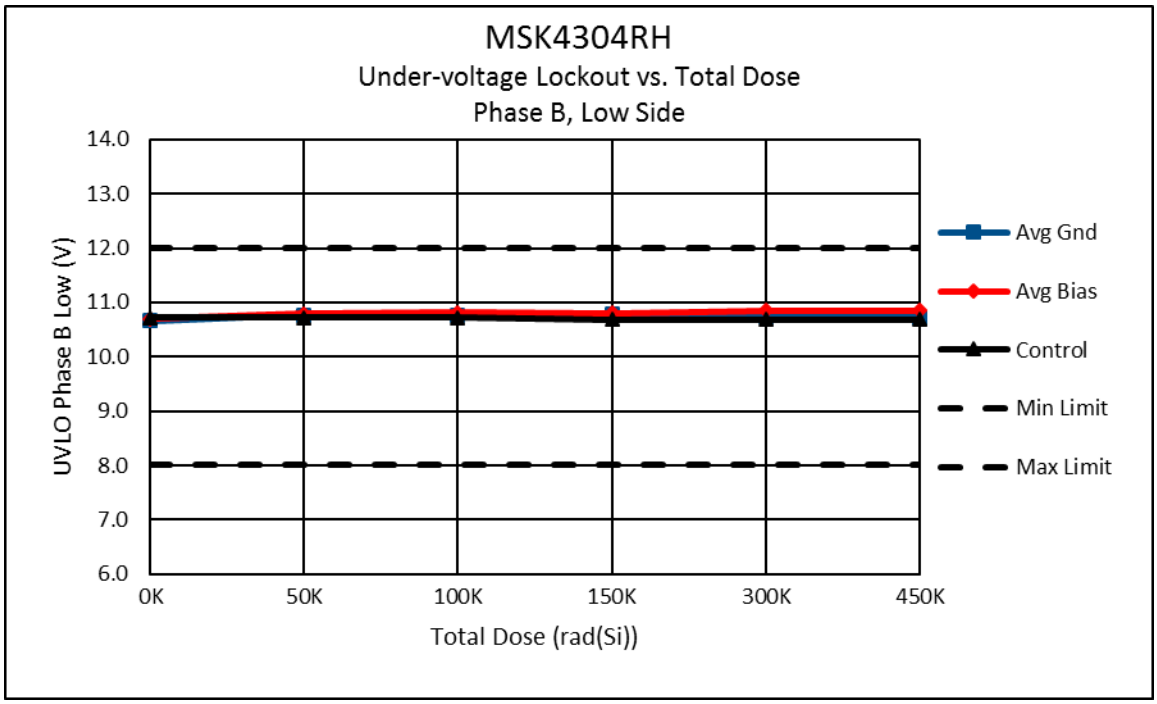

MSK4304RH
+VB Bias Current vs. Total Dose
+VB Bias Current (mA)
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit

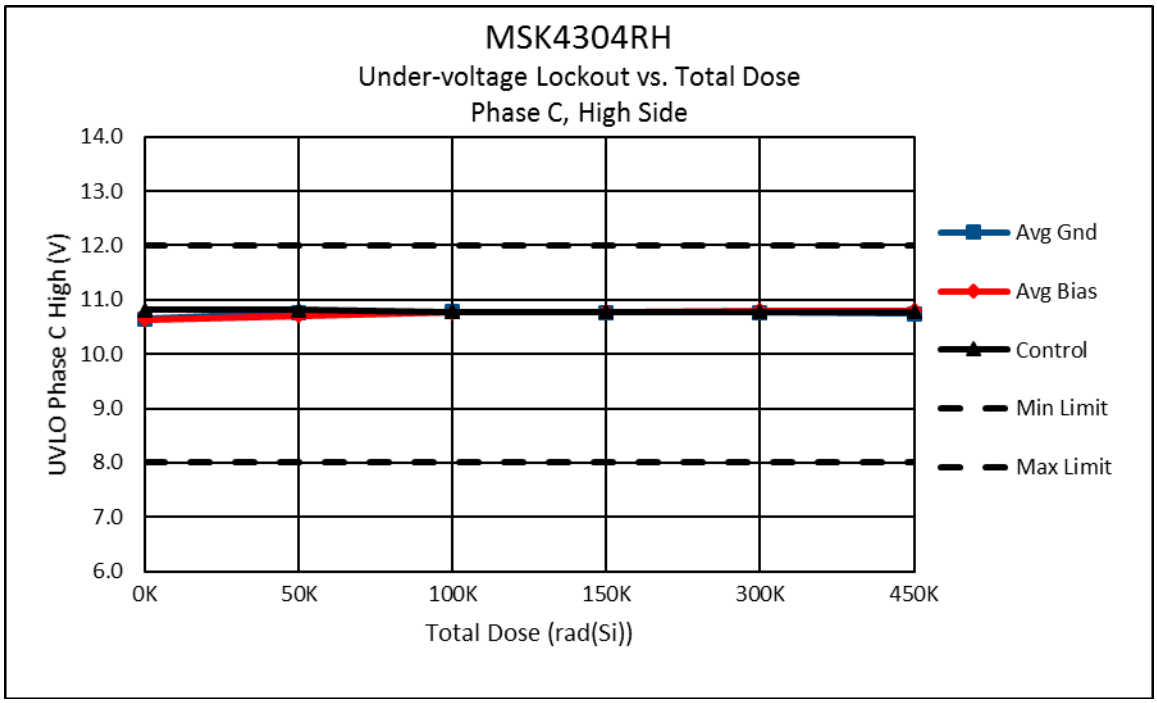

MSK4304RH
+VDD Bias Current vs. Total Dose
+VDD Bias Current (mA)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit

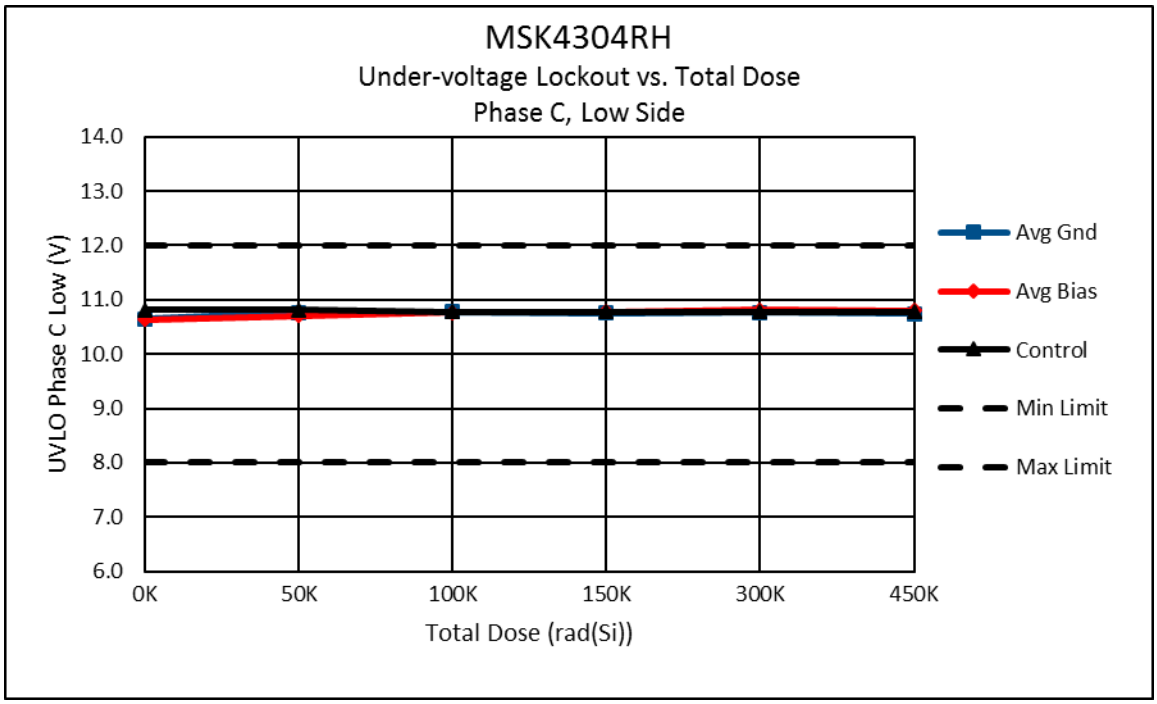

MSK4304RH
Under-voltage Lockout vs. Total Dose
Phase A, High Side
UVLO Phase A High(V)
14.0
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Min Limit
Max Limit

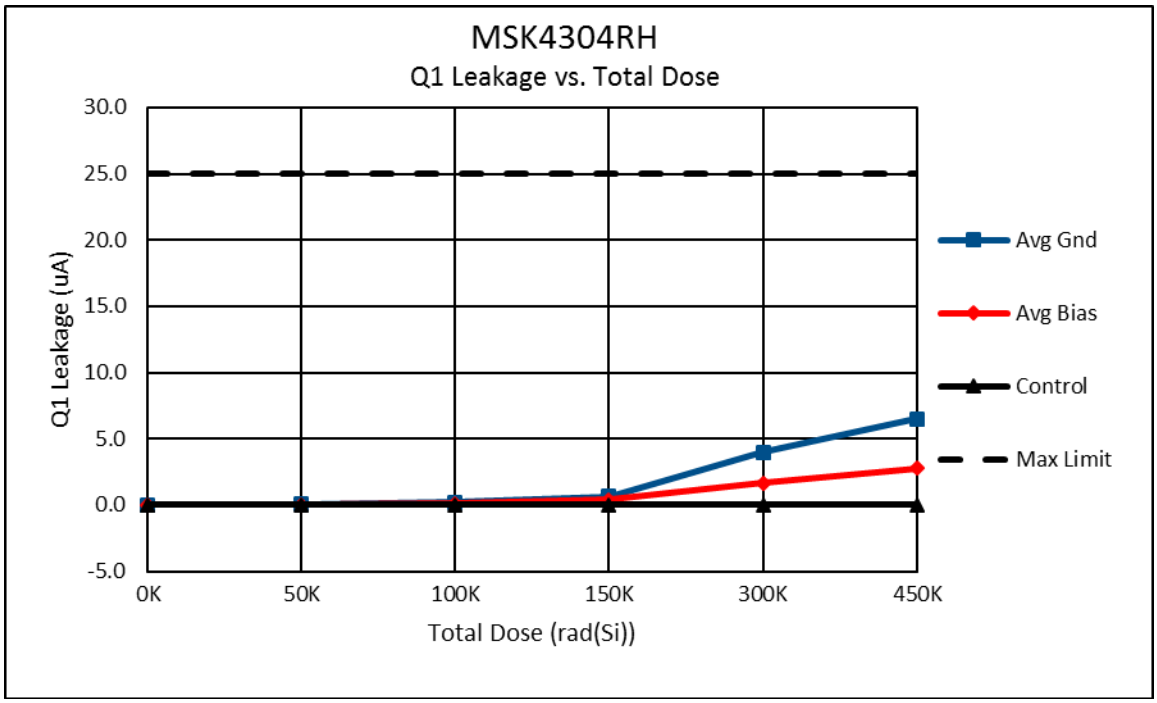

MSK4304RH
Under-voltage Lockout vs. Total Dose
Phase A, Low Side
UVLO Phase A Low (V)
14.0
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Min Limit
Max Limit

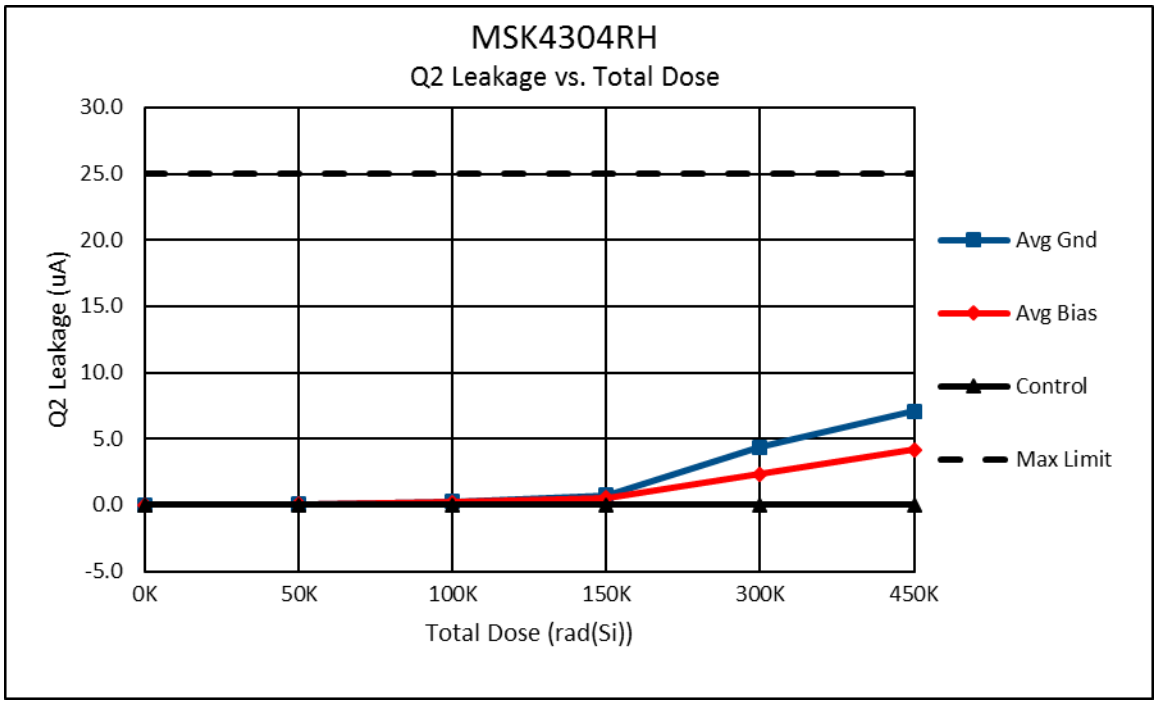

MSK4304RH
Under-voltage Lockout vs. Total Dose
Phase B, High Side
UVLO Phase B High (V)
14.0
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Min Limit
Max Limit

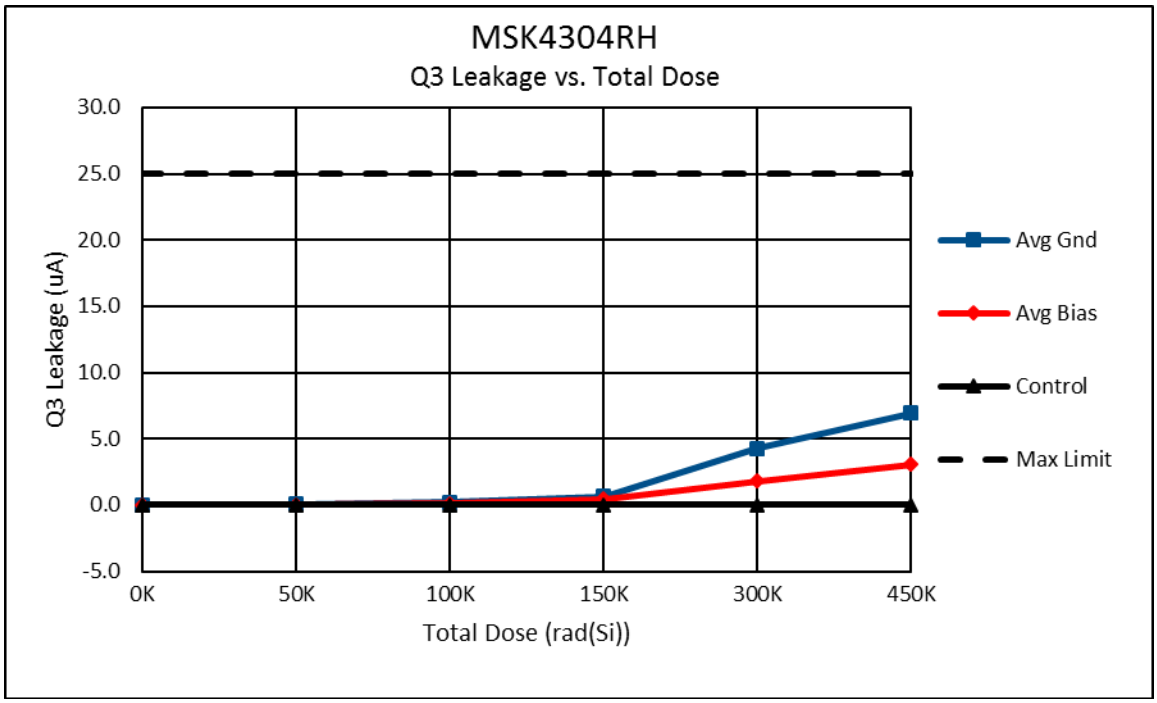

MSK4304RH
Under-voltage Lockout vs. Total Dose
Phase B, Low Side
UVLO Phase B Low (V)
14.0
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Min Limit
Max Limit

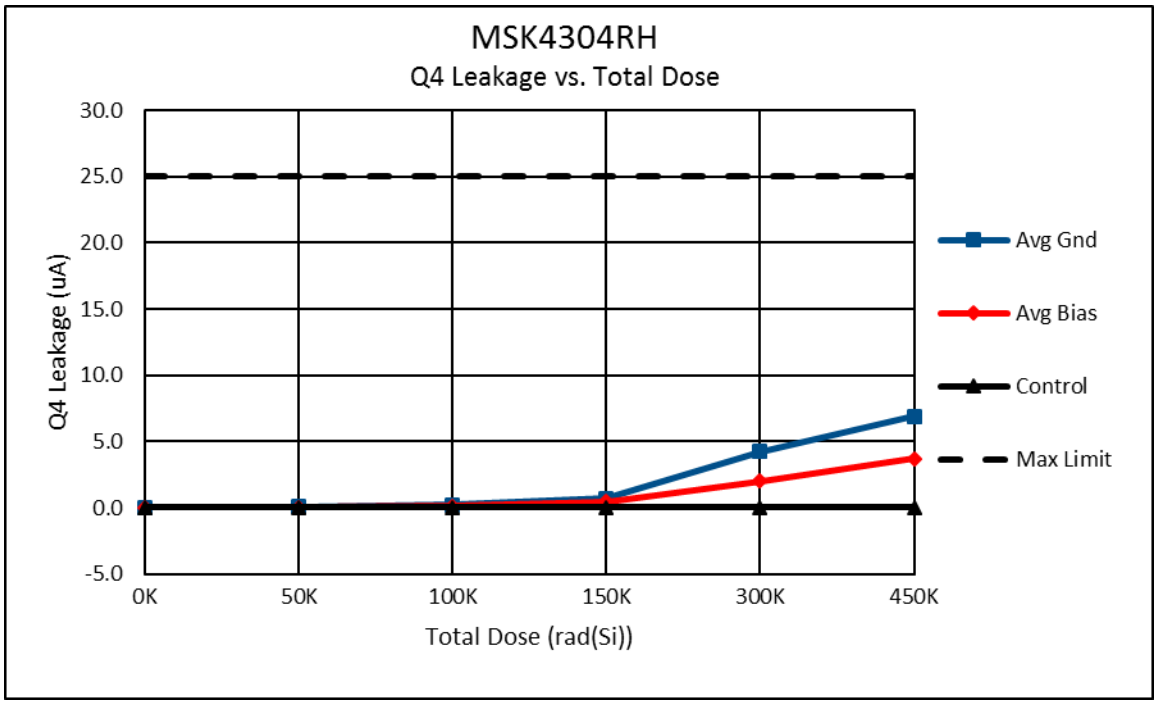

MSK4304RH
Under-voltage Lockout vs. Total Dose
Phase C, High Side
UVLO Phase C High (V)
14.0
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Min Limit
Max Limit

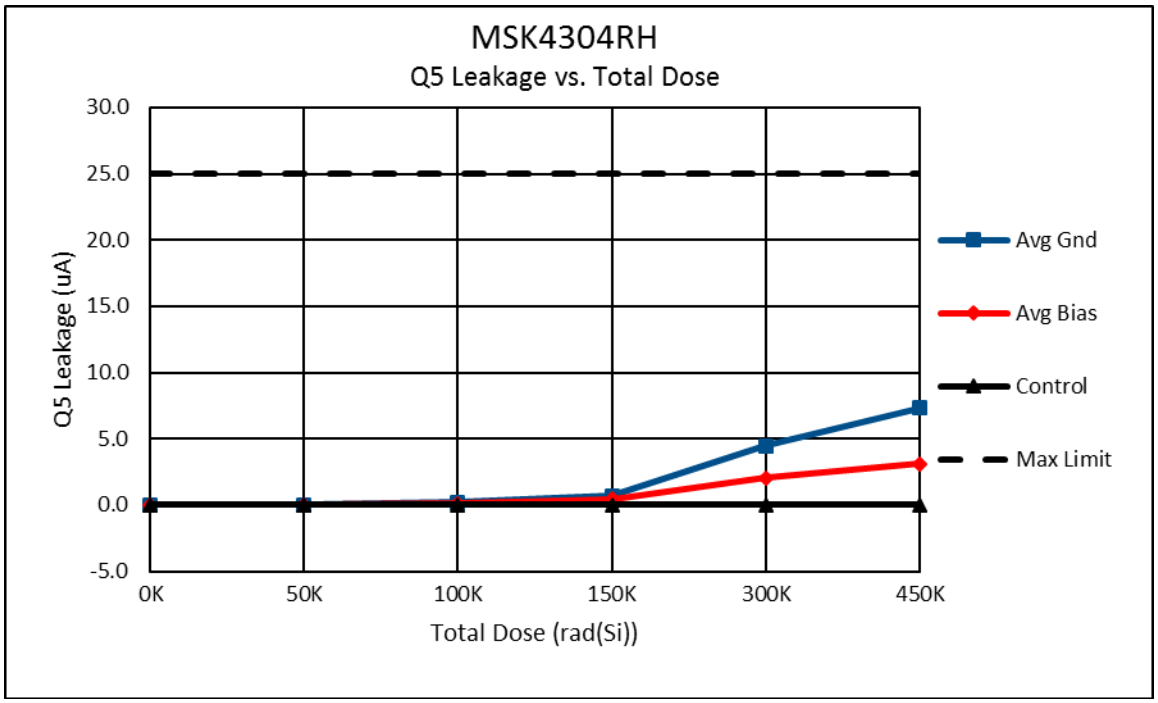

MSK4304RH
Under-voltage Lockout vs. Total Dose
Phase C, Low Side
UVLO Phase C Low (V)
14.0
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Min Limit
Max Limit

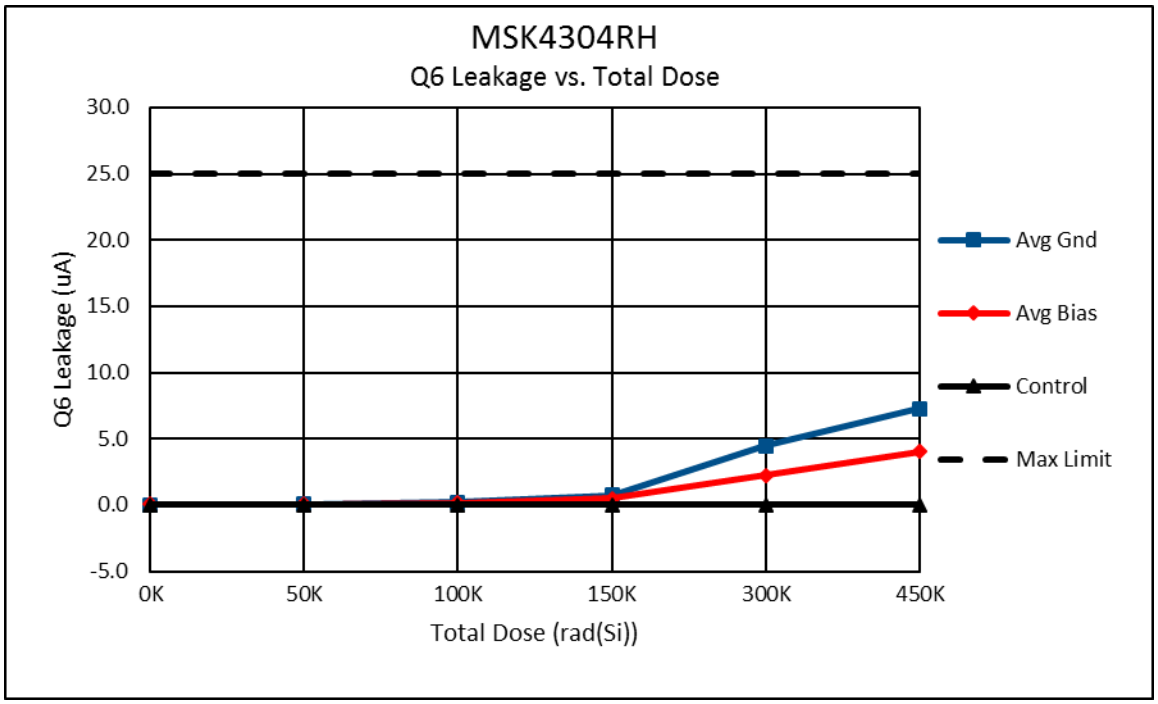

MSK4304RH
Q1 Leakage vs. Total Dose
Q1 Leakage (uA)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit

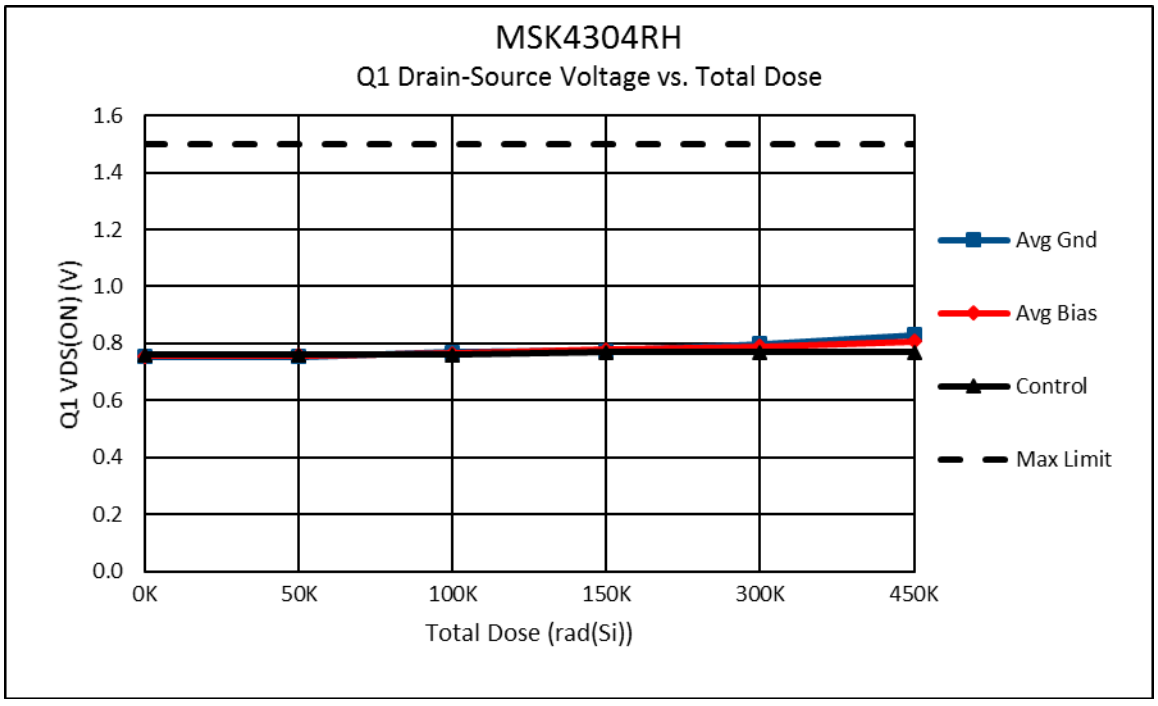

MSK4304RH
Q2 Leakage vs. Total Dose
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
Q2 Leakage (uA)
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit

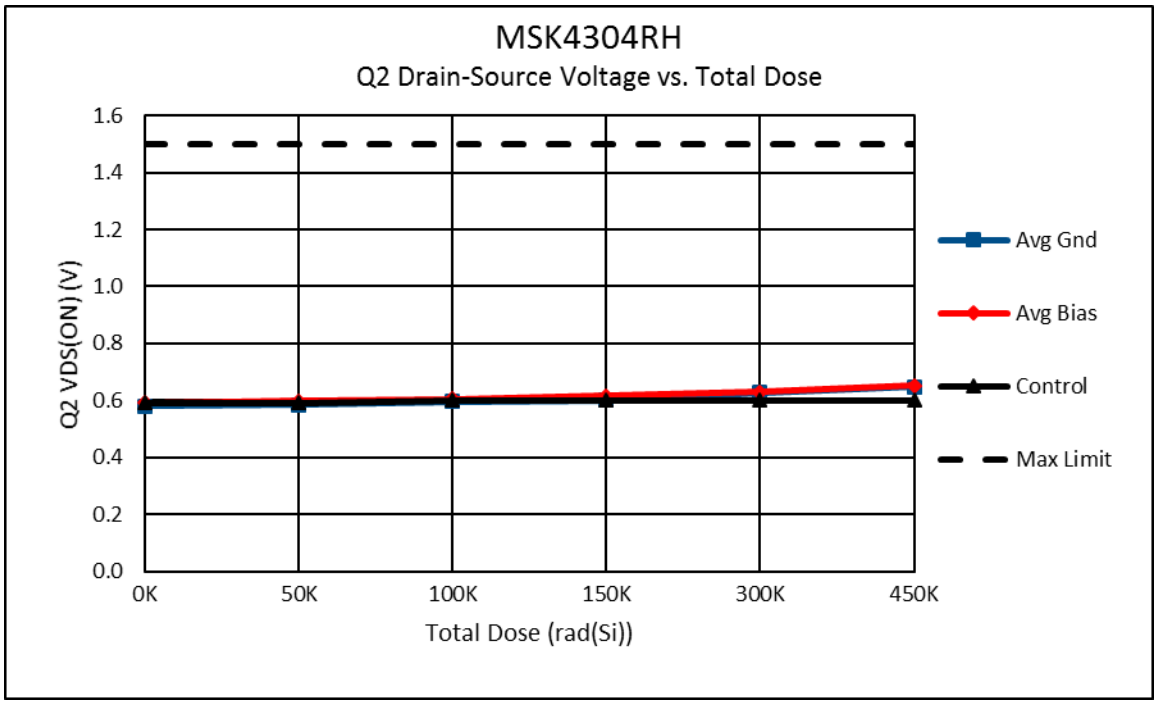

MSK4304RH
Q3 Leakage vs. Total Dose
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
Q3 Leakage (uA)
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit

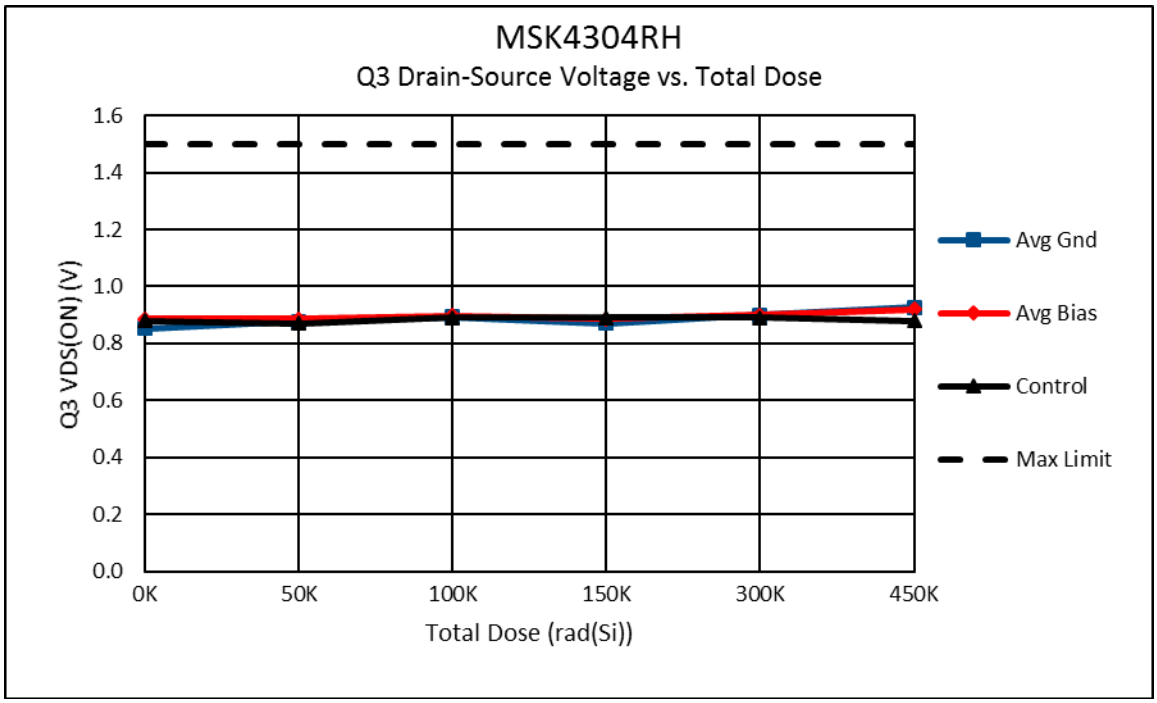

MSK4304RH
Q4 Leakage vs. Total Dose
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
Q4 Leakage (uA)
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit

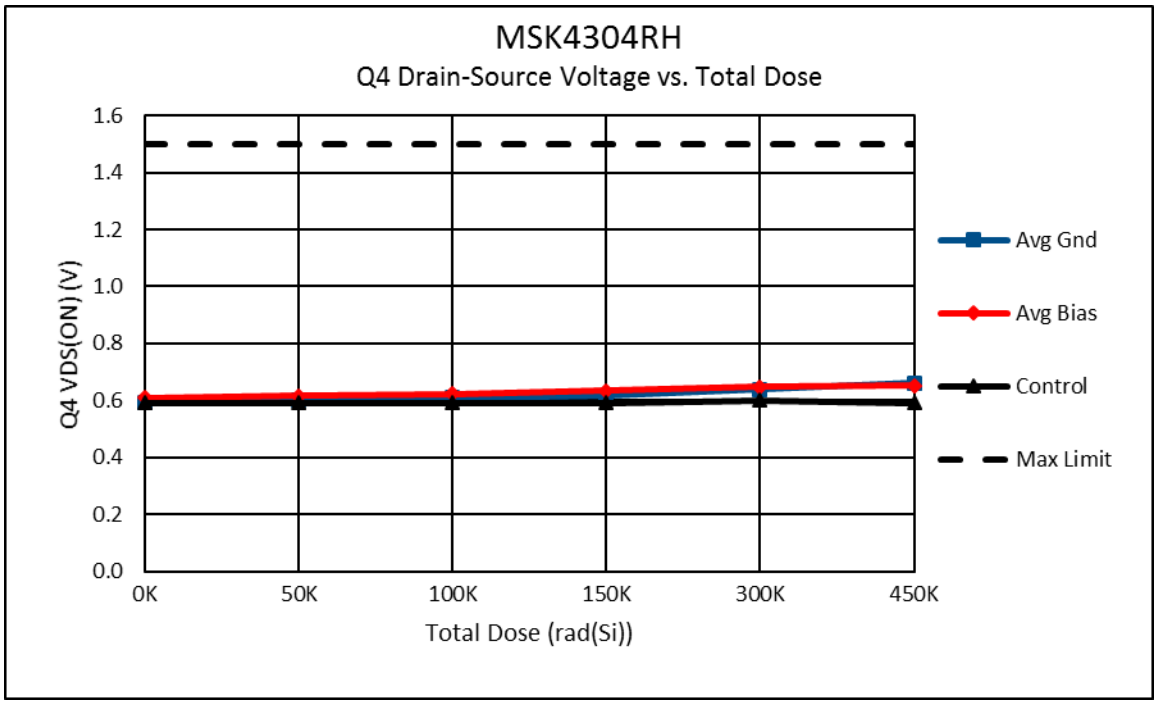

MSK4304RH
Q5 Leakage vs. Total Dose
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
Q5 Leakage (uA)
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit

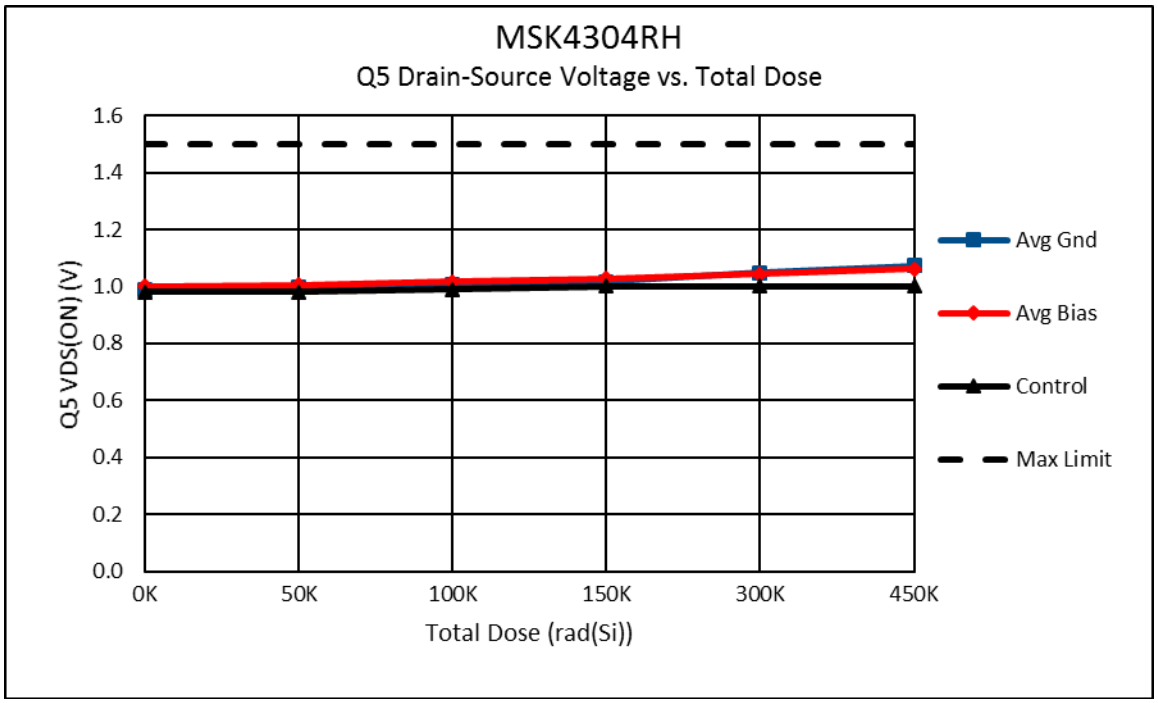

MSK4304RH
Q6 Leakage vs. Total Dose
Q6 Leakage (uA)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit

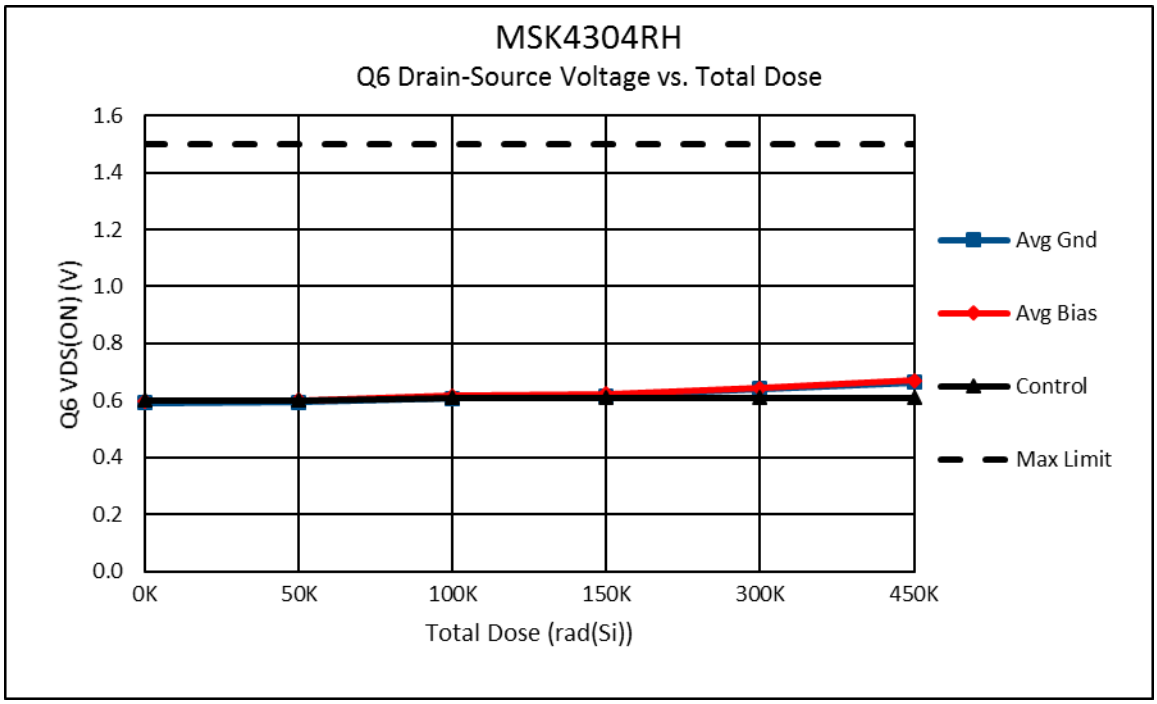

MSK4304RH
Q1 Drain-Source Voltage vs. Total Dose
Q1 VDS(ON) (V)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit

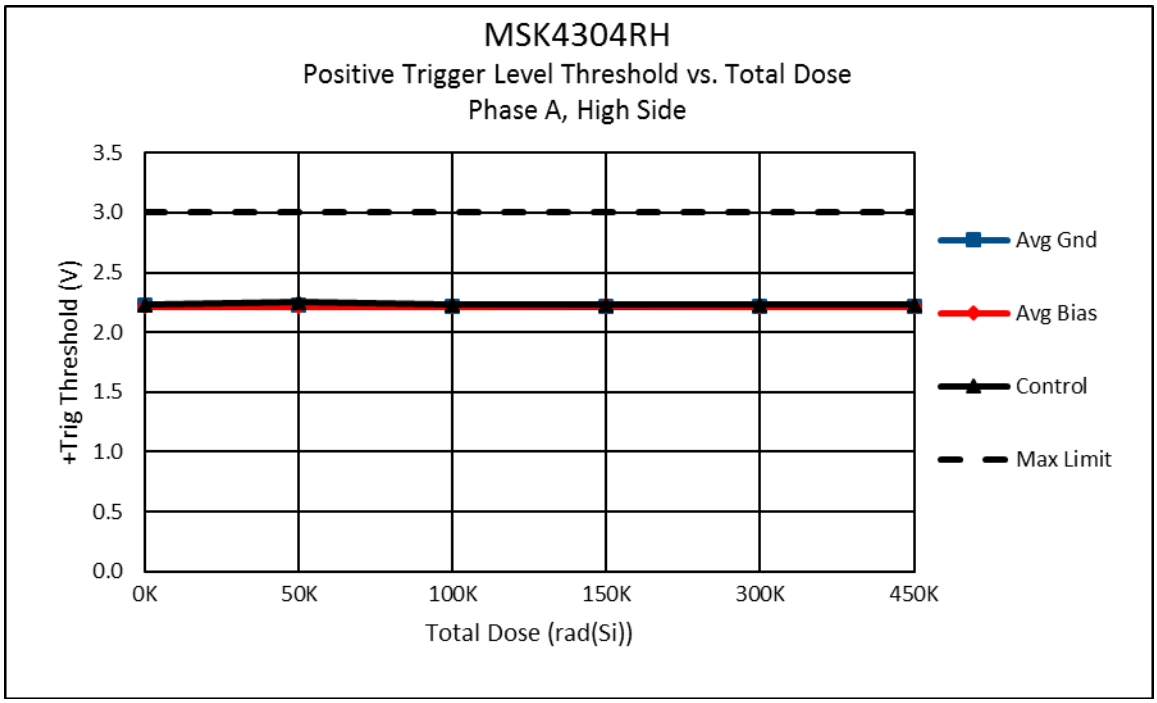

MSK4304RH
Q2 Drain-Source Voltage vs. Total Dose
Q2 VDS(ON) (V)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit

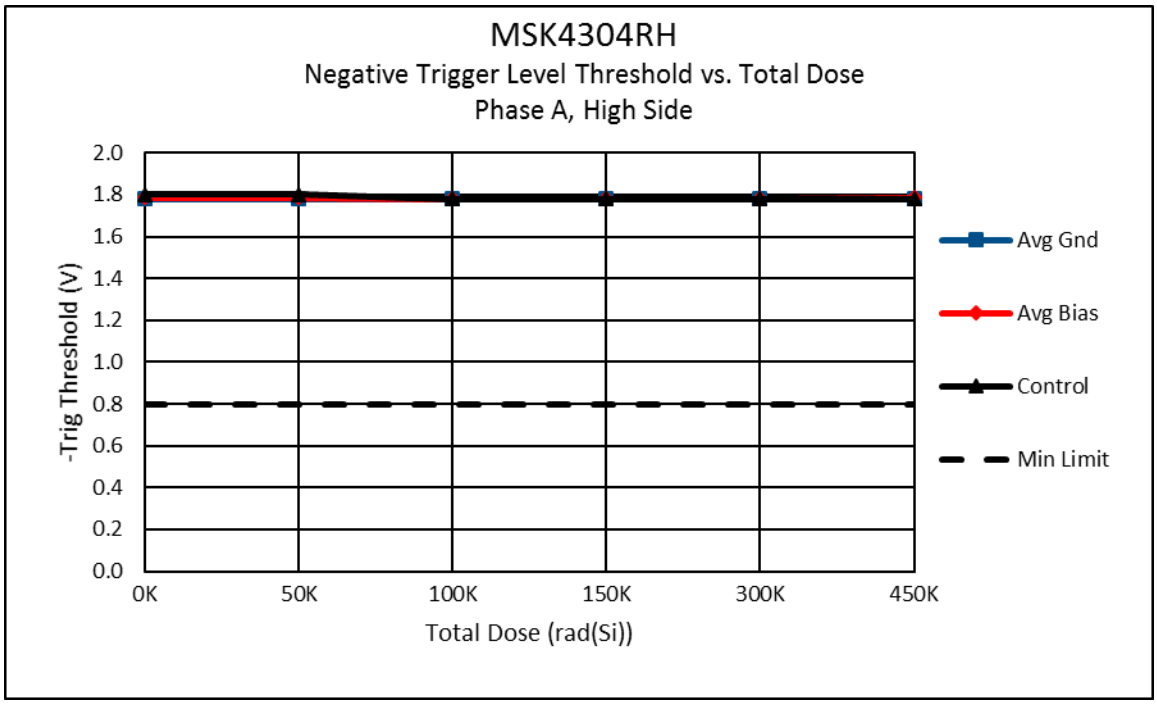

MSK4304RH
Q3 Drain-Source Voltage vs. Total Dose
Q3 VDS(ON) (V)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit

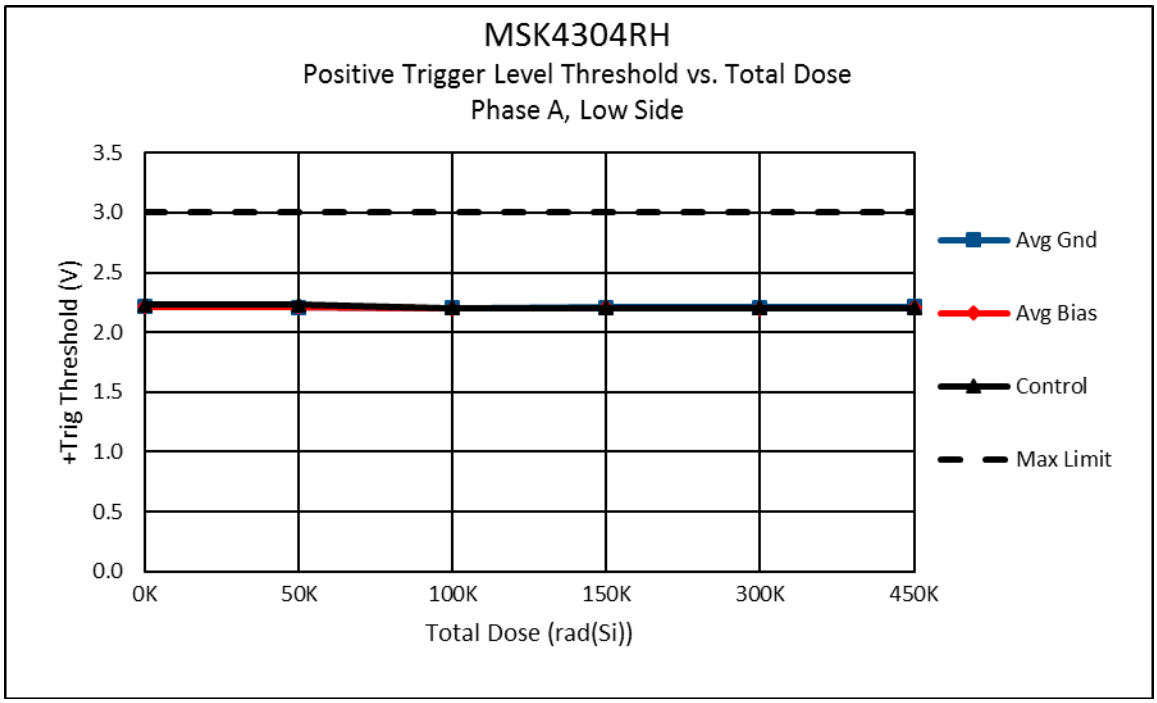

MSK4304RH
Q4 Drain-Source Voltage vs. Total Dose
Q4 VDS(ON) (V)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit

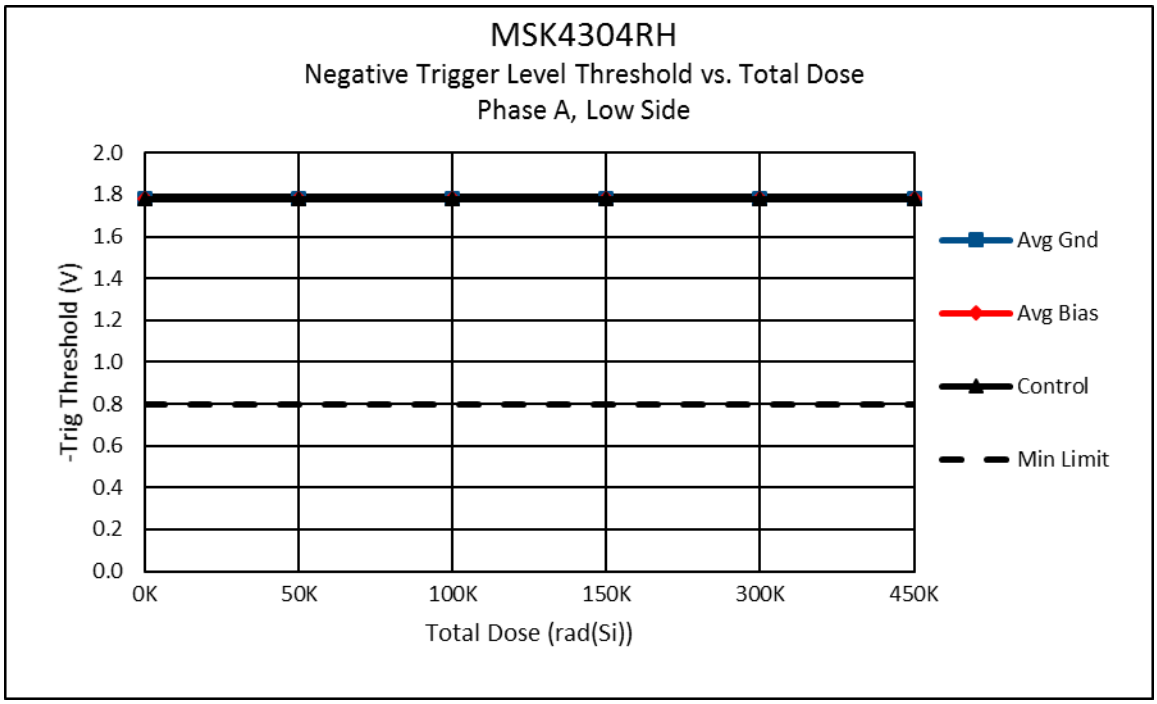

MSK4304RH
Q5 Drain-Source Voltage vs. Total Dose
Q5 VDS(ON) (V)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit

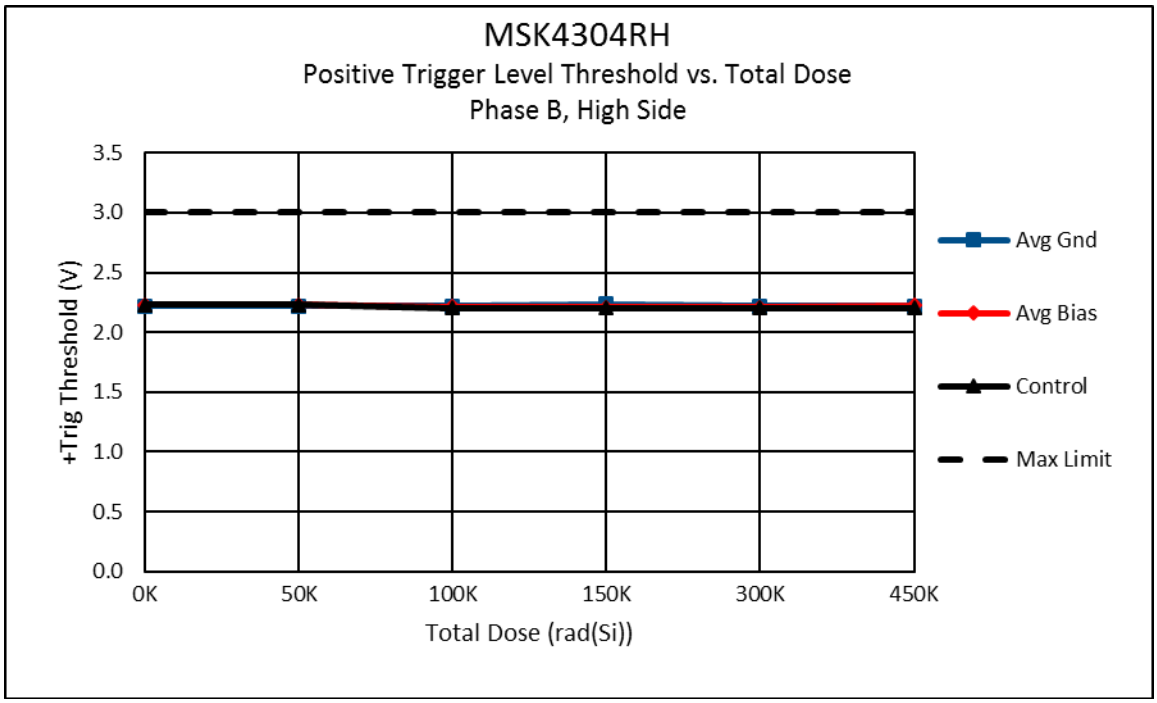

MSK4304RH
Q6 Drain-Source Voltage vs. Total Dose
Q6 VDS(ON) (V)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit

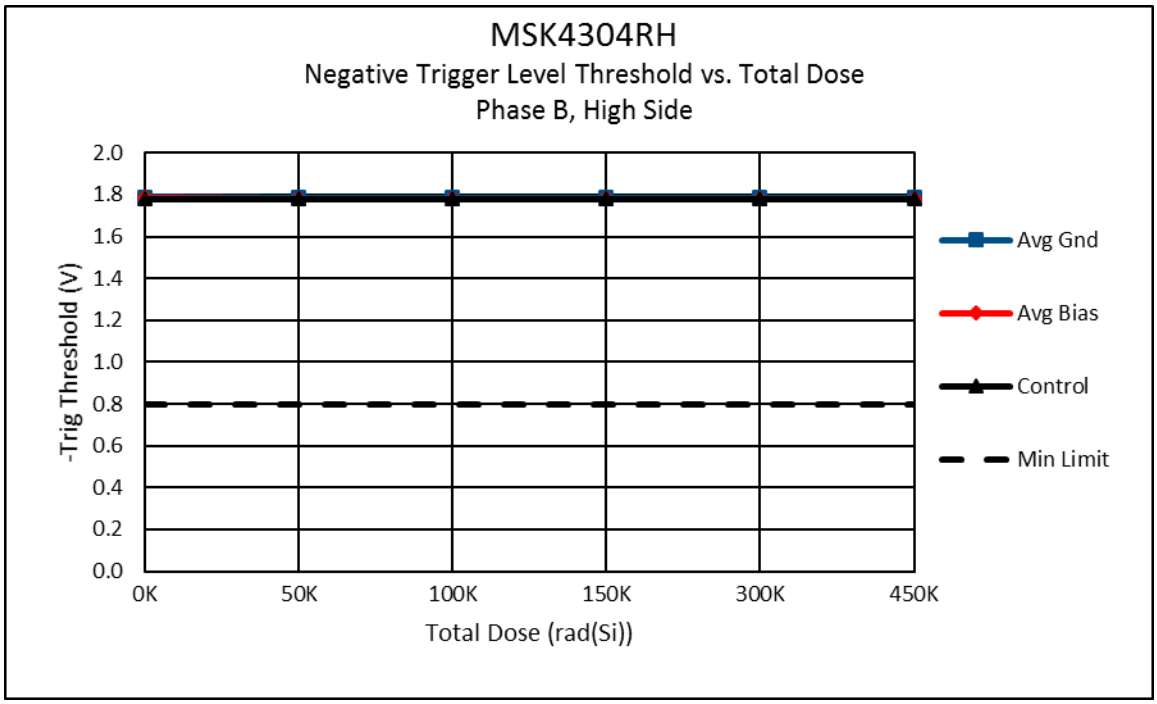

MSK4304RH
Positive Trigger Level Threshold vs. Total Dose
Phase A, High Side
+Trig Threshold (V)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit

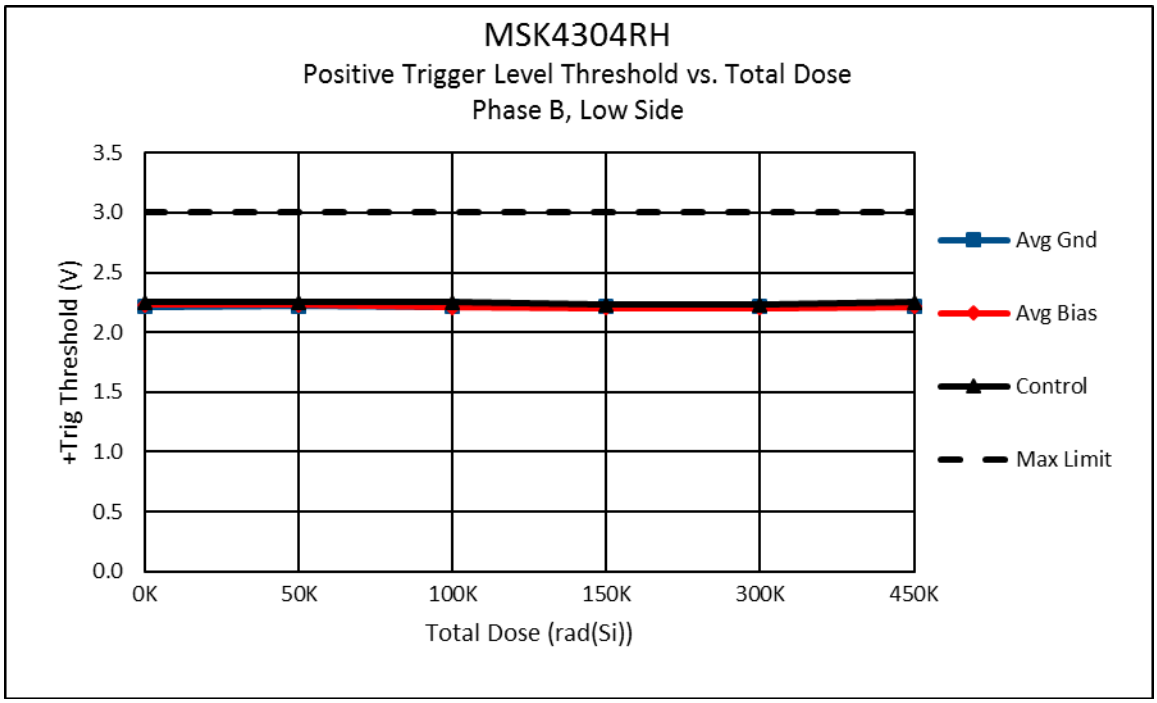

MSK4304RH
Negative Trigger Level Threshold vs. Total Dose
Phase A, High Side
-Trig Threshold (V)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Min Limit

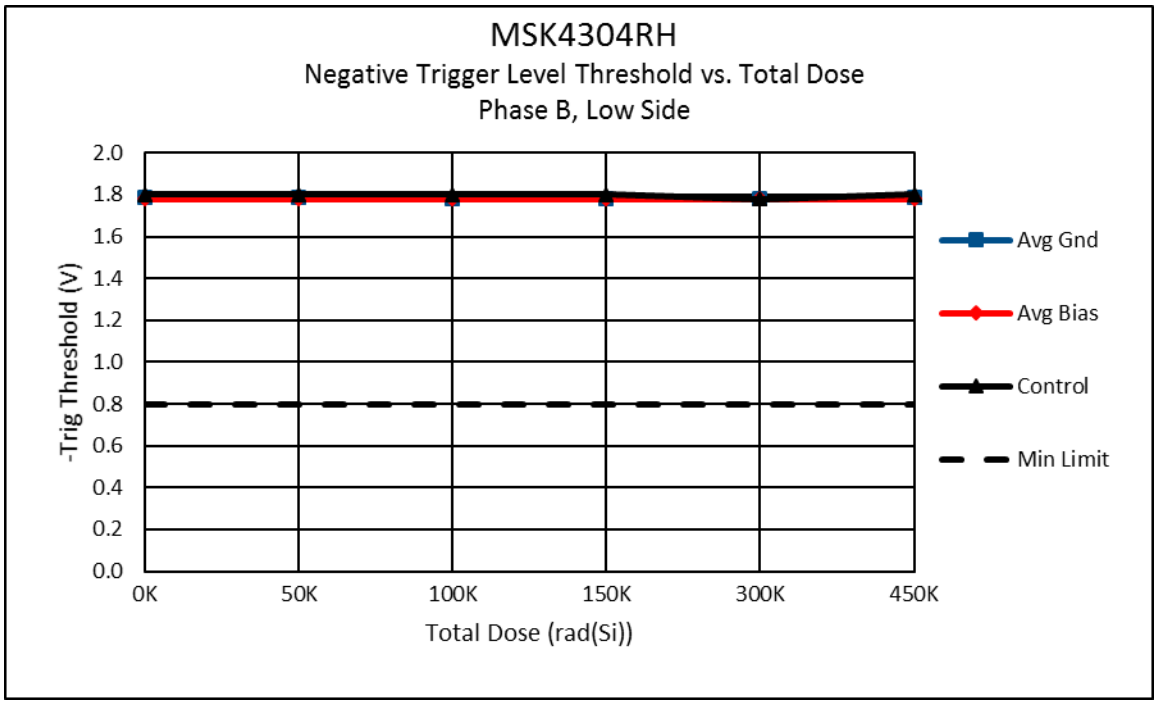

MSK4304RH
Positive Trigger Level Threshold vs. Total Dose
Phase A, Low Side
+Trig Threshold (V)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit

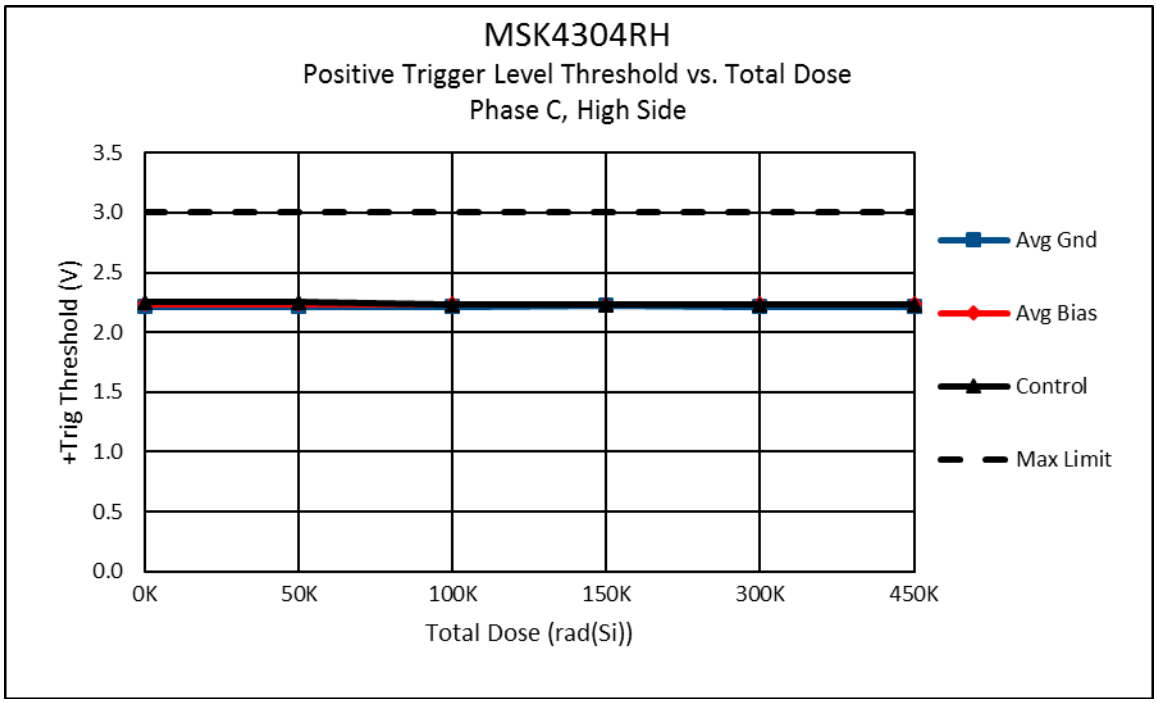

MSK4304RH
Negative Trigger Level Threshold vs. Total Dose
Phase A, Low Side
-Trig Threshold (V)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Min Limit

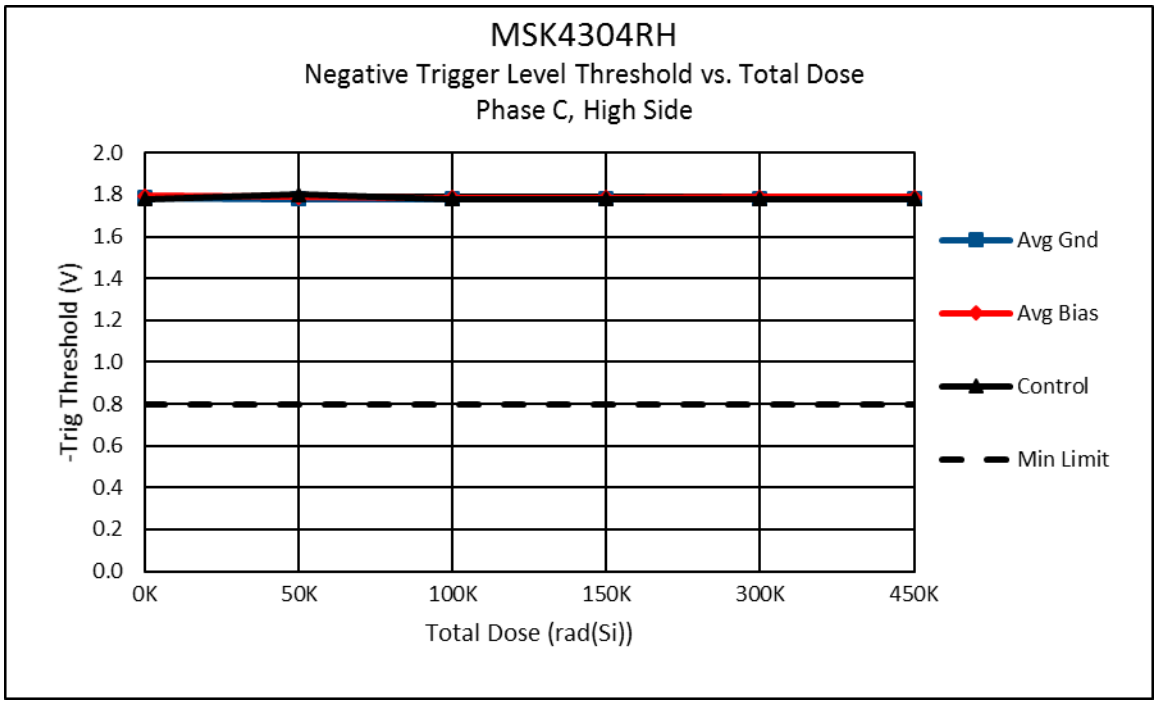

MSK4304RH
Positive Trigger Level Threshold vs. Total Dose
Phase B, High Side
+Trig Threshold (V)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit

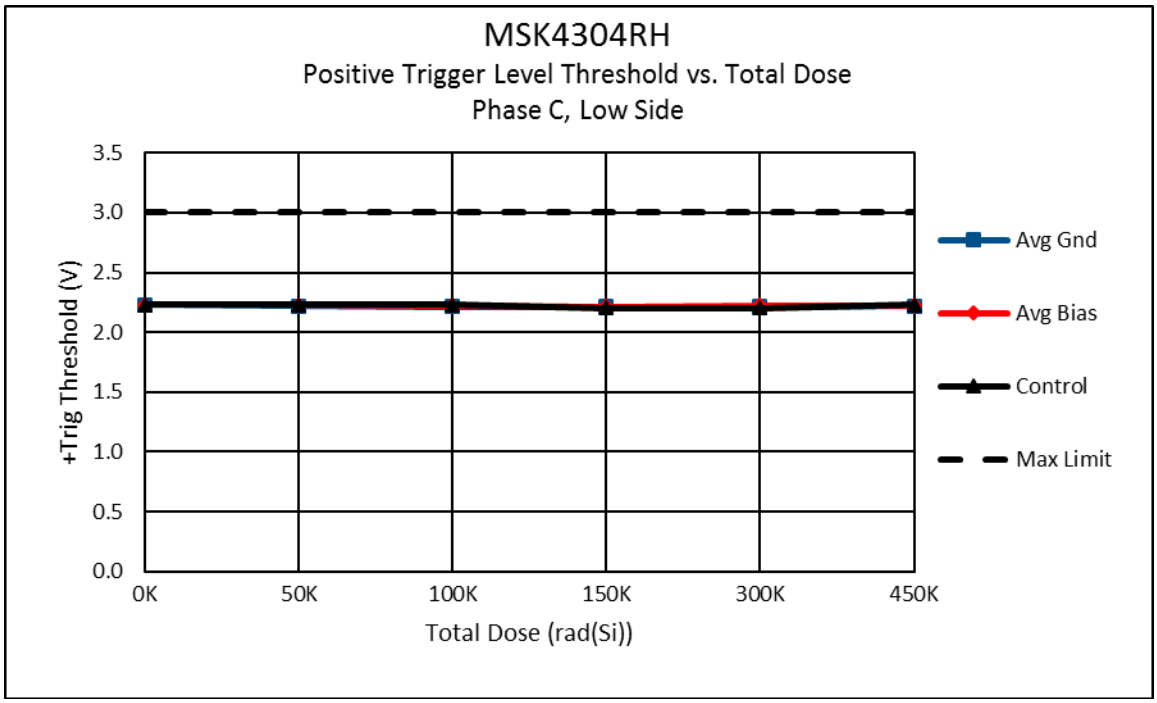

MSK4304RH
Negative Trigger Level Threshold vs. Total Dose
Phase B, High Side
-Trig Threshold (V)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Min Limit

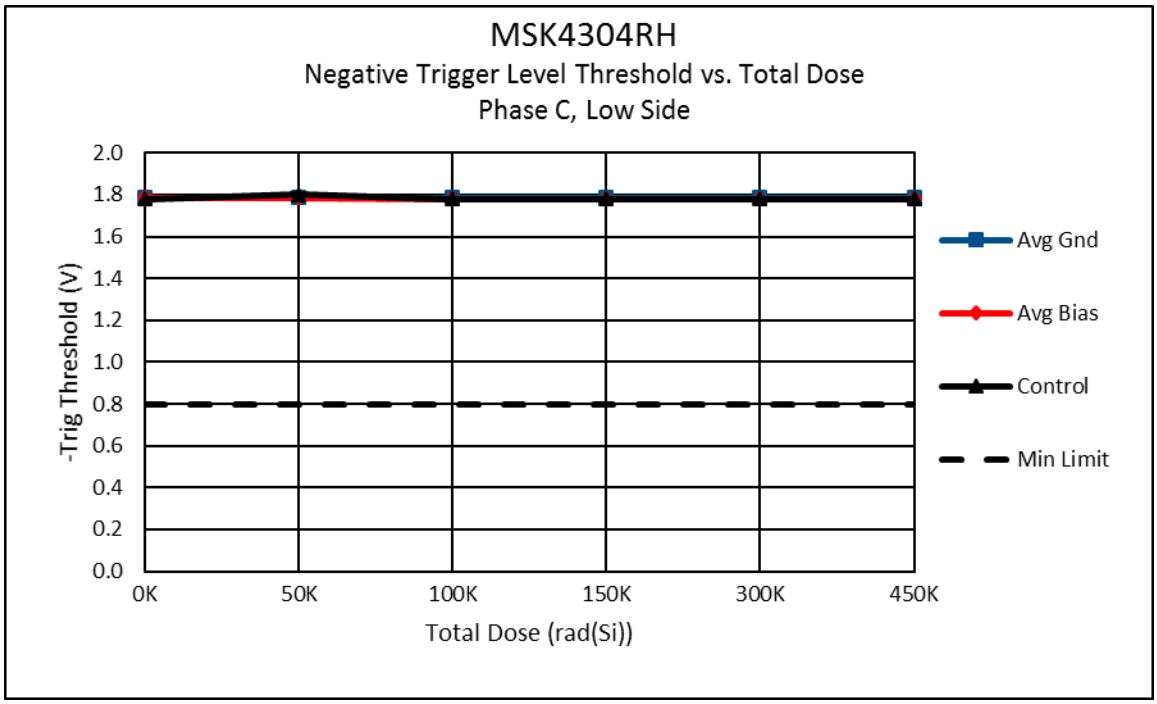

MSK4304RH
Positive Trigger Level Threshold vs. Total Dose
Phase B, Low Side
+Trig Threshold (V)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit

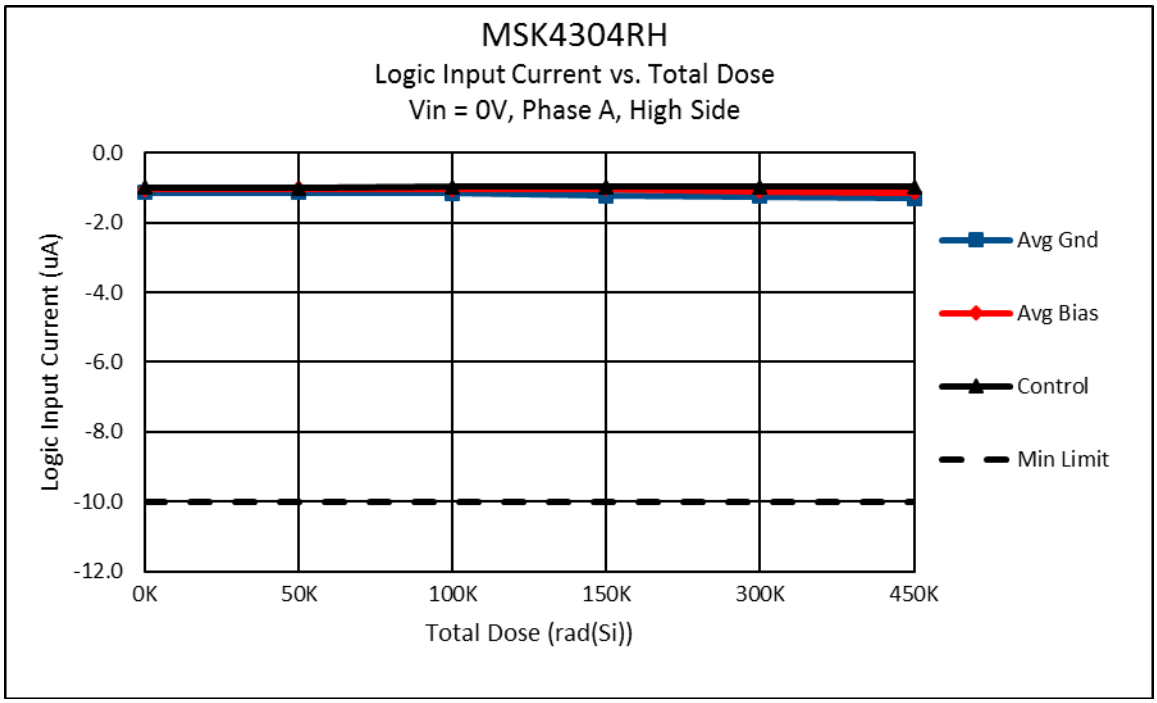

MSK4304RH
Negative Trigger Level Threshold vs. Total Dose
Phase B, Low Side
-Trig Threshold (V)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Min Limit

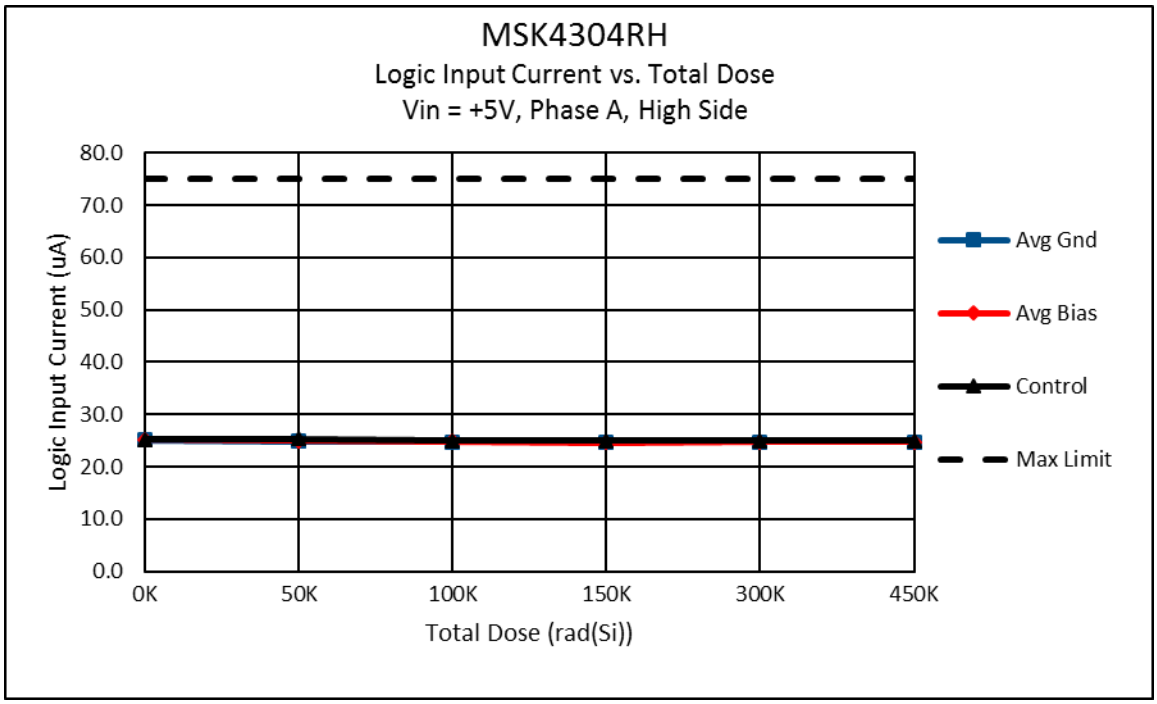

MSK4304RH
Positive Trigger Level Threshold vs. Total Dose
Phase C, High Side
+Trig Threshold (V)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit

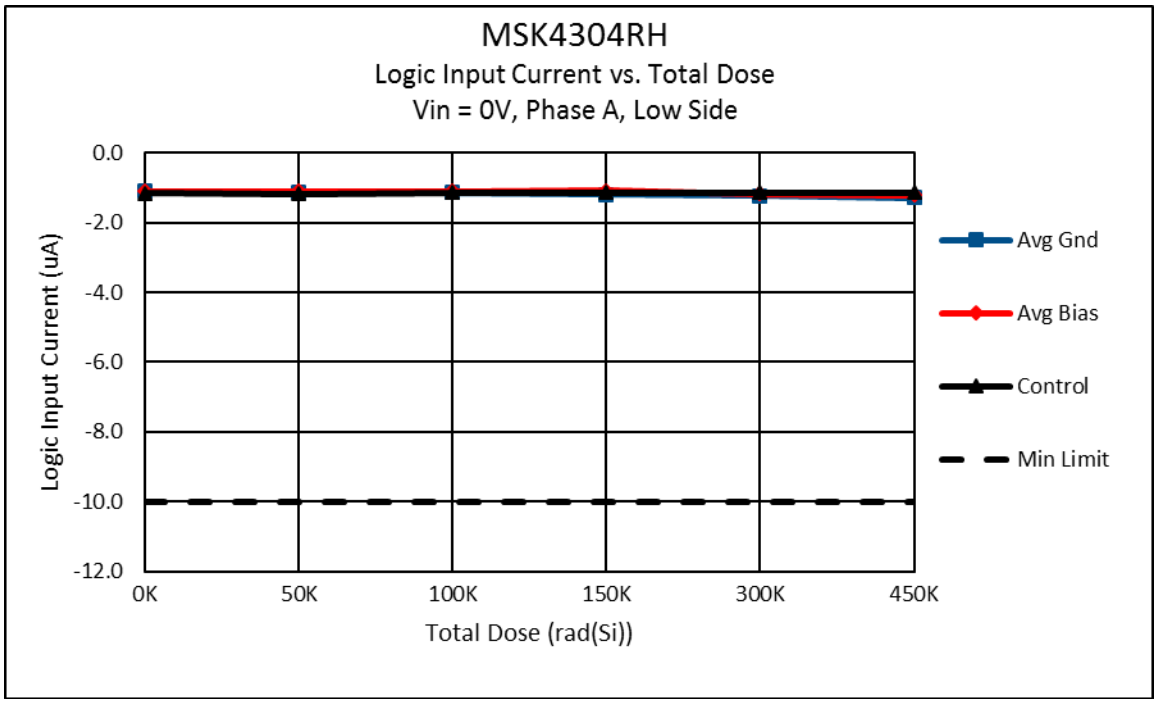

MSK4304RH
Negative Trigger Level Threshold vs. Total Dose
Phase C, High Side
-Trig Threshold (V)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Min Limit

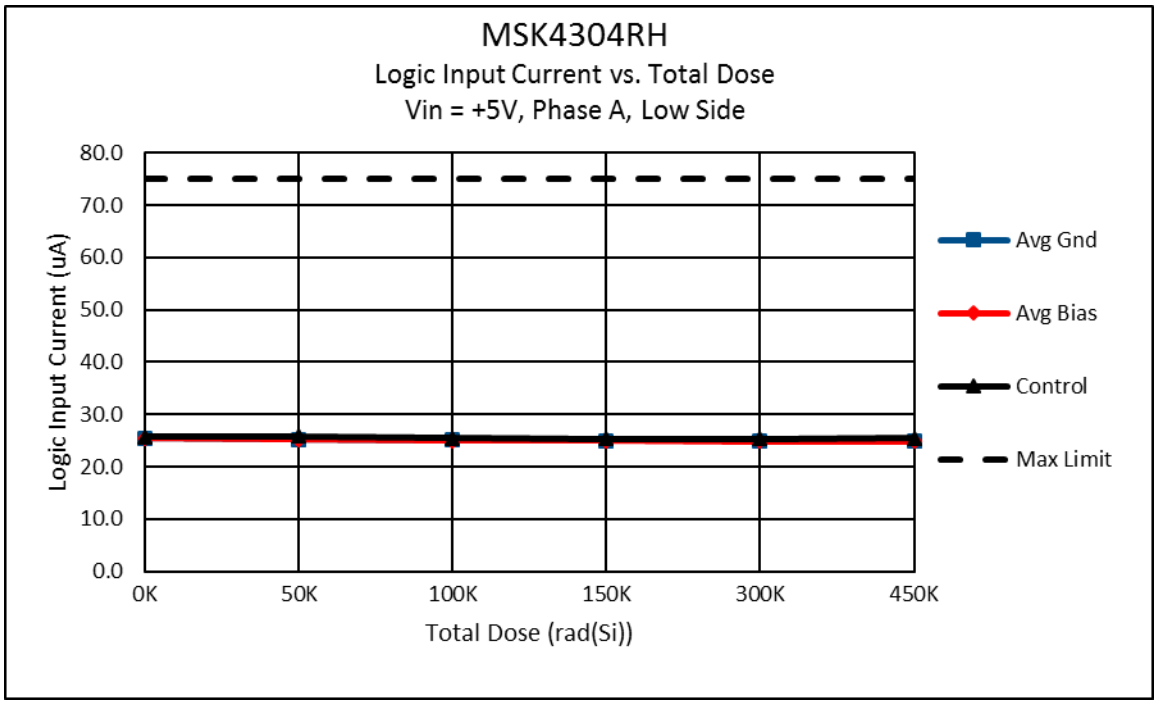

MSK4304RH
Positive Trigger Level Threshold vs. Total Dose
Phase C, Low Side
+Trig Threshold (V)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit

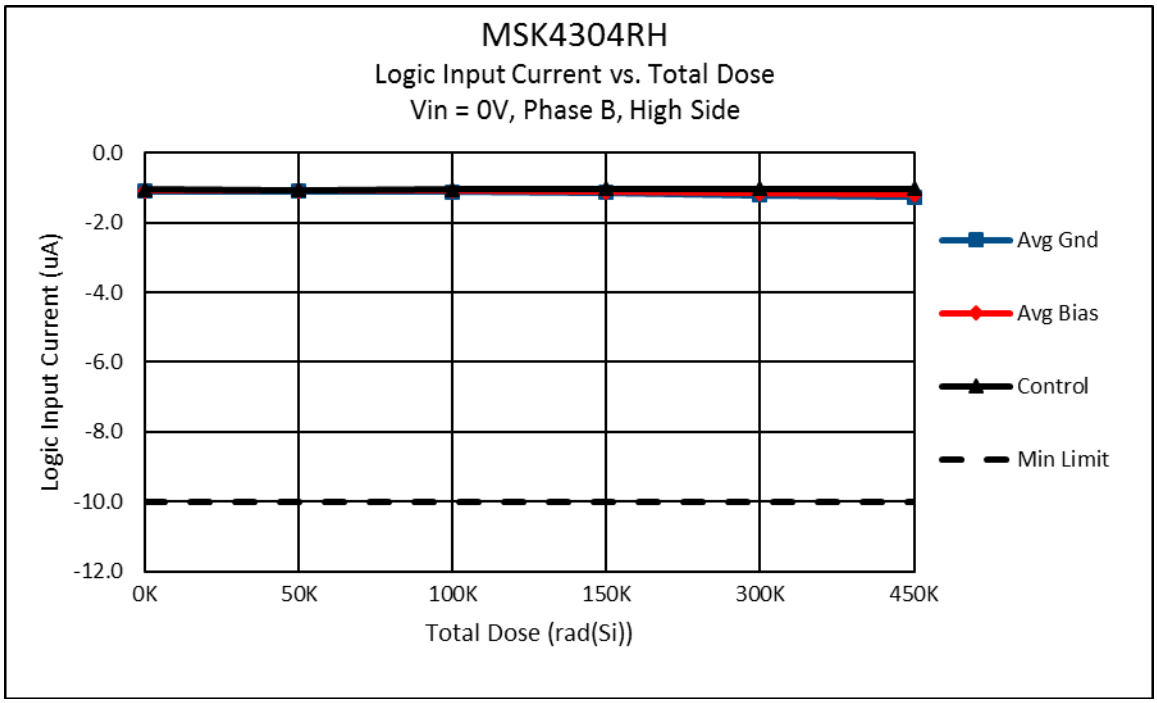

MSK4304RH
Negative Trigger Level Threshold vs. Total Dose
Phase C, Low Side
-Trig Threshold (V)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Min Limit

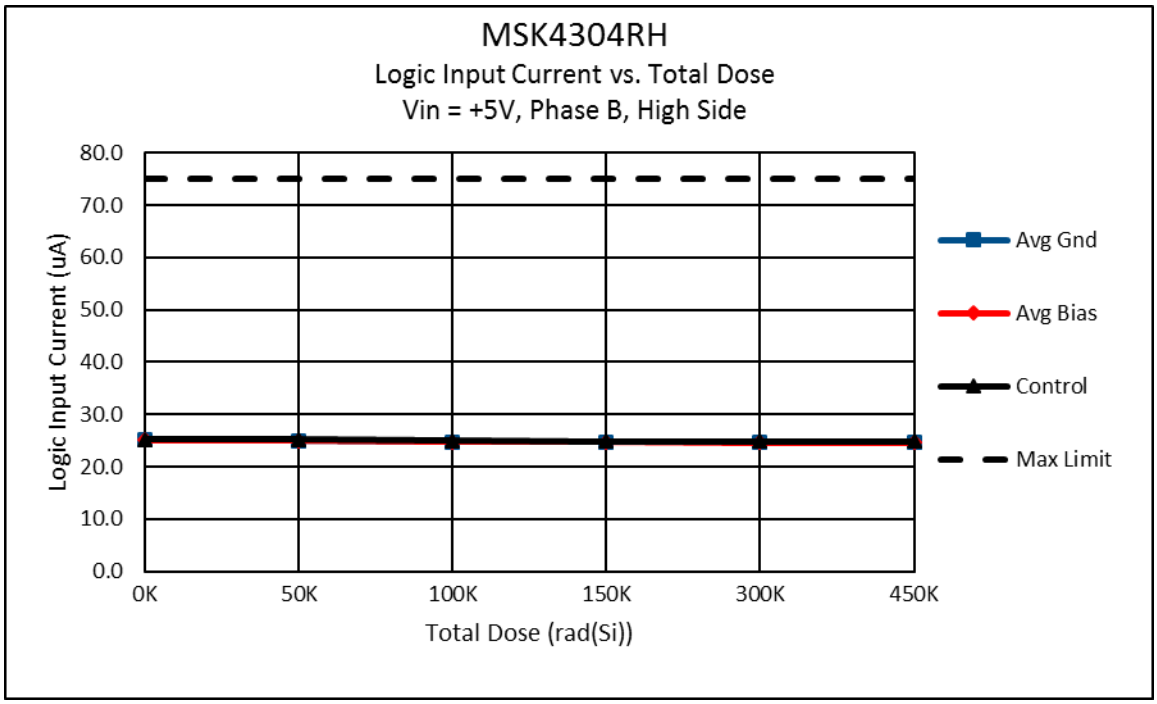

MSK4304RH
Logic Input Current vs. Total Dose
Vin = 0V, Phase A, High Side
Logic Input Current (uA)
0.0
-2.0
-4.0
-6.0
-8.0
-10.0
-12.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Min Limit

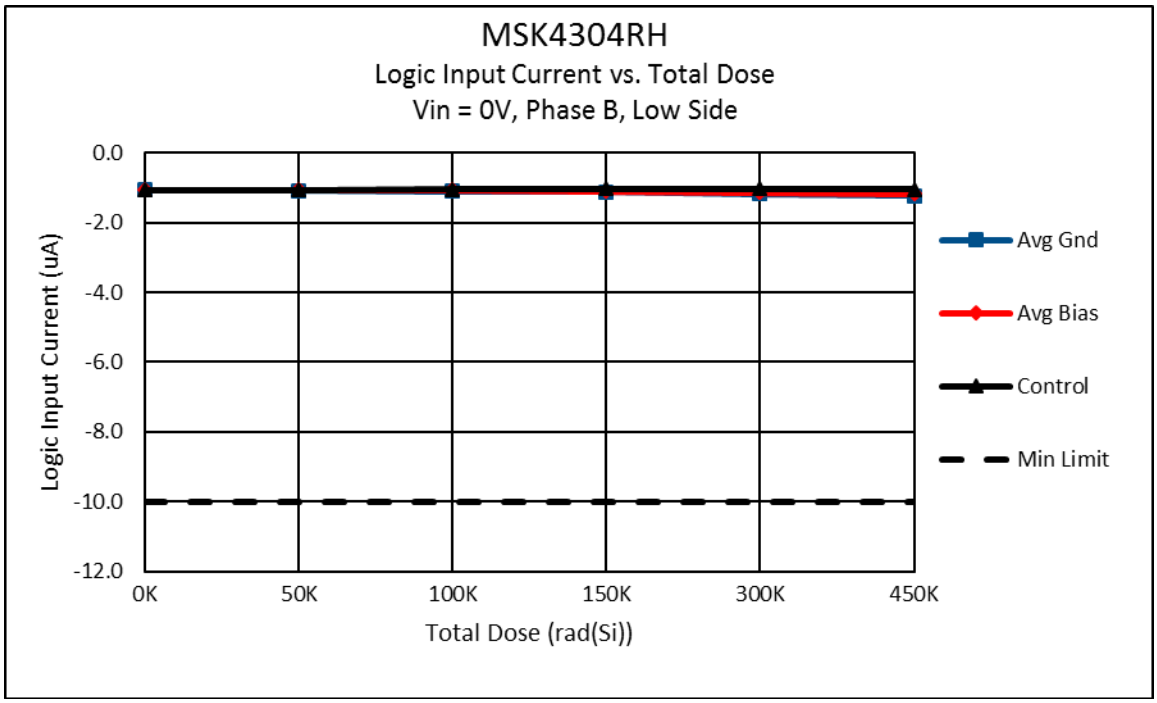

MSK4304RH
Logic Input Current vs. Total Dose
Vin = +5V, Phase A, High Side
Logic Input Current (uA)
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit

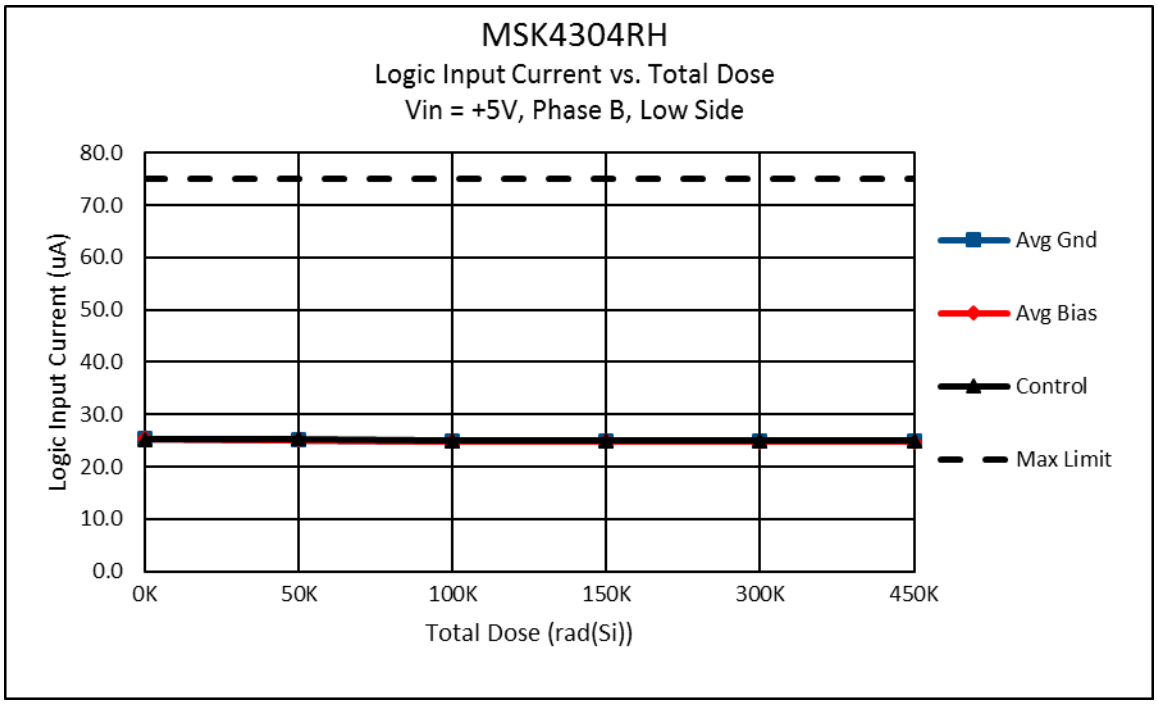

MSK4304RH
Logic Input Current vs. Total Dose
Vin = 0V, Phase A, Low Side
Logic Input Current (uA)
0.0
-2.0
-4.0
-6.0
-8.0
-10.0
-12.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Min Limit

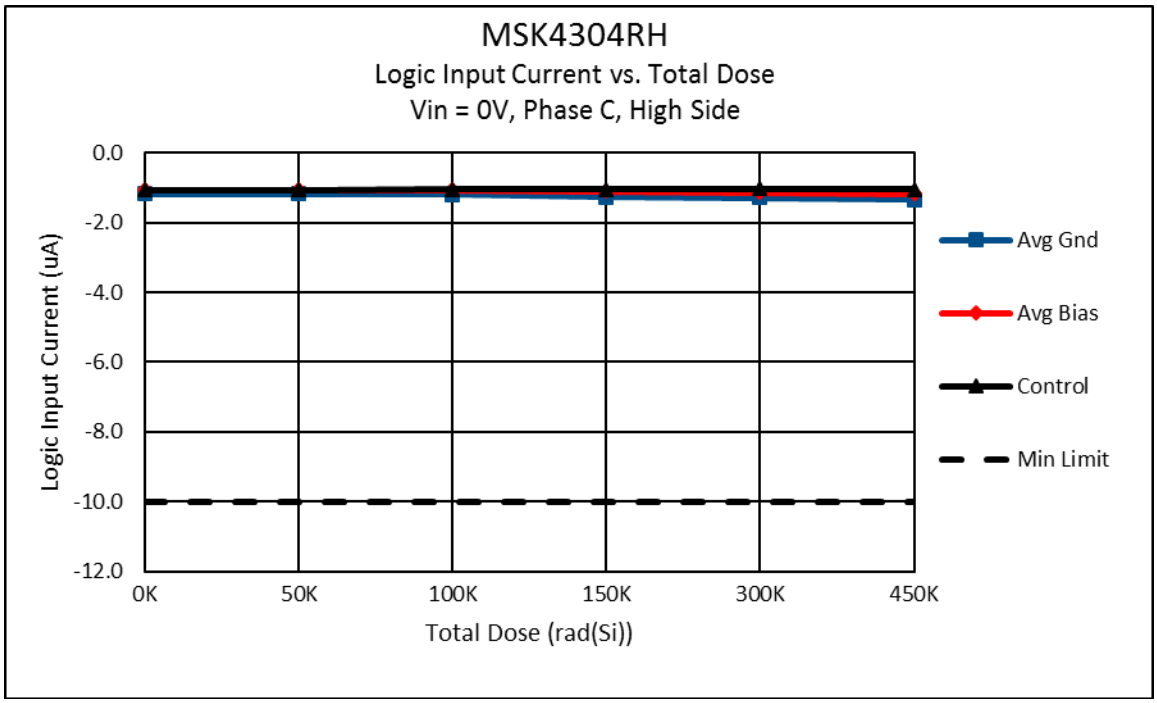

MSK4304RH
Logic Input Current vs. Total Dose
Vin = +5V, Phase A, Low Side
Logic Input Current (uA)
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit

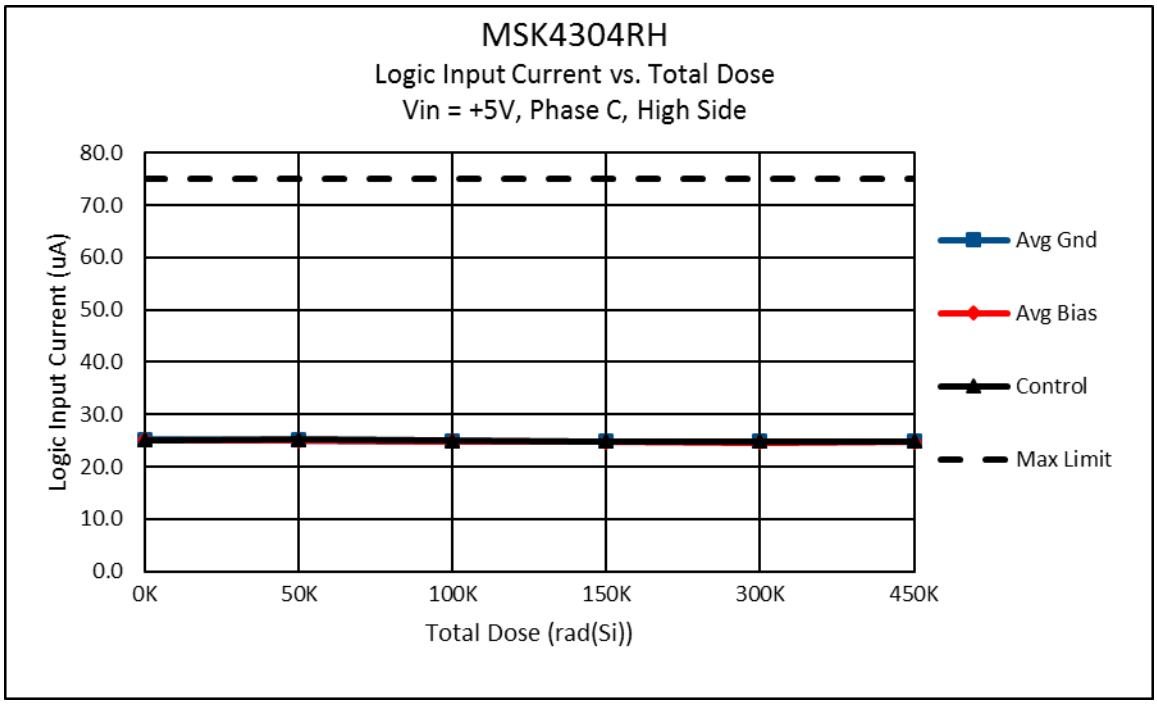

MSK4304RH
Logic Input Current vs. Total Dose
Vin = 0V, Phase B, High Side
Logic Input Current (uA)
0.0
-2.0
-4.0
-6.0
-8.0
-10.0
-12.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Min Limit

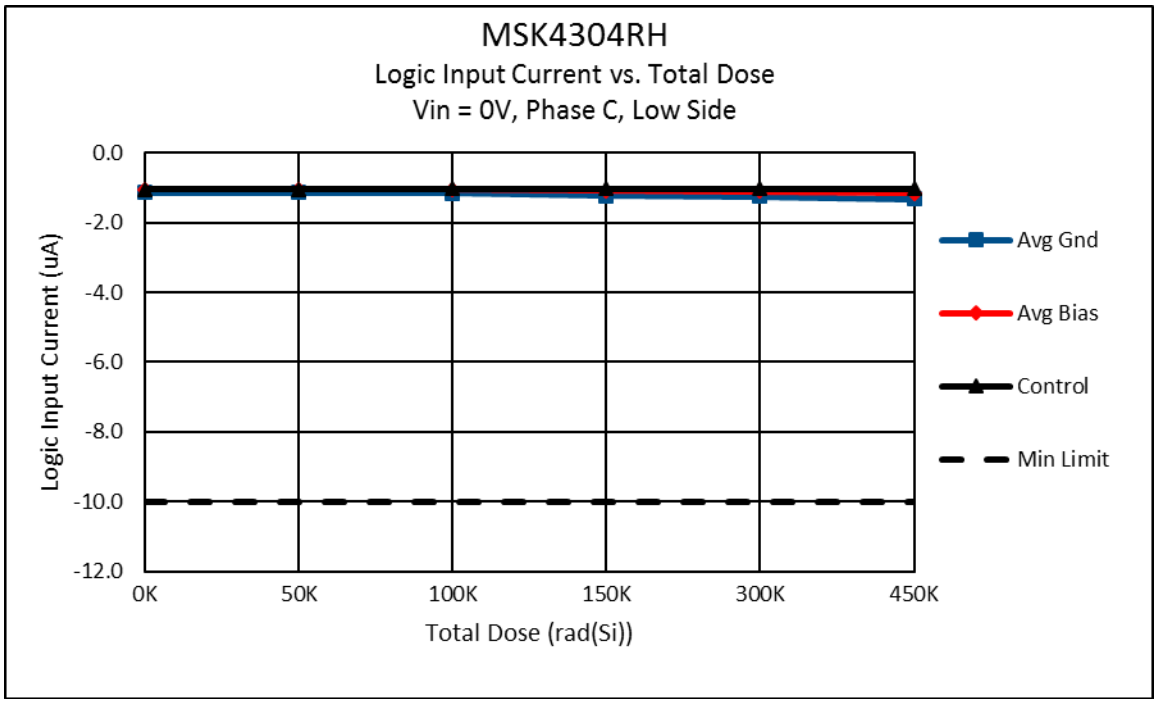

MSK4304RH
Logic Input Current vs. Total Dose
Vin = +5V, Phase B, High Side
Logic Input Current (uA)
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit

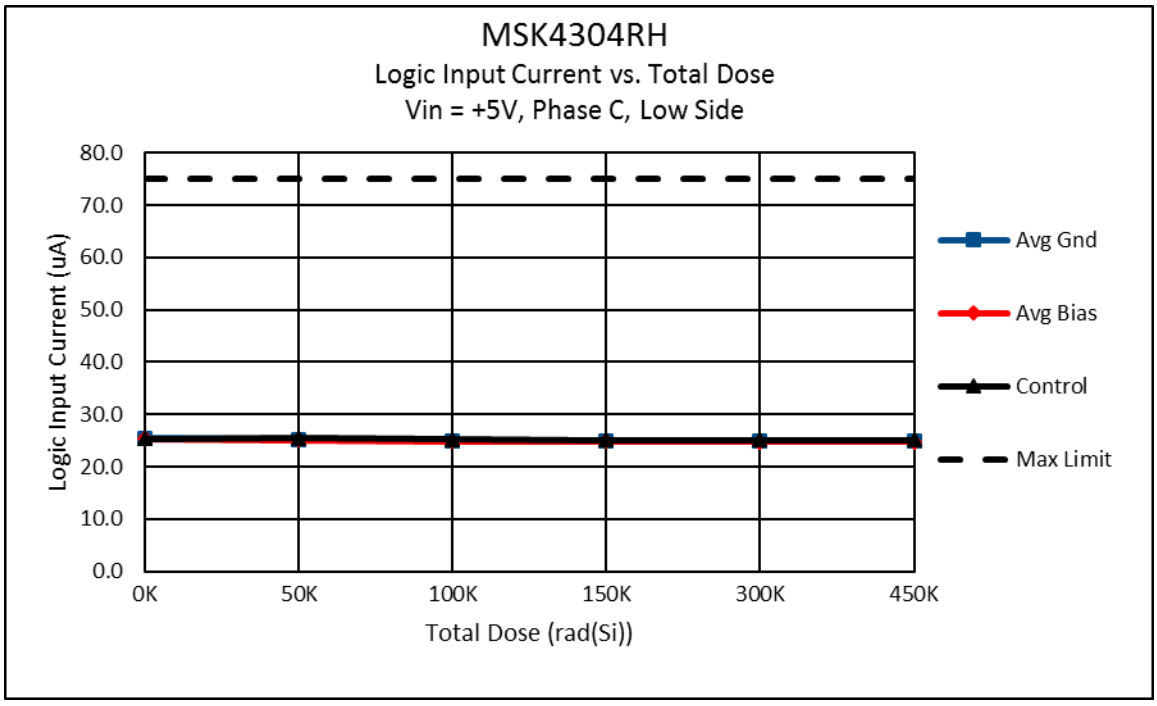

MSK4304RH
Logic Input Current vs. Total Dose
Vin = 0V, Phase B, Low Side
Logic Input Current (uA)
0.0
-2.0
-4.0
-6.0
-8.0
-10.0
-12.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Min Limit


MSK4304RH
Logic Input Current vs. Total Dose
Vin = +5V, Phase B, Low Side
Logic Input Current (uA)
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit


MSK4304RH
Logic Input Current vs. Total Dose
Vin = 0V, Phase C, High Side
Logic Input Current (uA)
0.0
-2.0
-4.0
-6.0
-8.0
-10.0
-12.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Min Limit


MSK4304RH
Logic Input Current vs. Total Dose
Vin = +5V, Phase C, High Side
Logic Input Current (uA)
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit


MSK4304RH
Logic Input Current vs. Total Dose
Vin = 0V, Phase C, Low Side
Logic Input Current (uA)
0.0
-2.0
-4.0
-6.0
-8.0
-10.0
-12.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Min Limit


MSK4304RH
Logic Input Current vs. Total Dose
Vin = +5V, Phase C, Low Side
Logic Input Current (uA)
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit

Total Dose Radiation Test Report

MSK 4304RH

3 - Phase Motor Drive Hybrid

June 14, 2007 (1st test)
November 6, 2013 (2nd test: IC Wafer Lot: DJA6ENC
Transistor Wafer Lot: BA1016MFA #16)

B. Horton
R. Wakeman

M.S. Kennedy Corporation
Liverpool, NY

I. Introduction:

The total dose radiation test plan for the MSK 4304 RH was developed to qualify the devices as RAD Hard to 300 KRAD (Si). The testing was performed beyond 300 KRAD (Si) to show trends in device performance as a function of total dose. The test does not classify maximum radiation tolerance of the device, but simply offers designers insight to the critical parameter-shifts up to the specified total dose level.

MIL-STD-883 Method 1019.7 and ASTM F1892-06 were used as guidelines in the development and implementation of the total dose test plan for the MSK 4304 RH.

II. Radiation Source:

Total dose was performed at the University of Massachusetts, Lowell, using a cobalt 60 radiation source. The dose rate was determined to be 88 Rads(Si)/sec. The total dose schedule can be found in Table I.

III. Test Setup:

All test samples were subjected to Group A Electrical Test at 25°C in accordance with the device data sheet. In addition, all devices received 320 hours of burn-in per MIL-STD-883 Method 1015. For test platform verification, one control device was tested at 25°C. Four devices (12 samples, See para. IV) were then tested at 25°C, prior to irradiation, and were found to be within acceptable test limits.

The devices were vertically aligned with the radiation source and enclosed in a lead/aluminum container during irradiation. Two devices (six samples) were biased during irradiation. Two devices (six samples) had all leads grounded during irradiation for the unbiased condition.

After each irradiation the device leads were shorted together and transported to the MSK automatic electrical test platform and tested IAW MSK device data sheet. Testing was performed on irradiated devices, as well as the control device, at each total dose level. Electrical tests were completed within one hour of irradiation. Devices were subjected to subsequent radiation doses within two hours of removal from the radiation field.

IV. Data:

Each device contains three identical and independently operating circuits. For each MSK4304RH tested the effective sample size is three. All performance curves are averaged from the test results of the biased and unbiased devices, respectively. If required, full test data can be obtained by contacting M.S. Kennedy Corporation.

V. Summary:

Based on the test data recorded during radiation testing, the MSK4304RH qualified as a 300 KRAD (Si) radiation hardened device. All performance curves stayed well within specification up to the maximum test dose, 450 KRAD (Si) TID

MSK 4304RH Biased/Unbiased Dose Rate Schedule

Dosimetry Equipment
Bruker Biospin # 0162

Irradiation Date
11/6/13

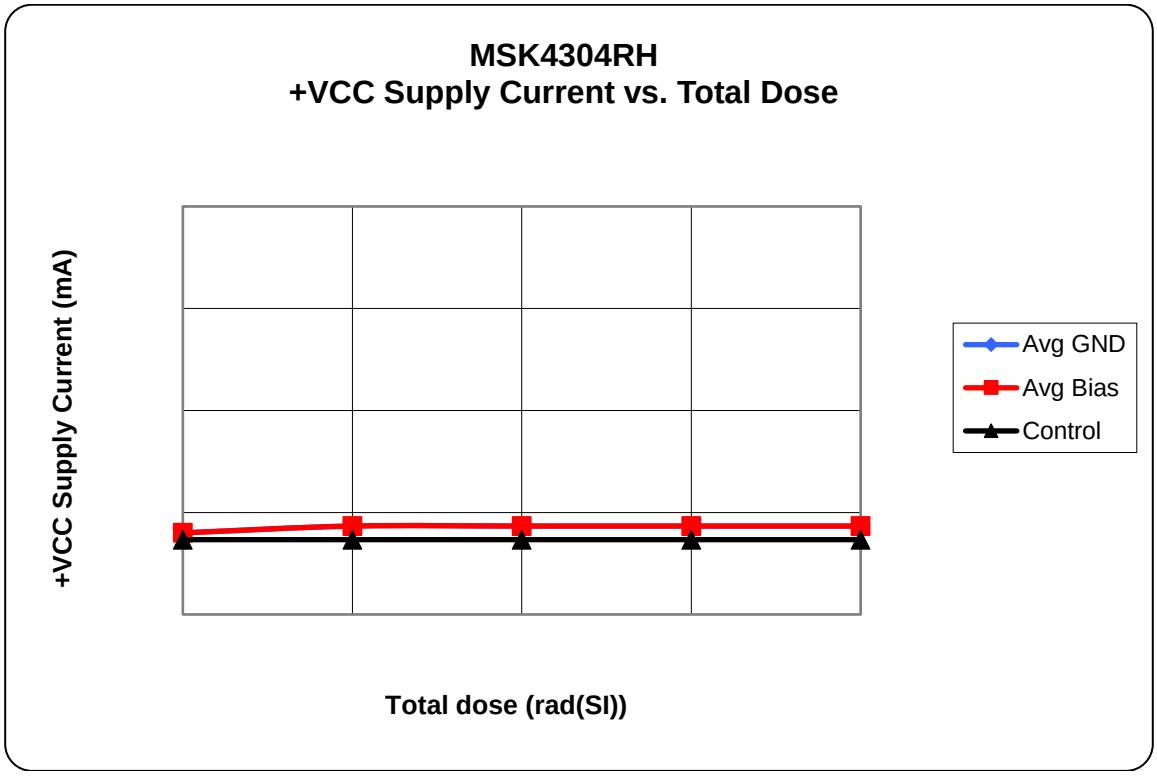
Exposure Length (min:sec)	Incremental Dose rads(Si)	Cumulative Dose rads(Si)
0:19:31	103,048	103,048
0:09:46	51,568	154,616
0:29:16	154,528	309,144
0:29:16	154,528	463,672

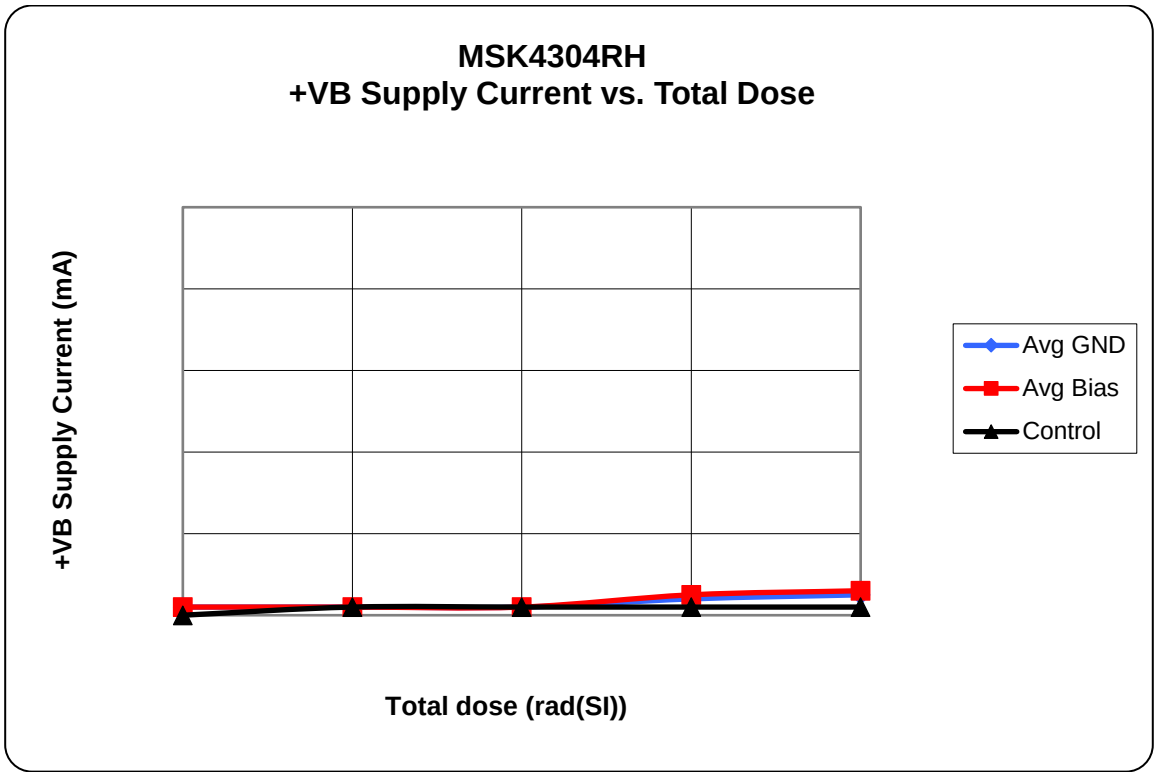
Biased S/N – 0154, 0155

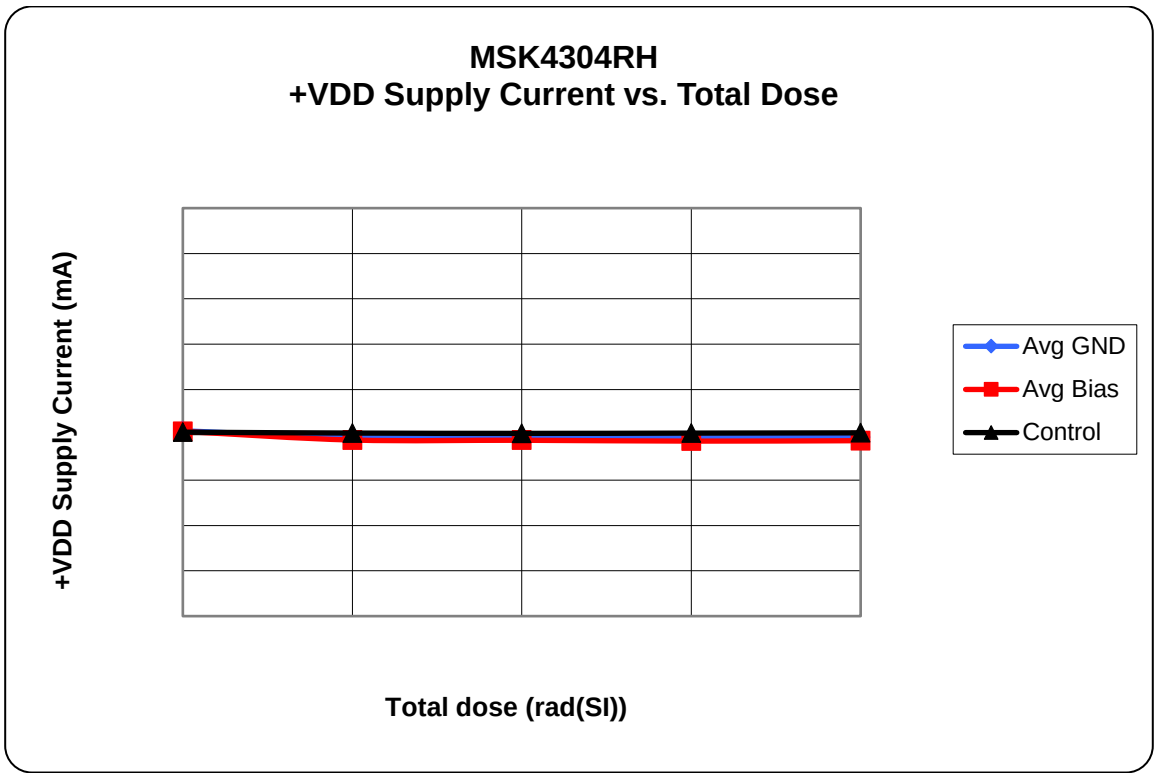
Unbiased S/N – 0156, 0157

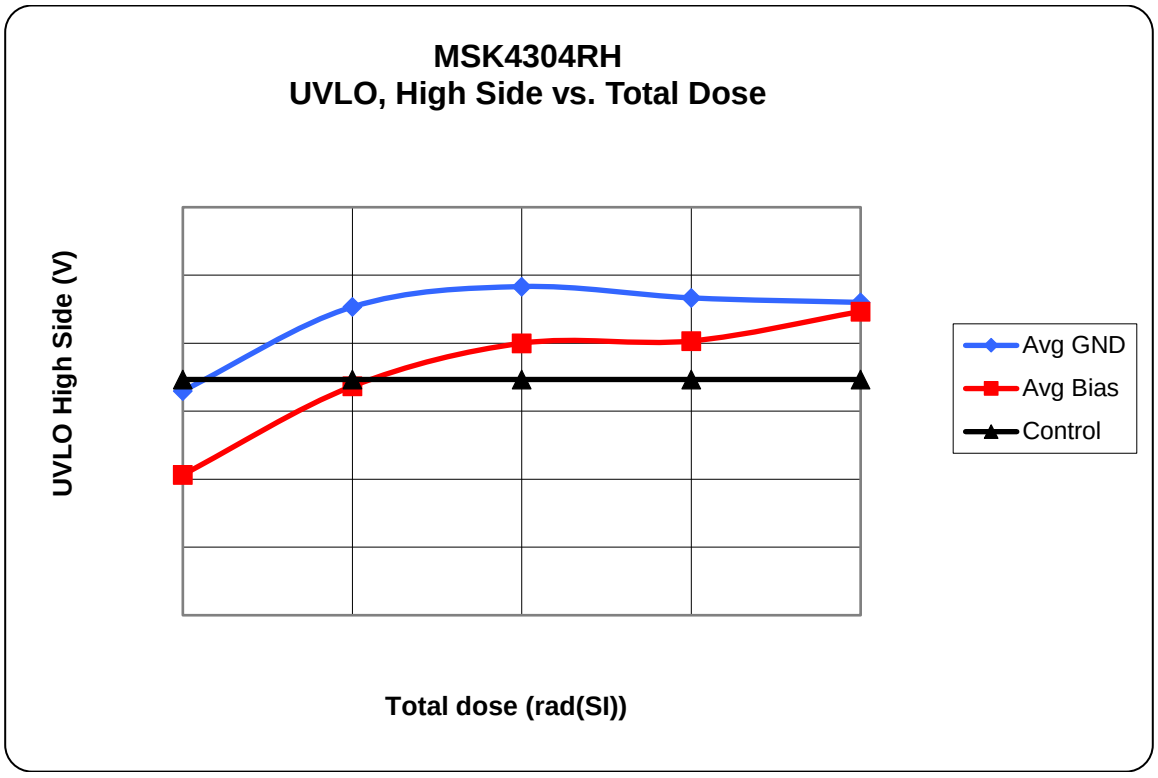
Table 1

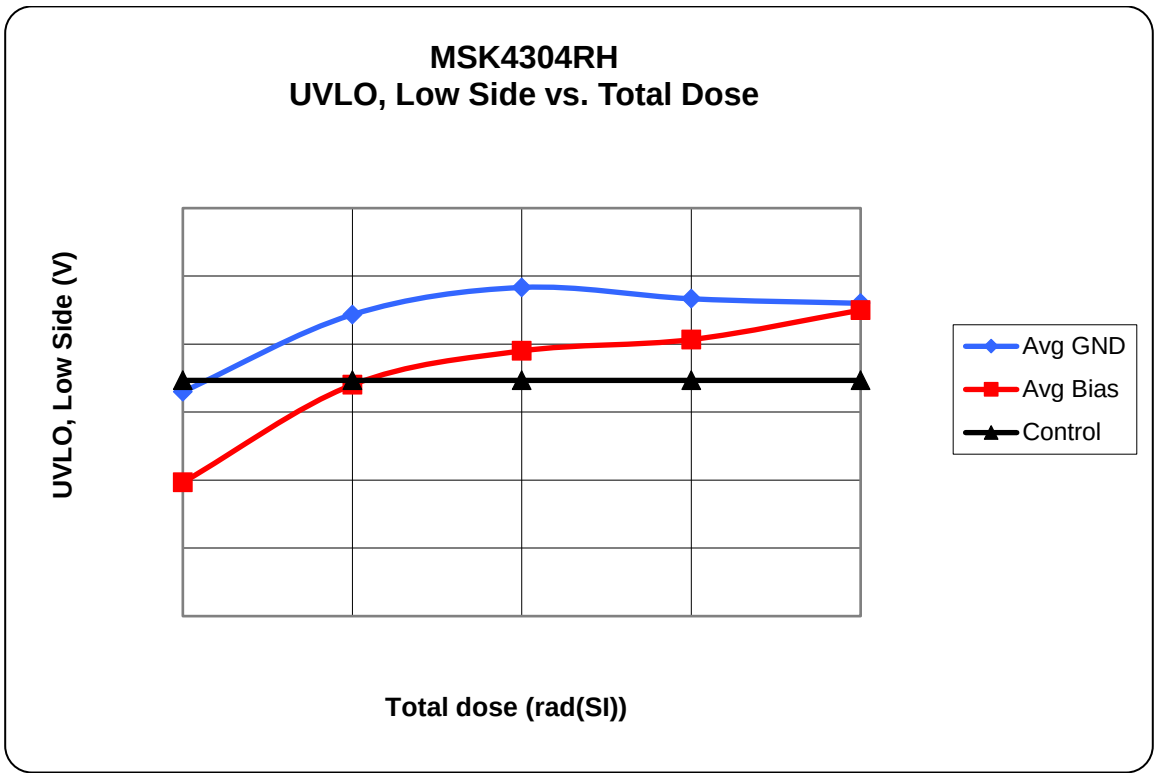
Dose Time, Incremental Dose and Total Cumulative Dose

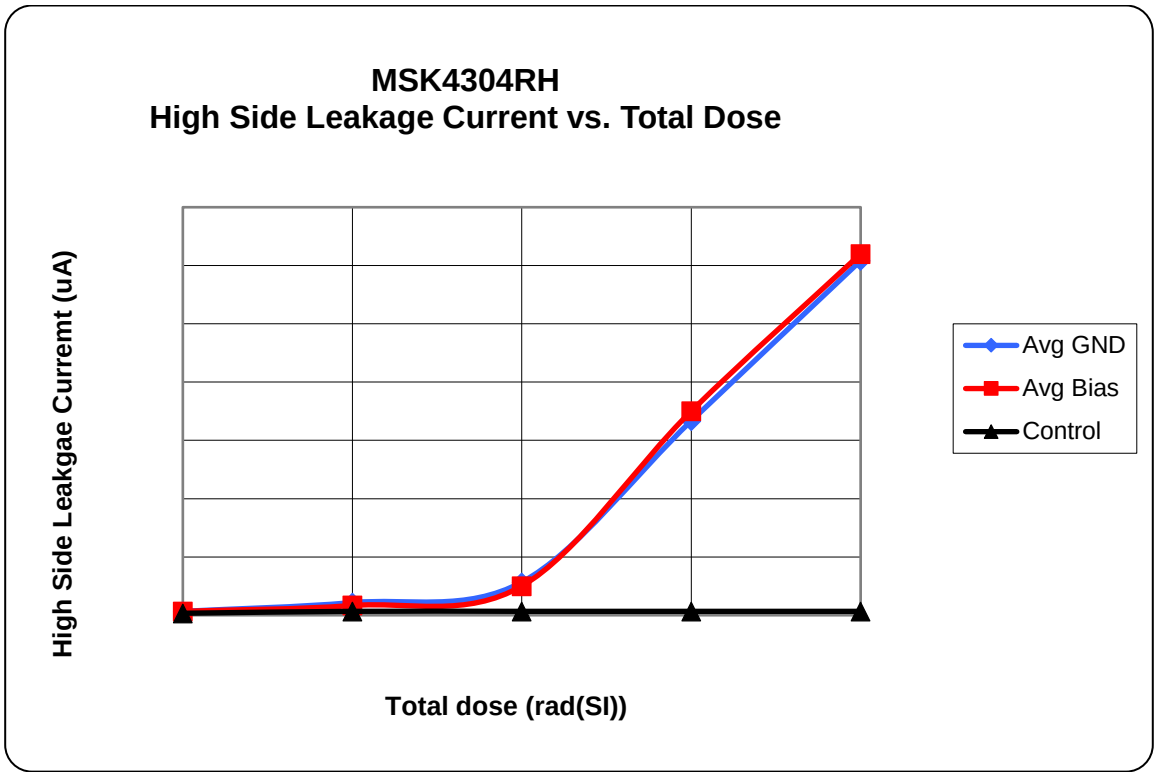

MSK4304RH
+VCC Supply Current vs. Total Dose
+VCC Supply Current (mA)
Total dose (rad(SI))
Avg GND
Avg Bias
Control

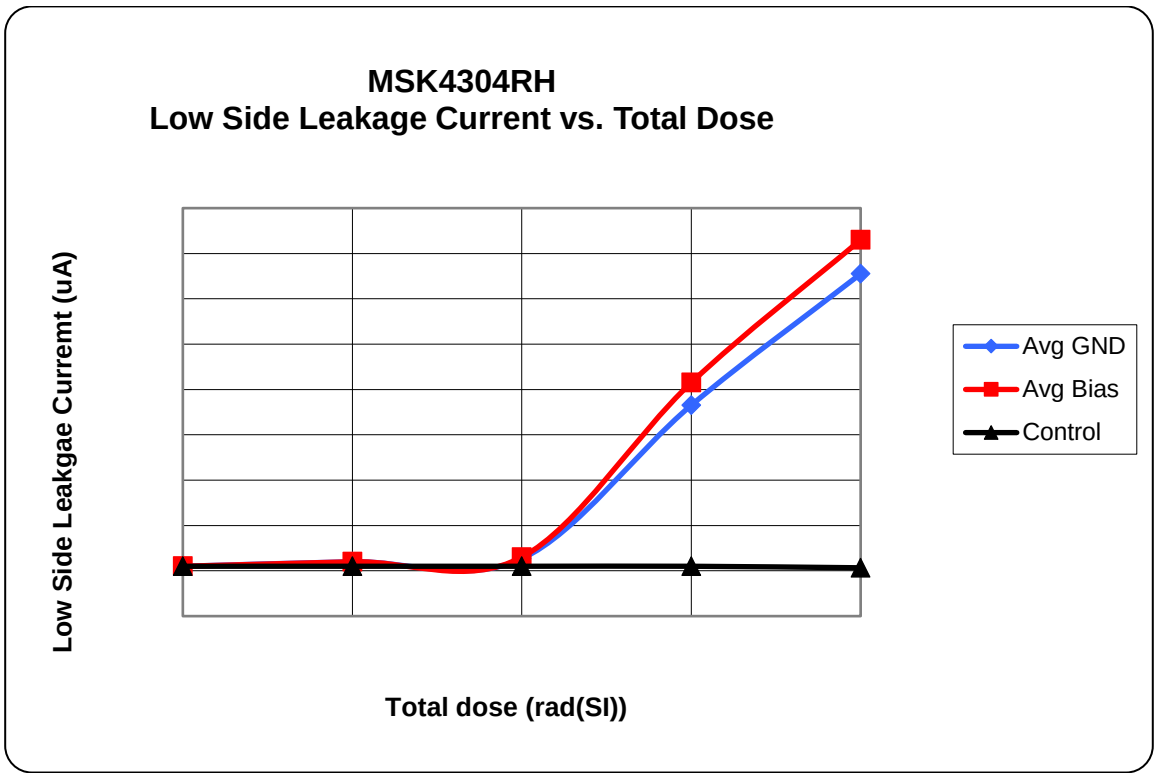

MSK4304RH
+VB Supply Current vs. Total Dose
+VB Supply Current (mA)
Total dose (rad(SI))
Avg GND
Avg Bias
Control

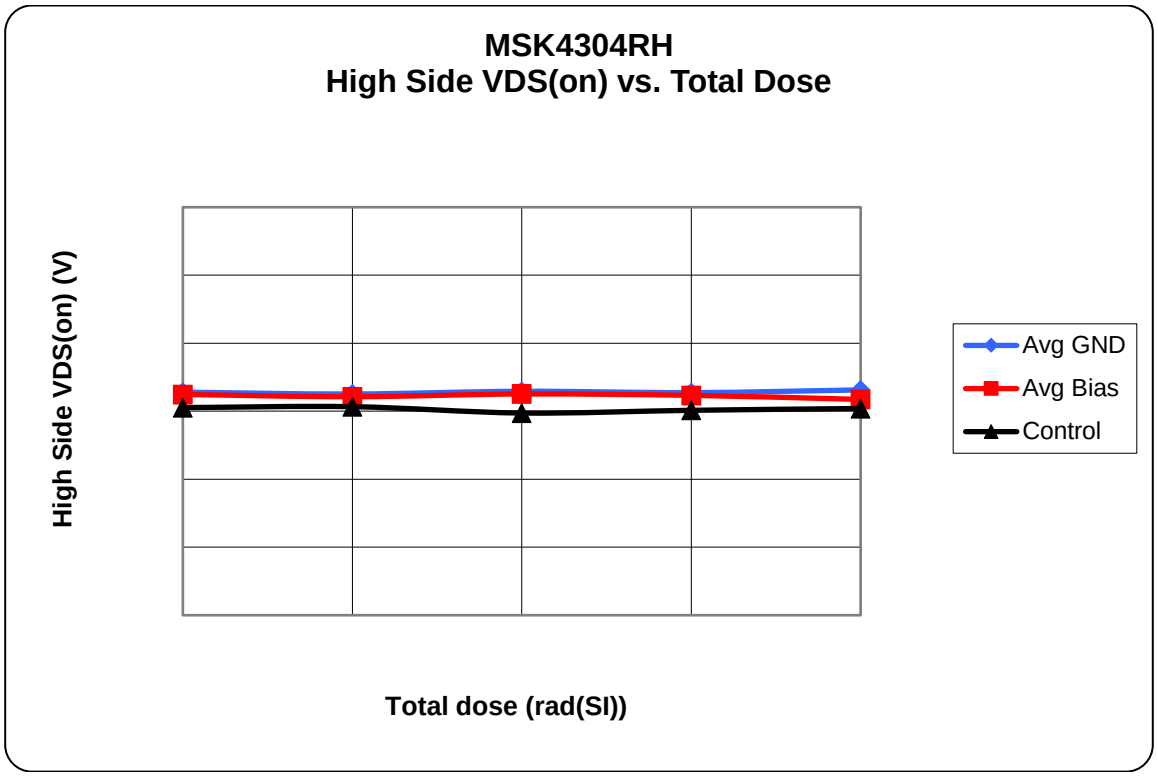

MSK4304RH
+VDD Supply Current vs. Total Dose
+VDD Supply Current (mA)
Total dose (rad(SI))
Avg GND
Avg Bias
Control

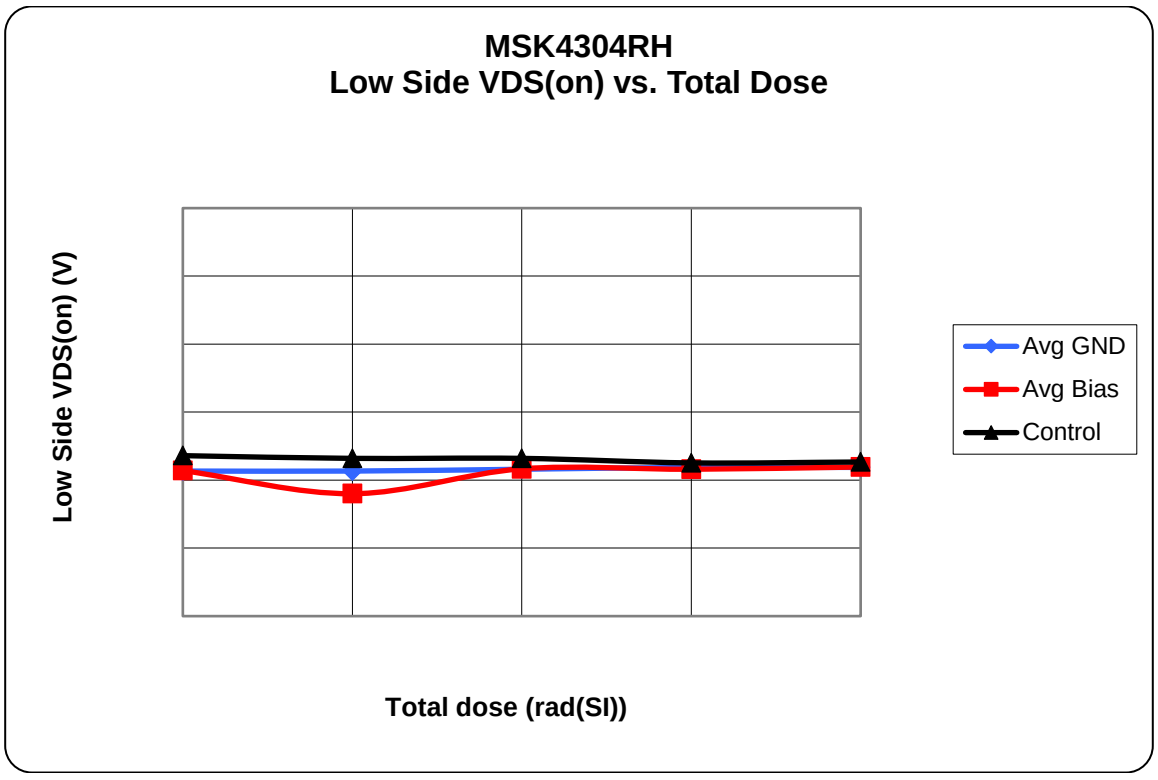

MSK4304RH
UVLO, High Side vs. Total Dose
UVLO High Side (V)
Total dose (rad(SI))
Avg GND
Avg Bias
Control

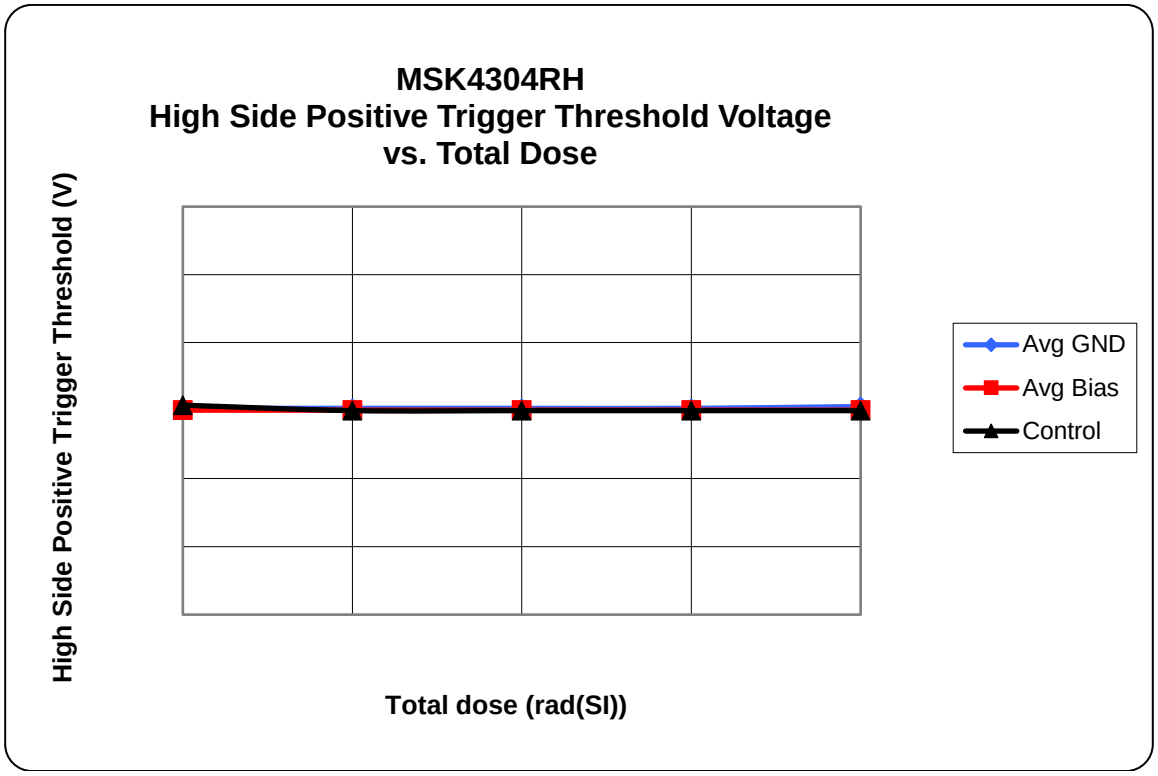

MSK4304RH
UVLO, Low Side vs. Total Dose
UVLO, Low Side (V)
Total dose (rad(SI))
Avg GND
Avg Bias
Control

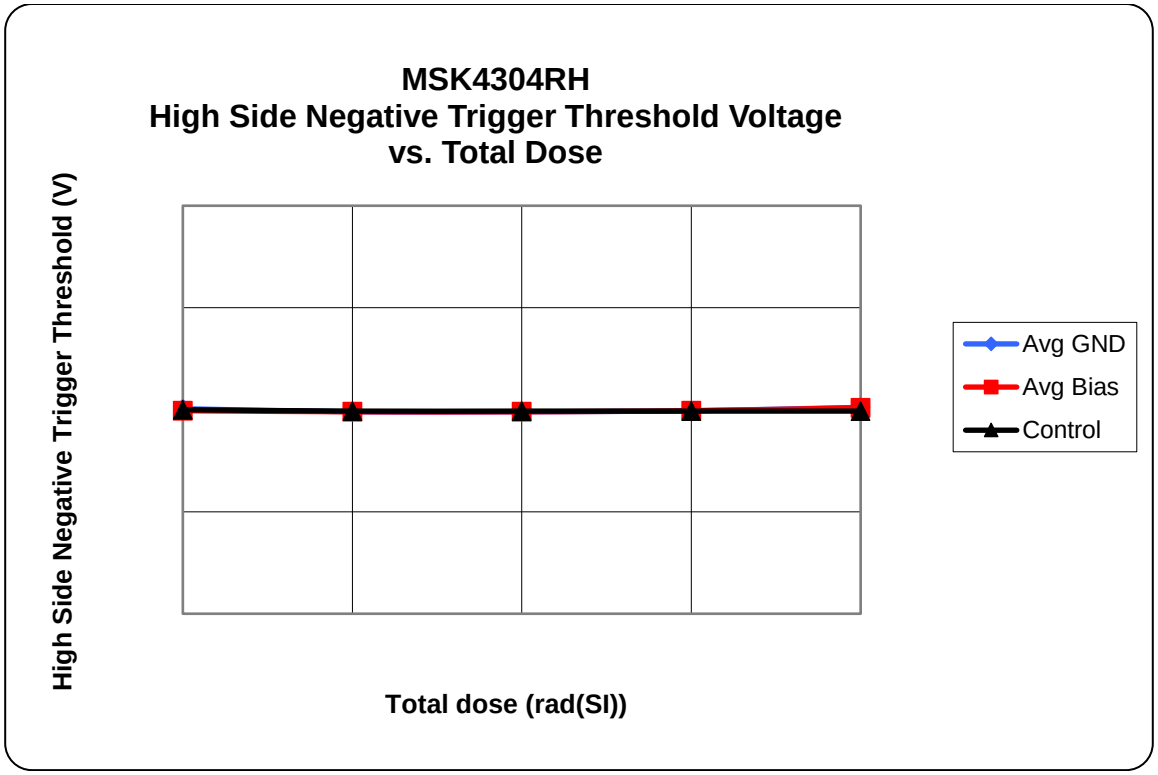

MSK4304RH
High Side Leakage Current vs. Total Dose
High Side Leakgae Curremt (uA)
Total dose (rad(SI))
Avg GND
Avg Bias
Control

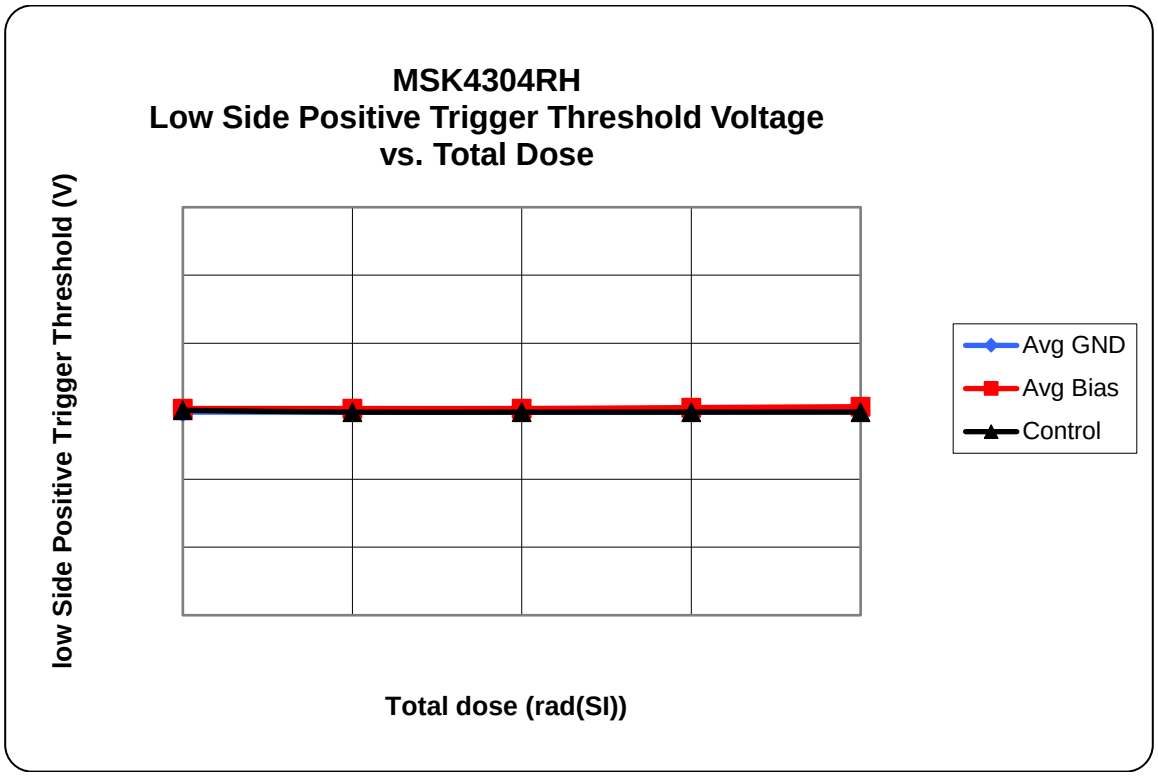

MSK4304RH
Low Side Leakage Current vs. Total Dose
Low Side Leakgae Curremt (uA)
Total dose (rad(SI))
Avg GND
Avg Bias
Control

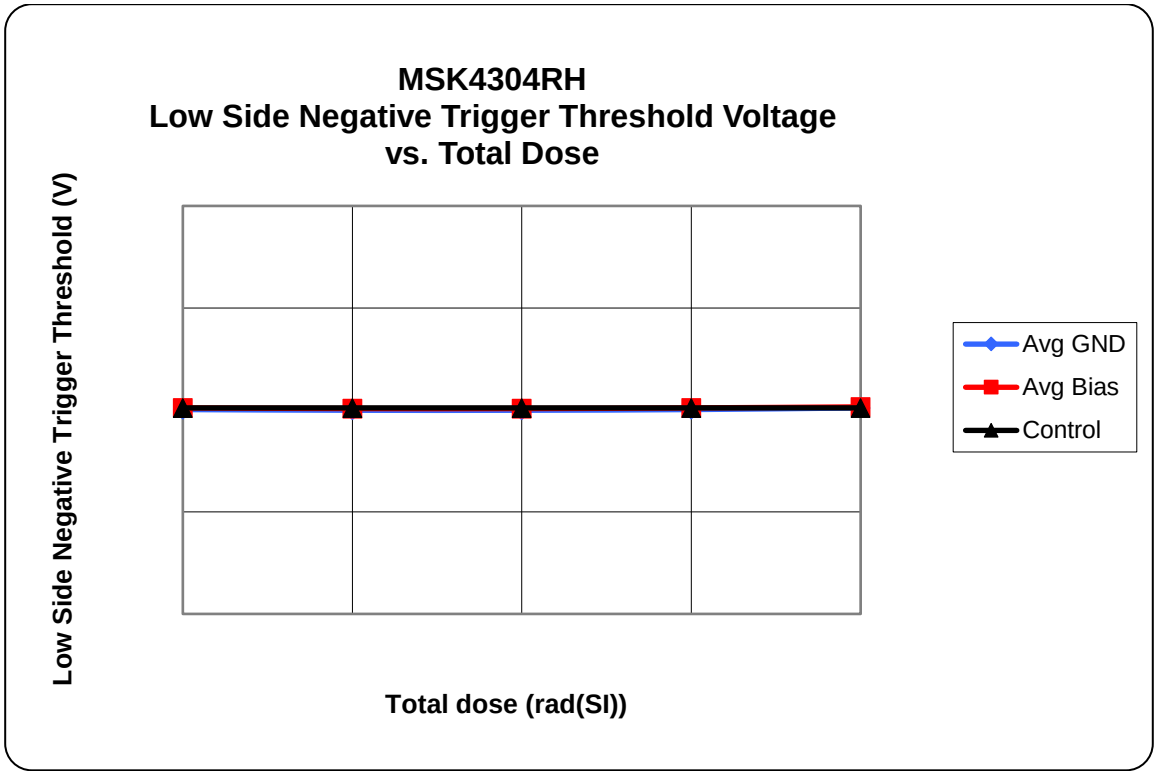

MSK4304RH
High Side VDS(on) vs. Total Dose
High Side VDS(on) (V)
Total dose (rad(SI))
Avg GND
Avg Bias
Control

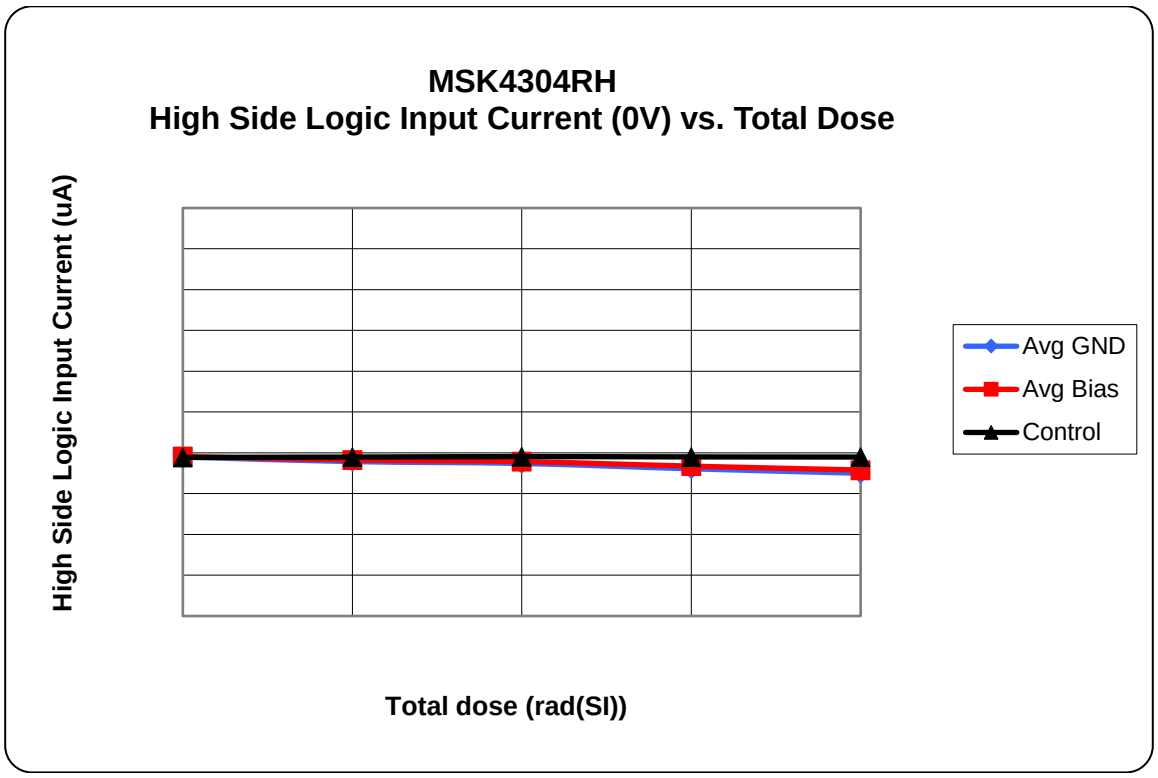

MSK4304RH
Low Side VDS(on) vs. Total Dose
Low Side VDS(on) (V)
Total dose (rad(SI))
Avg GND
Avg Bias
Control

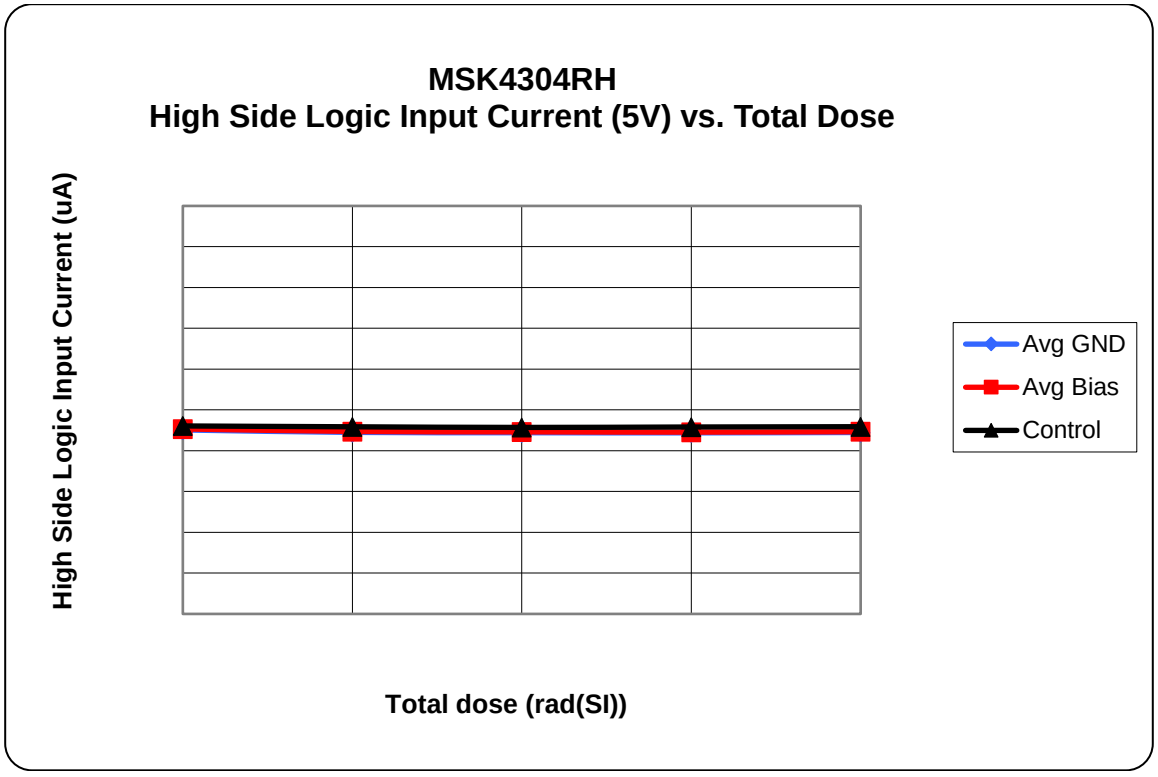

MSK4304RH
High Side Positive Trigger Threshold Voltage
vs. Total Dose
High Side Positive Trigger Threshold (V)
Total dose (rad(Si))
Avg GND
Avg Bias
Control

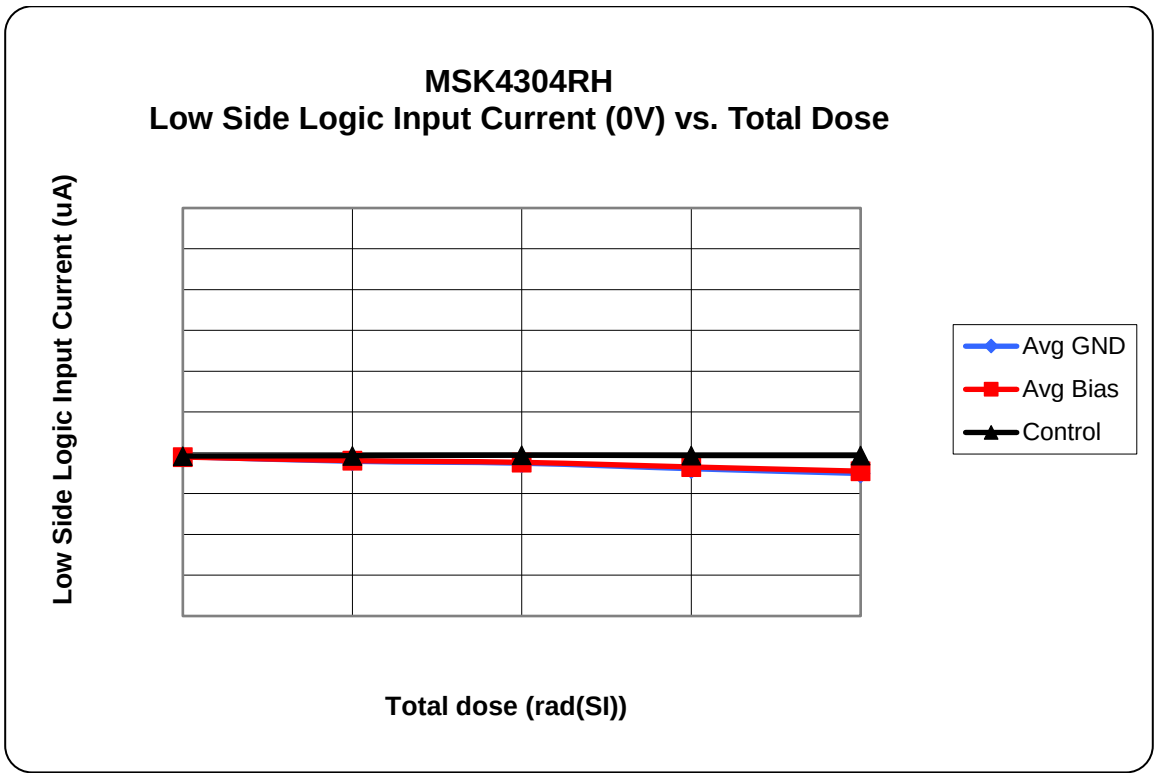

MSK4304RH
High Side Negative Trigger Threshold Voltage
vs. Total Dose
High Side Negative Trigger Threshold (V)
Total dose (rad(Si))
Avg GND
Avg Bias
Control

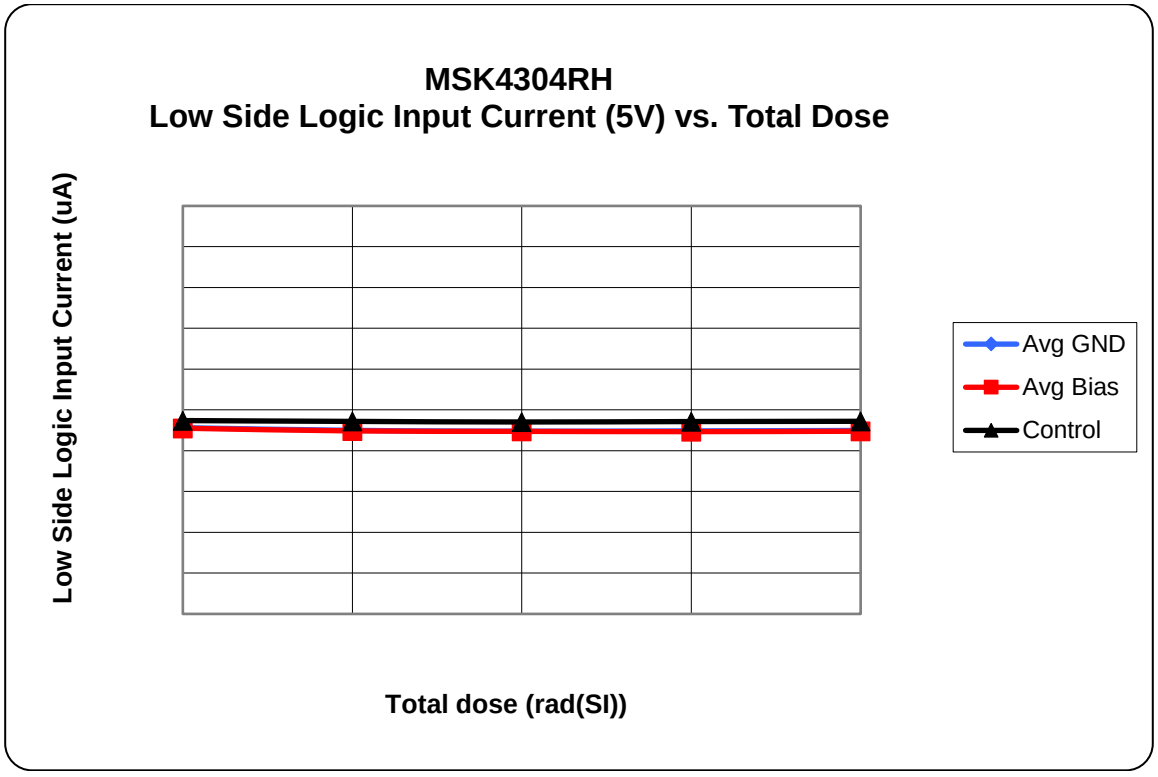

MSK4304RH
Low Side Positive Trigger Threshold Voltage
vs. Total Dose
low Side Positive Trigger Threshold (V)
Total dose (rad(SI))
Avg GND
Avg Bias
Control


MSK4304RH
Low Side Negative Trigger Threshold Voltage
vs. Total Dose
Low Side Negative Trigger Threshold (V)
Total dose (rad(SI))
Avg GND
Avg Bias
Control


MSK4304RH
High Side Logic Input Current (0V) vs. Total Dose
High Side Logic Input Current (uA)
Total dose (rad(SI))
Avg GND
Avg Bias
Control


MSK4304RH
High Side Logic Input Current (5V) vs. Total Dose
High Side Logic Input Current (uA)
Total dose (rad(SI))
Avg GND
Avg Bias
Control


MSK4304RH
Low Side Logic Input Current (0V) vs. Total Dose
Low Side Logic Input Current (uA)
Total dose (rad(SI))
Avg GND
Avg Bias
Control


MSK4304RH
Low Side Logic Input Current (5V) vs. Total Dose
Low Side Logic Input Current (uA)
Total dose (rad(SI))
Avg GND
Avg Bias
Control

Total Dose Radiation Test Report

MSK 4304RH

3 - Phase Motor Drive Hybrid

June 14, 2007

J. Douglas
B. Erwin

M.S. Kennedy Corporation
Liverpool, NY

I. Introduction:

The total dose radiation test plan for the MSK 4304RH was developed to qualify the device as a radiation tolerant device to 300 Krad(Si). The testing was performed up to 450 Krad to show trends in device performance as a function of total dose.

MIL-STD-883 Method 1019.7 and ASTM F1892-98 were used as guidelines in the development and implementation of the total dose test plan for the MSK 4304RH.

II. Radiation Source:

Total dose was performed at the University of Massachusetts, Lowell, using a cobalt 60 radiation source. Alanine dosimetry was performed and the dose rate was determined to be 118 Rads(Si)/sec. The total dose schedule can be found in Table I.

III. Test Setup:

All test samples were subjected to Group A Electrical Test in accordance with MSK4304RH Electrical Test Procedure 1702-12750 Rev -. In addition, all devices received 320 hours of burn-in per MIL-STD-883 Method 1015 and were electrically tested prior to irradiation. For test platform verification, one control device was tested at 25°C.

The devices were vertically aligned with the radiation source and enclosed in a lead/aluminum container during irradiation. Four devices were kept under bias during irradiation. Four devices had all leads grounded during irradiation for the unbiased condition.

After each irradiation the device leads were held electrically common and the devices were transported to the MSK electrical test platform and tested IAW the MSK 4304RH Electrical Test Procedure 1702-12750 Rev -. Testing was performed on irradiated devices, as well as the control device, at each total dose level. Electrical tests were completed within one hour of irradiation.

IV. Data:

All performance curves are averaged from the test results of the biased and unbiased devices respectively.

V. Summary:

Based on the test data recorded during radiation testing, the MSK 4304RH qualified as a 300 Krad(Si) radiation tolerant device. All test parameters stayed within specification up to and beyond 450 Krad(Si) TID.

Dosimetry Equipment: Bruker Biospin #0141

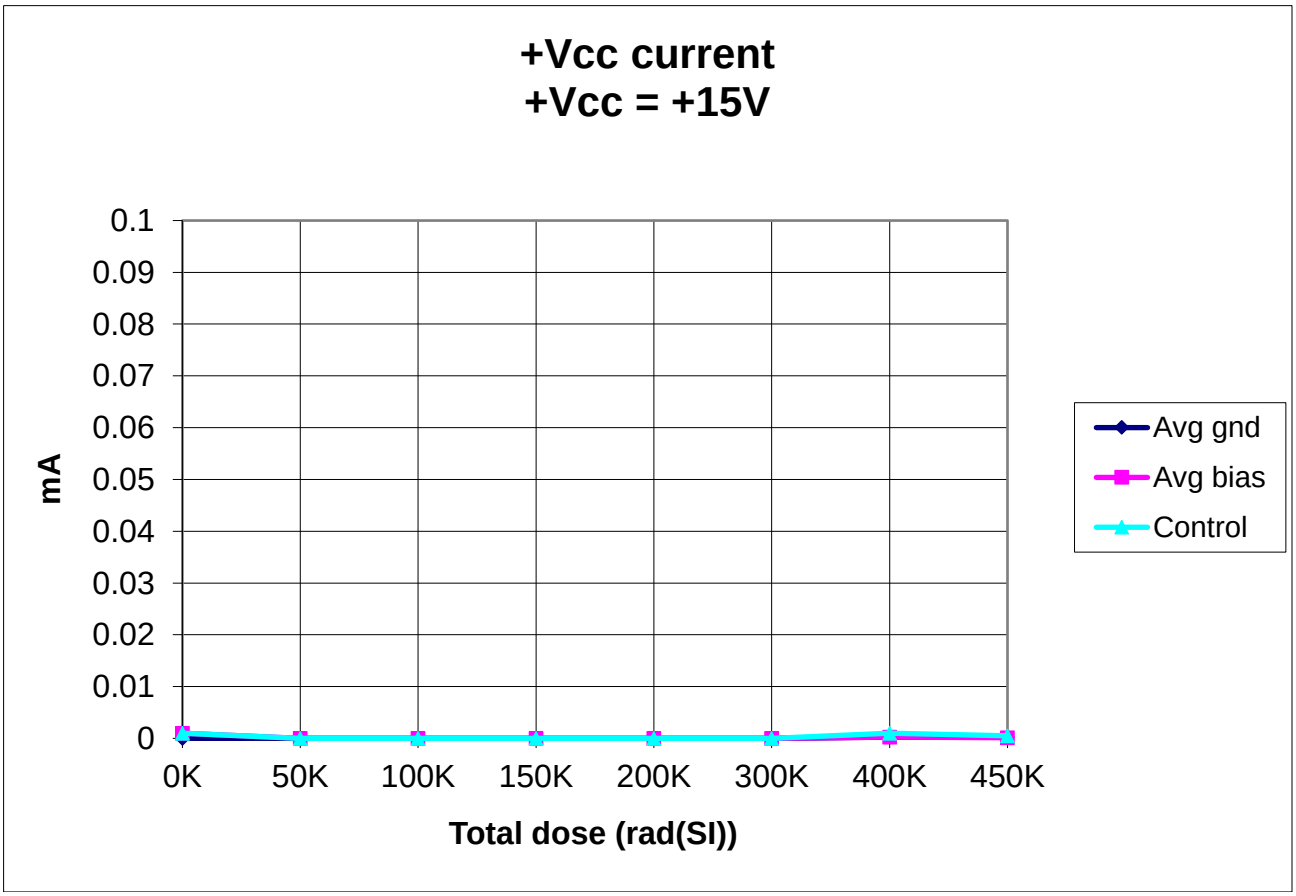
Dose Rate = 118 Rads(Si)/Sec
Device Date Code 0721

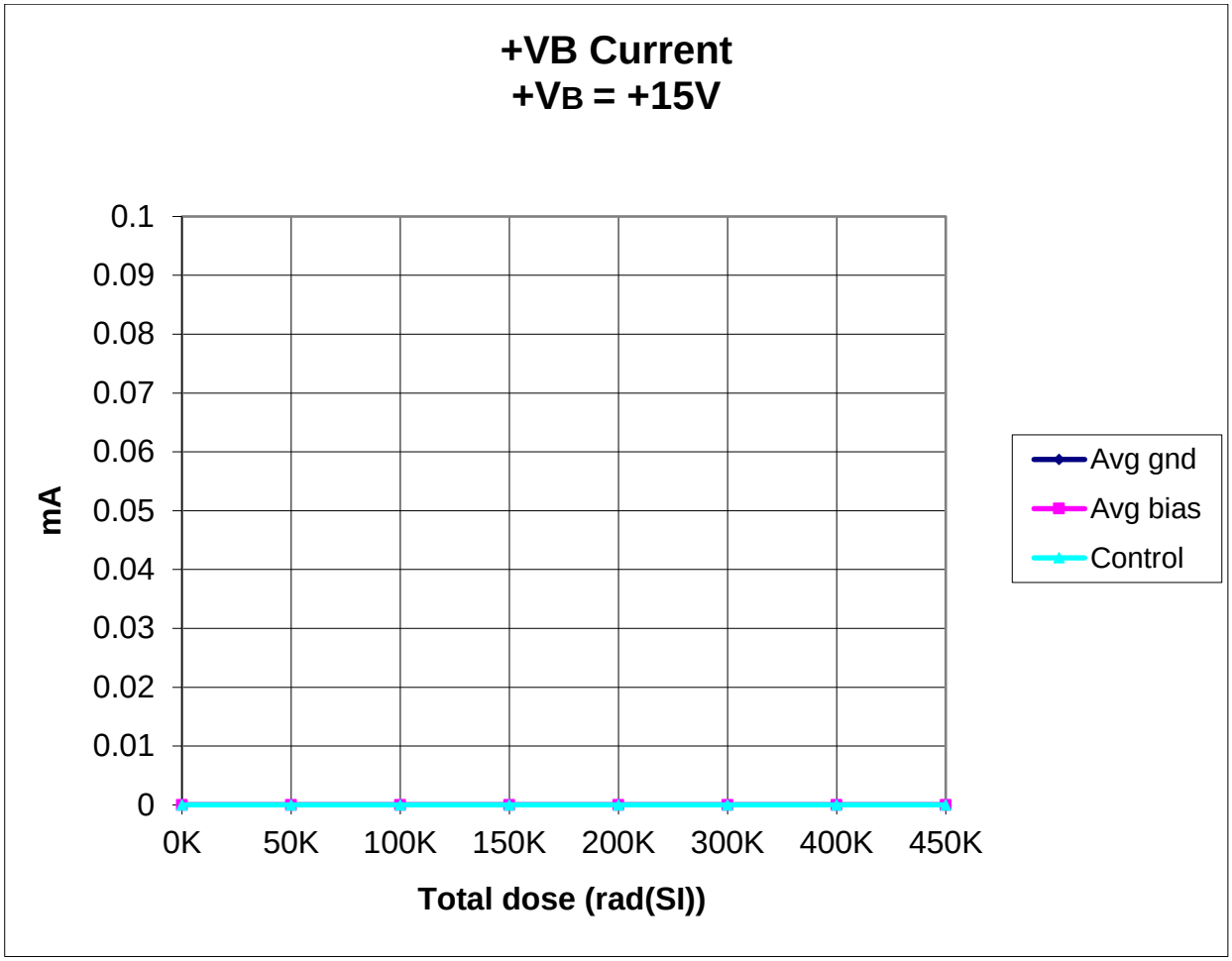
Testing Performed: 6/12/2007

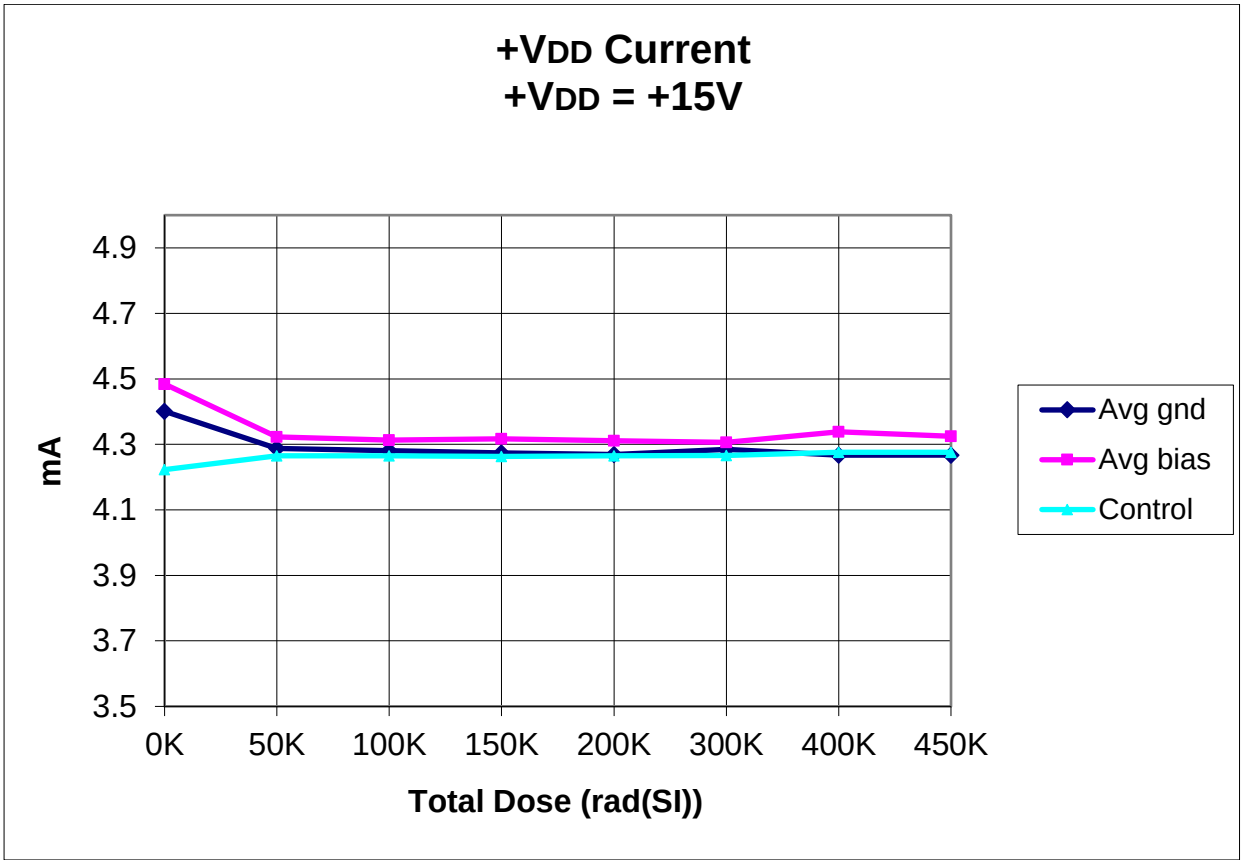
Board Identification MSK 4304 GND		
Exposure Length (min:sec)	Incremental Dose Rads(Si)	Cumulative Dose Rads(Si)
07:17	51,556	51,556
07:17	51,556	103,132
07:17	51,556	154,698
07:17	51,556	206,264
14:33	103,014	309,278
14:33	103,014	412,292
14:33	103,014	515,306
Serial #'s: 3645, 3646, 3647 & 3648		

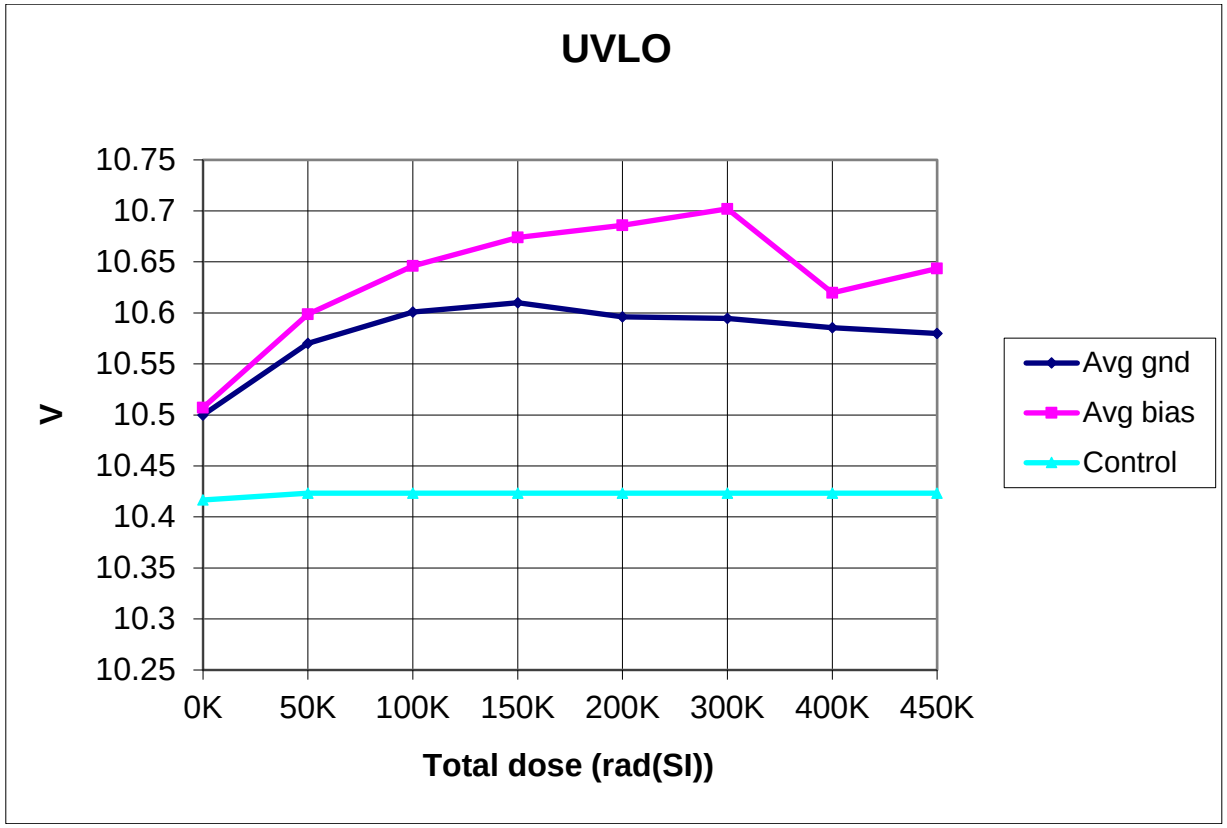
Board Identification 4304 BIAS		
Exposure Length (min:sec)	Incremental Dose Rads(Si)	Cumulative Dose Rads(Si)
07:17	51,556	51,556
07:17	51,556	103,132
07:17	51,556	154,698
07:17	51,556	206,264
14:33	103,014	309,278
14:33	103,014	412,292
14:33	103,014	515,306
Serial #'s: 3650, 3651, 3652 & 3654		

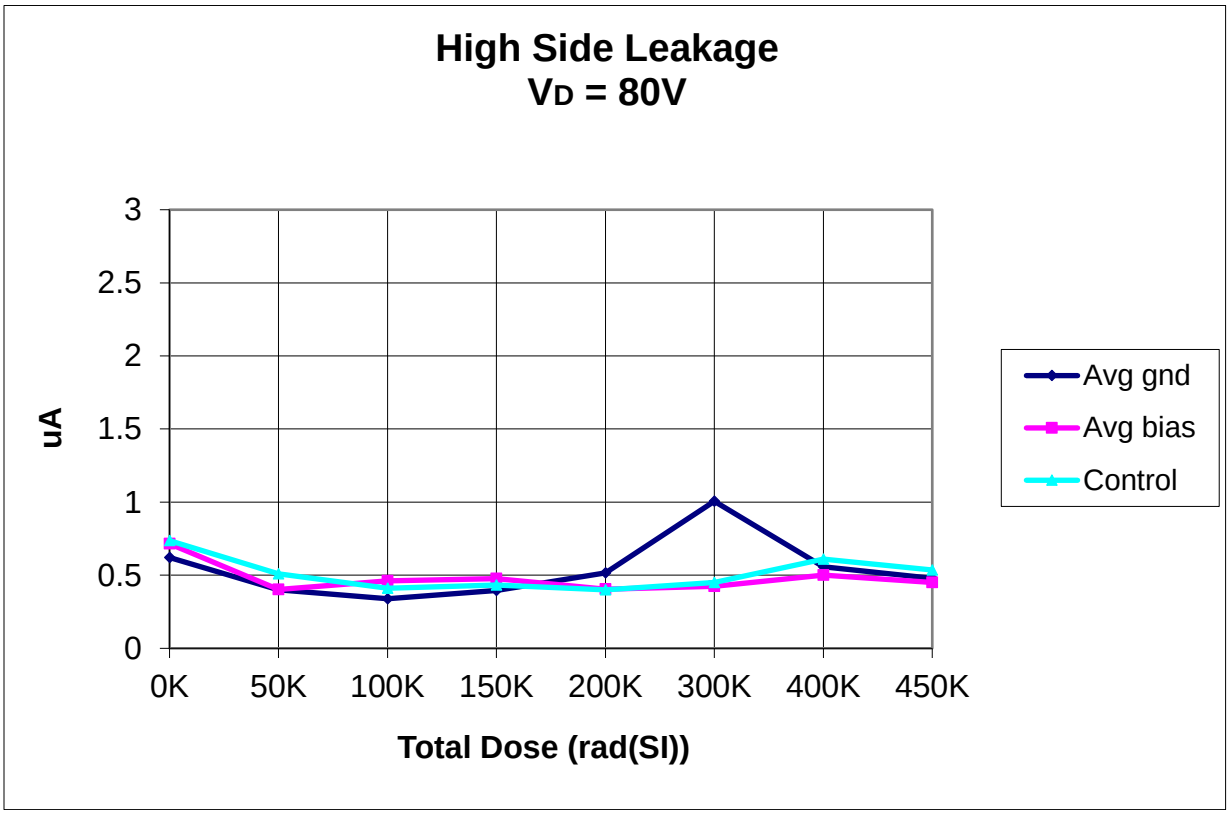
Table I
Dose Time, Incremental Dose and Total Cumulative Dos

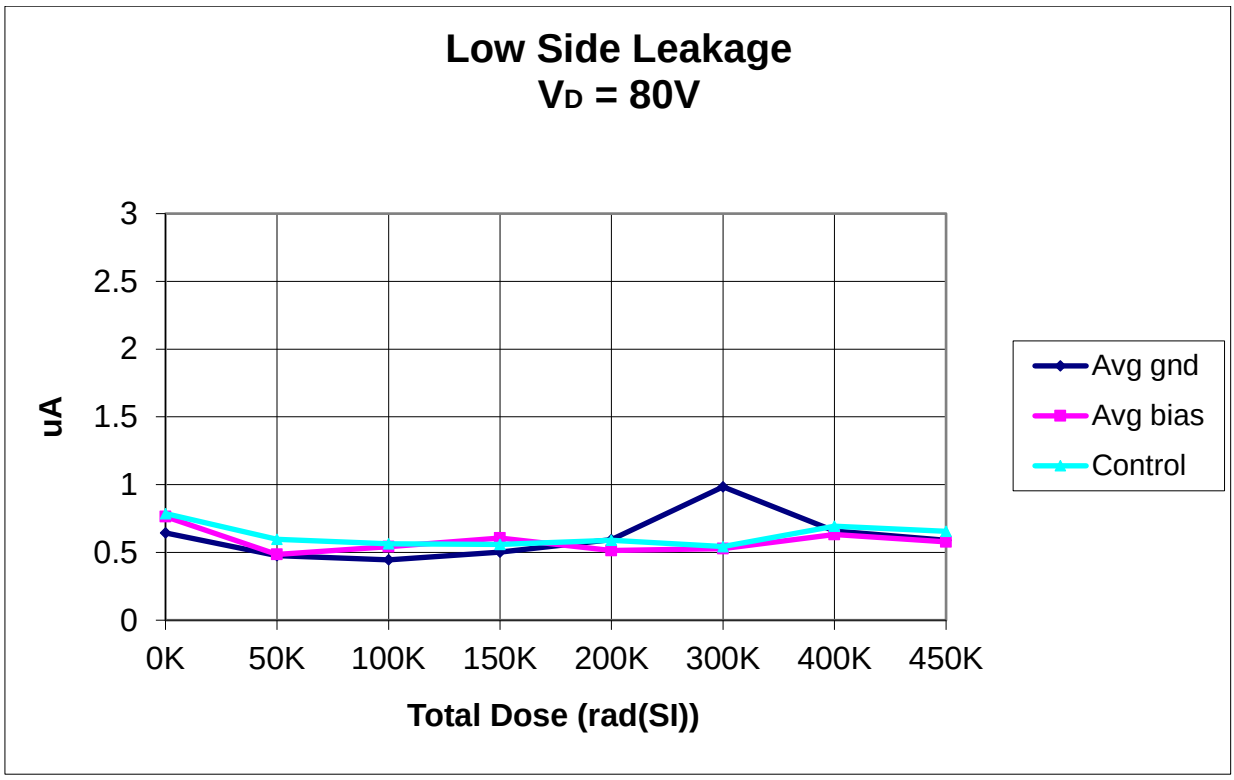


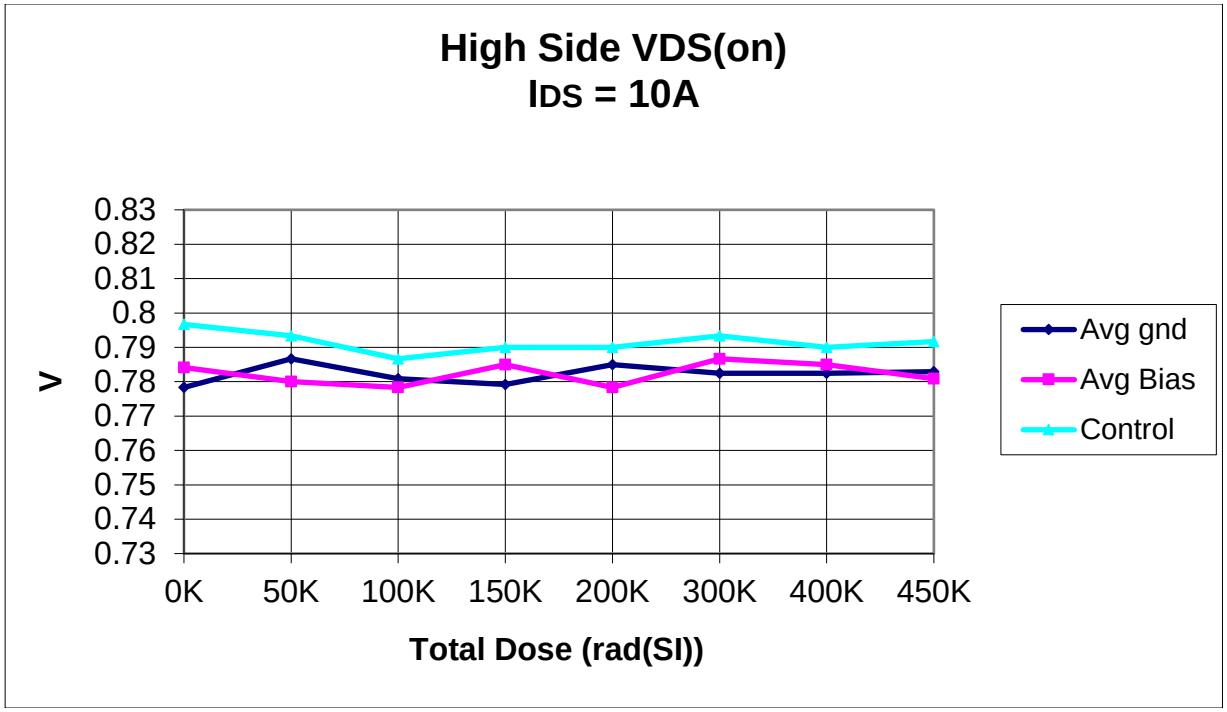

+VB Current
+VB = +15V
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
mA
0K
50K
100K
150K
200K
300K
400K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

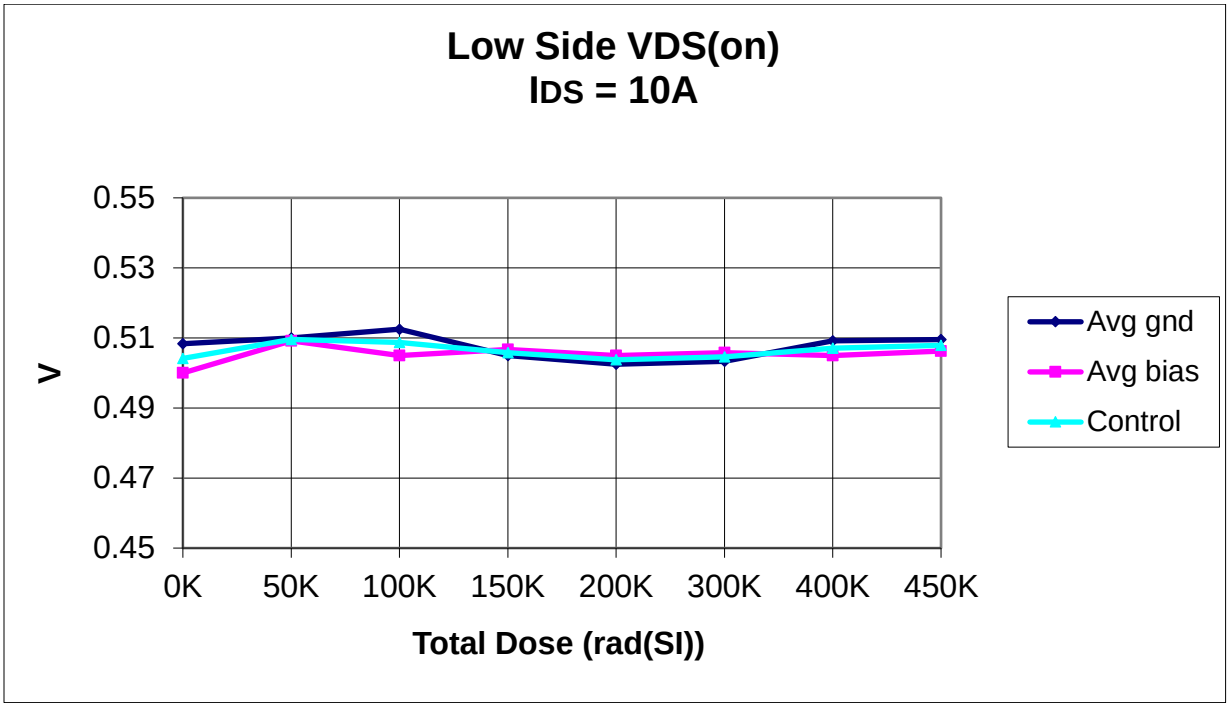

+VDD Current
+VDD = +15V
4.9
4.7
4.5
4.3
4.1
3.9
3.7
3.5
mA
0K
50K
100K
150K
200K
300K
400K
450K
Total Dose (rad(Si))
Avg gnd
Avg bias
Control

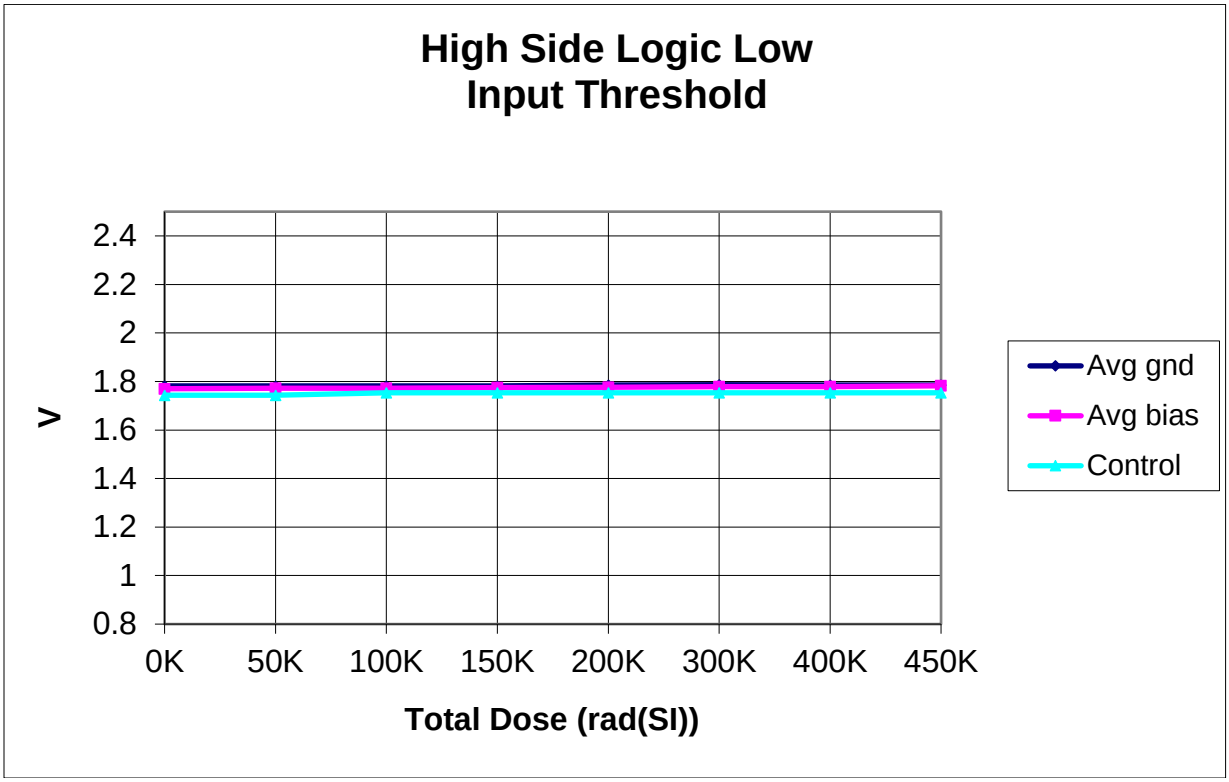

UVLO
10.75
10.7
10.65
10.6
10.55
10.5
10.45
10.4
10.35
10.3
10.25
V
0K
50K
100K
150K
200K
300K
400K
450K
Total dose (rad(SI))
Avg gnd
Avg bias
Control

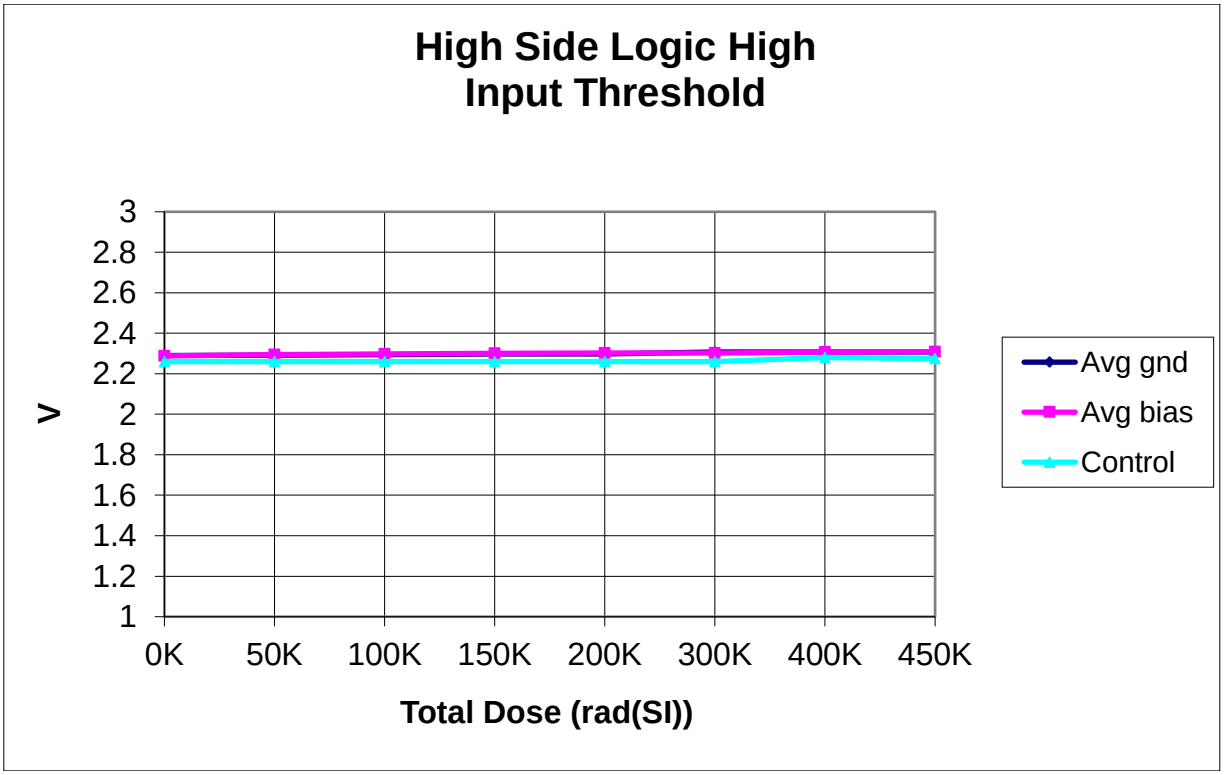

High Side Leakage
VD = 80V
3
2.5
2
1.5
1
0.5
0
uA
0K
50K
100K
150K
200K
300K
400K
450K
Total Dose (rad(SI))
Avg gnd
Avg bias
Control

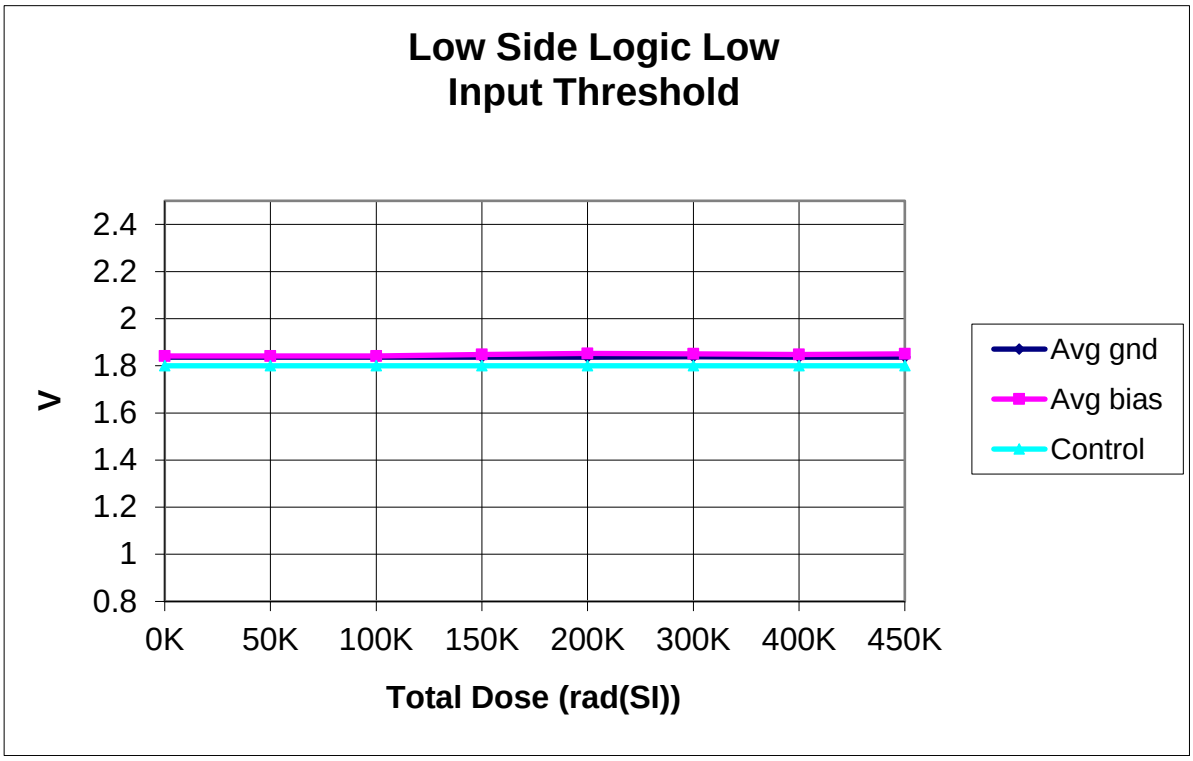

Low Side Leakage
VD = 80V
uA
3
2.5
2
1.5
1
0.5
0
0K
50K
100K
150K
200K
300K
400K
450K
Total Dose (rad(SI))
Avg gnd
Avg bias
Control

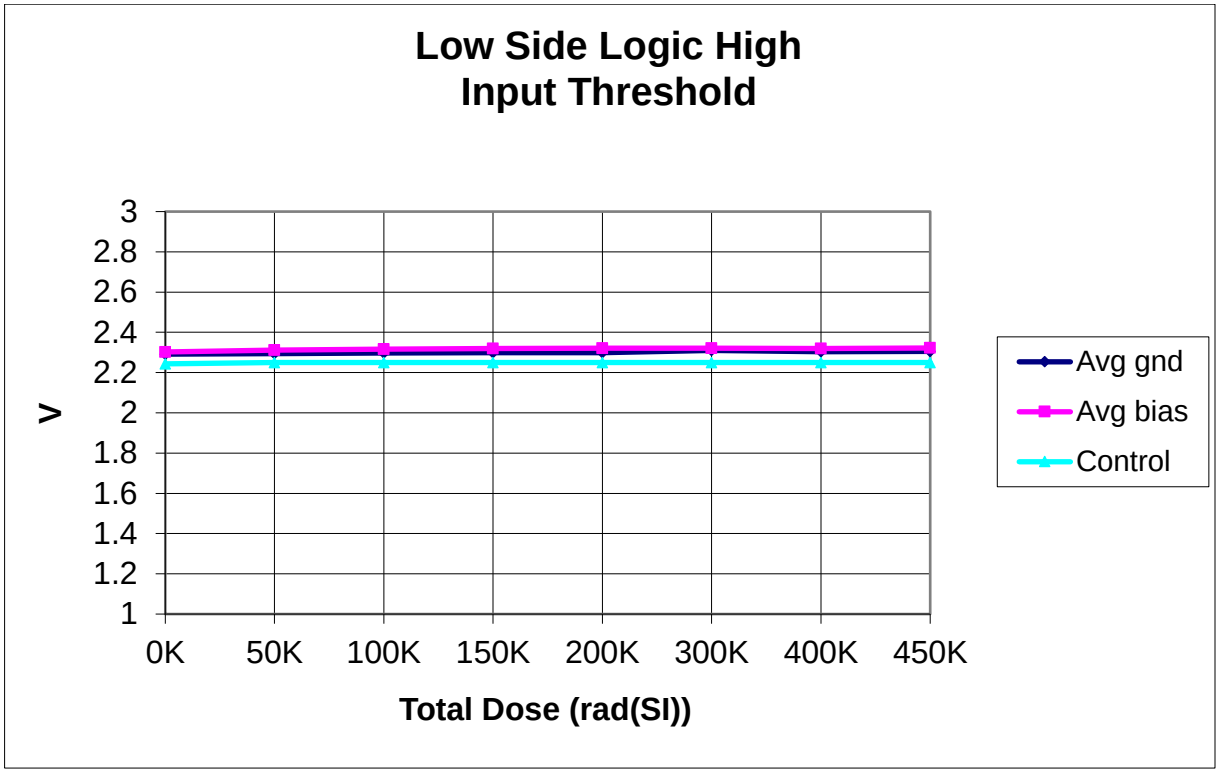

High Side VDS(on)
IDS = 10A
V
0.83
0.82
0.81
0.8
0.79
0.78
0.77
0.76
0.75
0.74
0.73
0K
50K
100K
150K
200K
300K
400K
450K
Total Dose (rad(SI))
Avg gnd
Avg Bias
Control

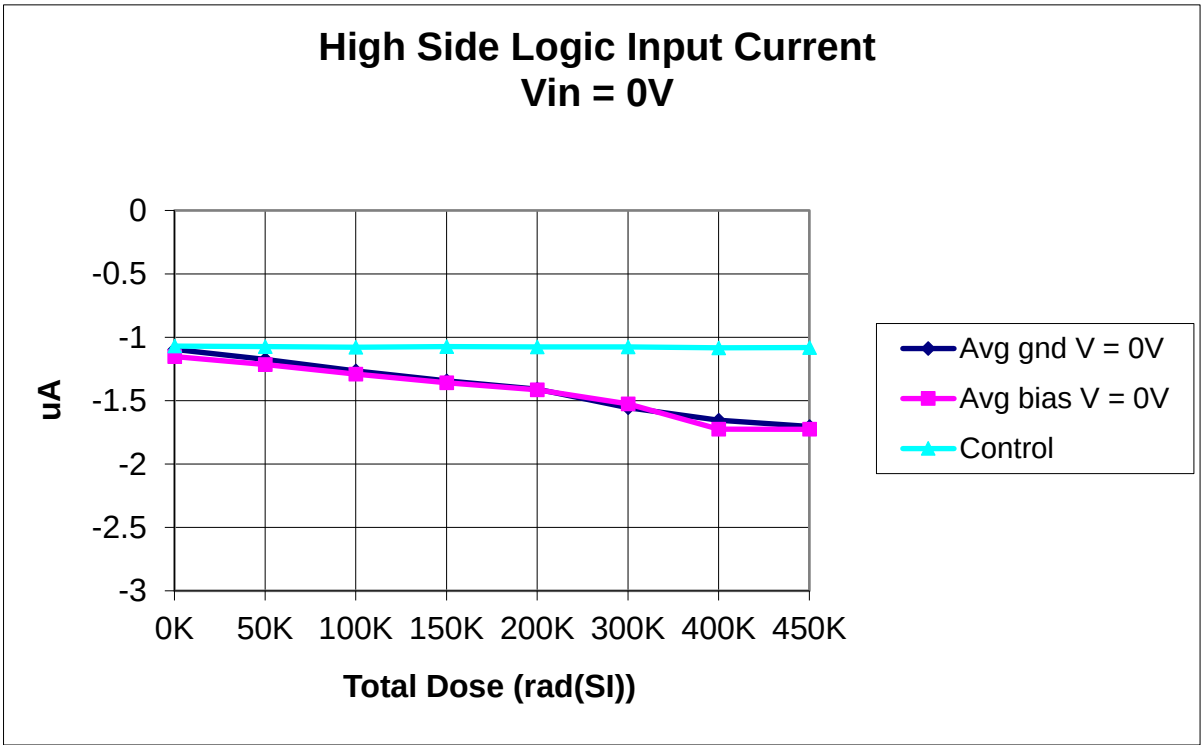

Low Side VDS(on)
IDS = 10A
0.55
0.53
0.51
0.49
0.47
0.45
V
0K
50K
100K
150K
200K
300K
400K
450K
Total Dose (rad(Si))
Avg gnd
Avg bias
Control

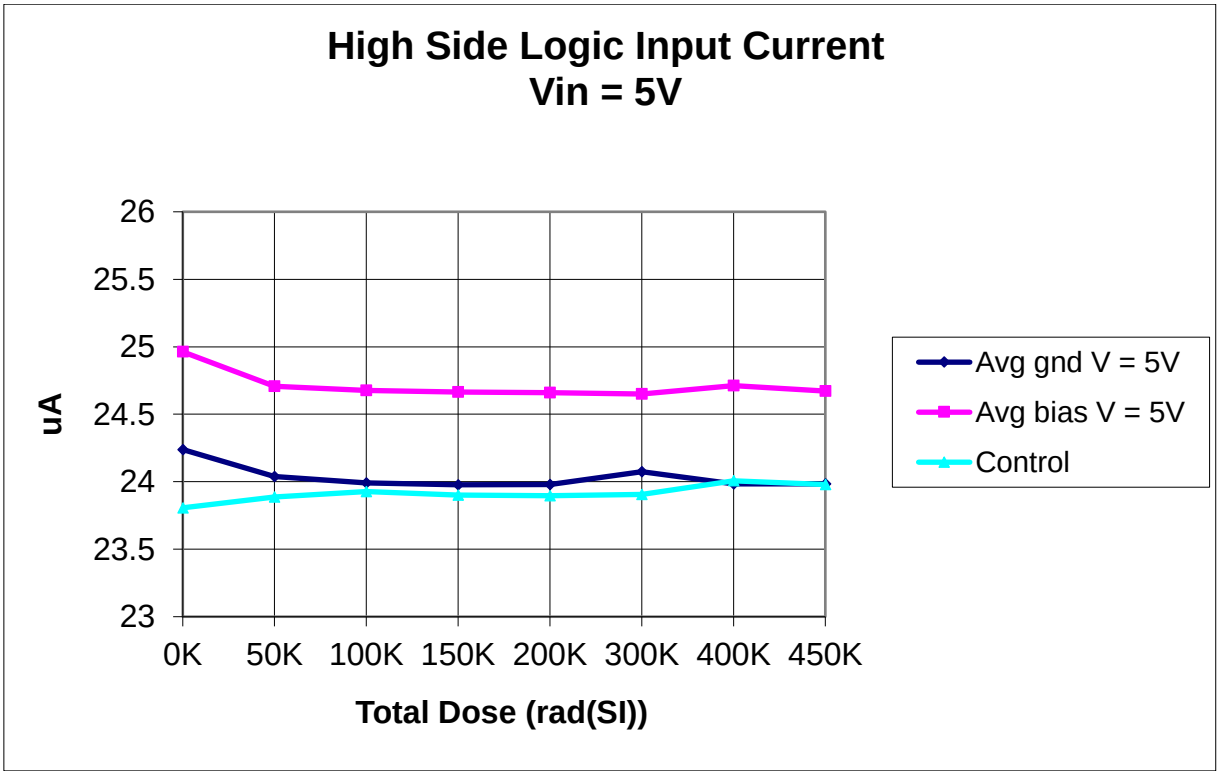

High Side Logic Low
Input Threshold
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
V
0K
50K
100K
150K
200K
300K
400K
450K
Total Dose (rad(Si))
Avg gnd
Avg bias
Control

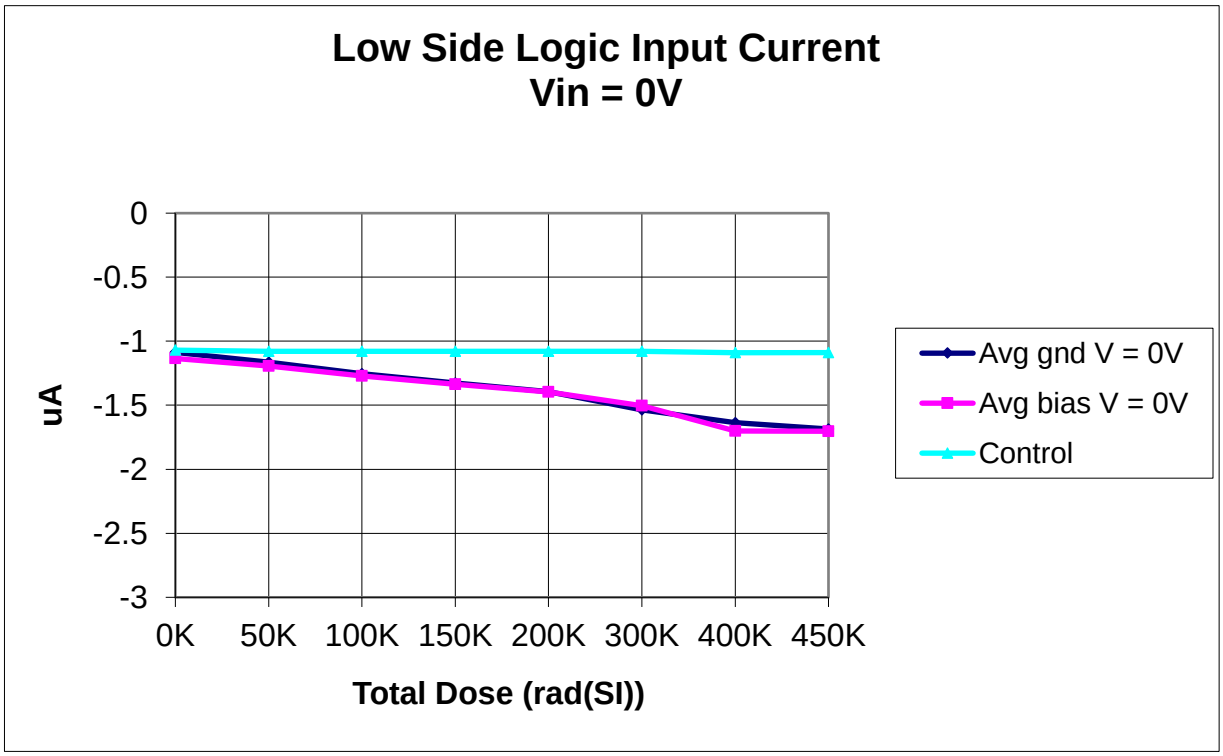

High Side Logic High
Input Threshold
V
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0K
50K
100K
150K
200K
300K
400K
450K
Total Dose (rad(Si))
Avg gnd
Avg bias
Control

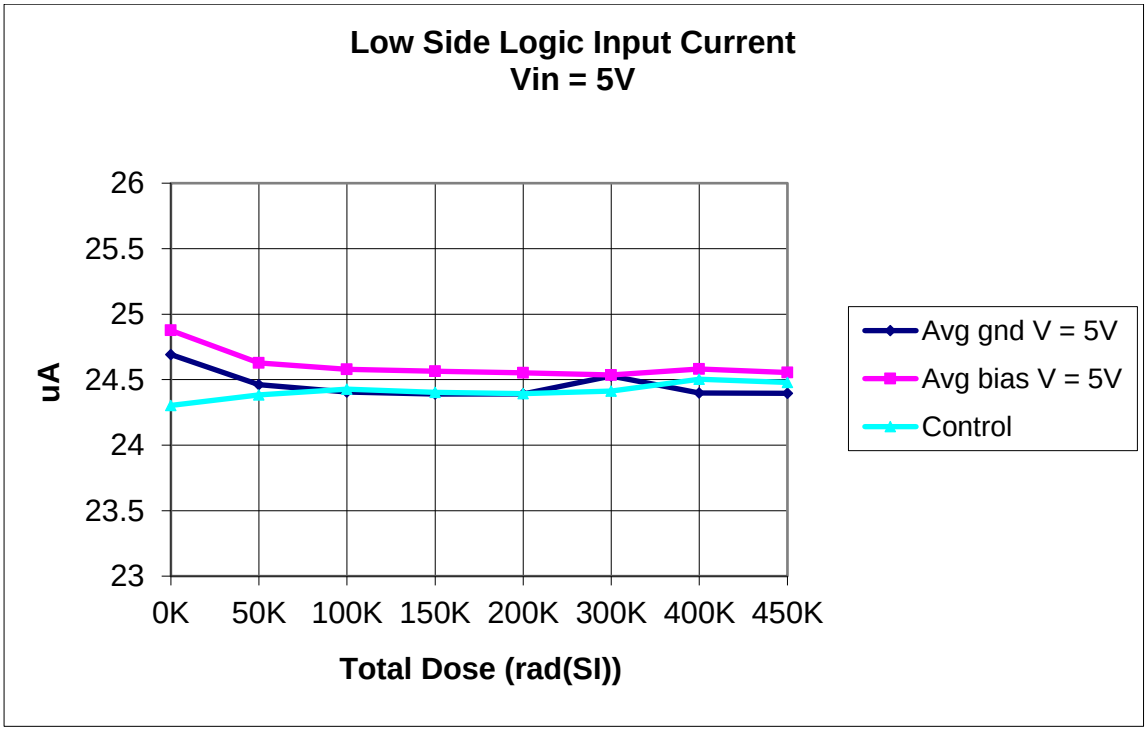

Low Side Logic Low
Input Threshold
V
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0K
50K
100K
150K
200K
300K
400K
450K
Total Dose (rad(Si))
Avg gnd
Avg bias
Control


Low Side Logic High
Input Threshold
V
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0K
50K
100K
150K
200K
300K
400K
450K
Total Dose (rad(Si))
Avg gnd
Avg bias
Control


High Side Logic Input Current
Vin = 0V
uA
0
-0.5
-1
-1.5
-2
-2.5
-3
0K
50K
100K
150K
200K
300K
400K
450K
Total Dose (rad(Si))
Avg gnd V = 0V
Avg bias V = 0V
Control


High Side Logic Input Current
Vin = 5V
uA
26
25.5
25
24.5
24
23.5
23
0K
50K
100K
150K
200K
300K
400K
450K
Total Dose (rad(Si))
Avg gnd V = 5V
Avg bias V = 5V
Control


Low Side Logic Input Current
Vin = 0V
uA
0
-0.5
-1
-1.5
-2
-2.5
-3
0K
50K
100K
150K
200K
300K
400K
450K
Total Dose (rad(Si))
Avg gnd V = 0V
Avg bias V = 0V
Control


Low Side Logic Input Current
Vin = 5V
uA
26
25.5
25
24.5
24
23.5
23
0K
50K
100K
150K
200K
300K
400K
450K
Total Dose (rad(Si))
Avg gnd V = 5V
Avg bias V = 5V
Control