Total Dose Radiation Test Report

MSK5059RH

Rad Hard 4.5A, 500 KHz Step Down Switching Regulator Controller

November 22, 2010 (TID – First Test)
March 4, 2011 (TID - Updated)
June, 2011 (ELDRS Test)
June 17, 2011 (TID – Second Test)
June 17, 2011 (TID – Third Test)
May 25, 2018 (TID, Forth Test Wafer Lot: W1309259.1 Wf#6)

N. Kresse
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Anaren, Inc – MSK Products

I. Introduction:

The total dose radiation test plan for the MSK5059RH was developed to qualify the devices as RAD Hard to 100 KRads(Si). The testing was performed beyond 100 KRads(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 MSK5059RH.

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 121.3 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 the device data sheet. In addition, all devices received 160 hours minimum of burn-in per MIL-STD-883 Method 1015. For test platform verification, two control devices were tested at 25°C. Ten 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. Five devices were kept under bias during irradiation. An operating voltage of +15 Volts was used for the bias condition. Five 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 MSK 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 device, at each 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. If required, full test data can be obtained by contacting MSK Products – Anaren Inc.

V. Summary:

Based on the test data recorded during radiation testing and statistical analysis, the MSK5059RH qualified as a 100 Krad(Si) radiation hardened device. The Feedback Input Bias Current and Switching Frequency exhibited the most significant change with irradiation, however all performance curves stayed within specification up to 150 Krad(Si) TID.

MSK5059RH Biased/Unbiased Dose Rate Schedule

Dosimetry Equipment
Bruker Biospin # 0162

Irradiation Date
5/25/18

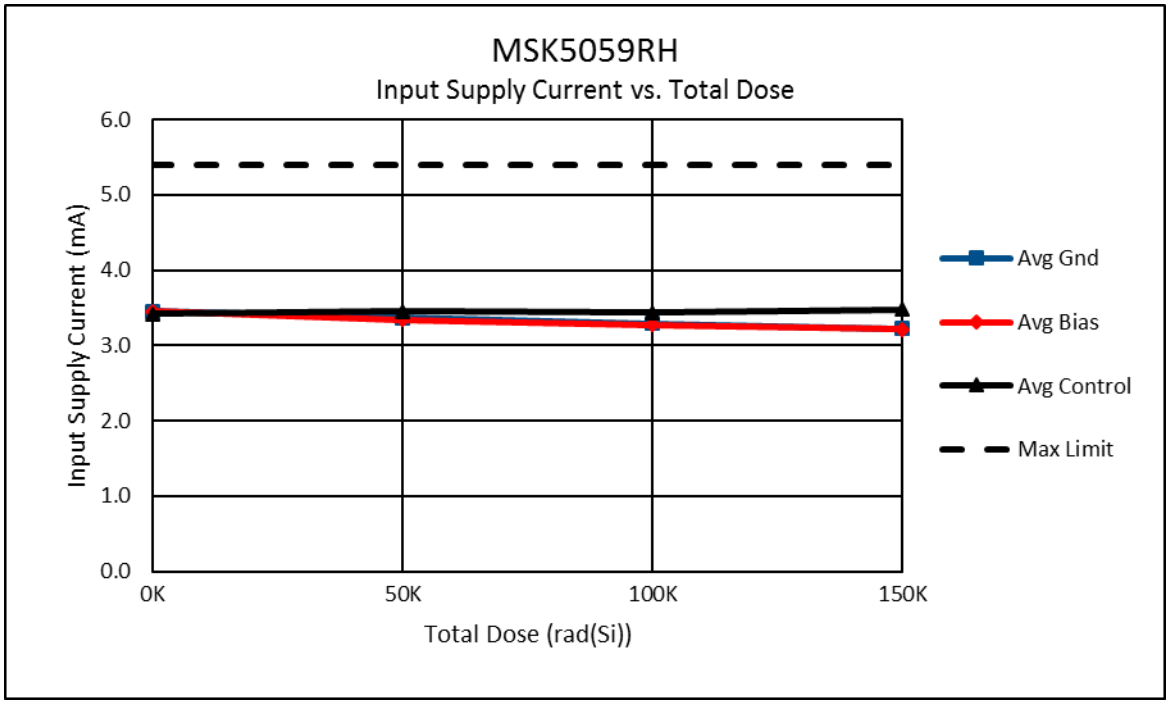
Exposure Length (min:sec)	Incremental Dose rads(Si)	Cumulative Dose rads(Si)
7:05	51,500	51,500
7:05	51,500	103,000
7:05	51,500	154,500

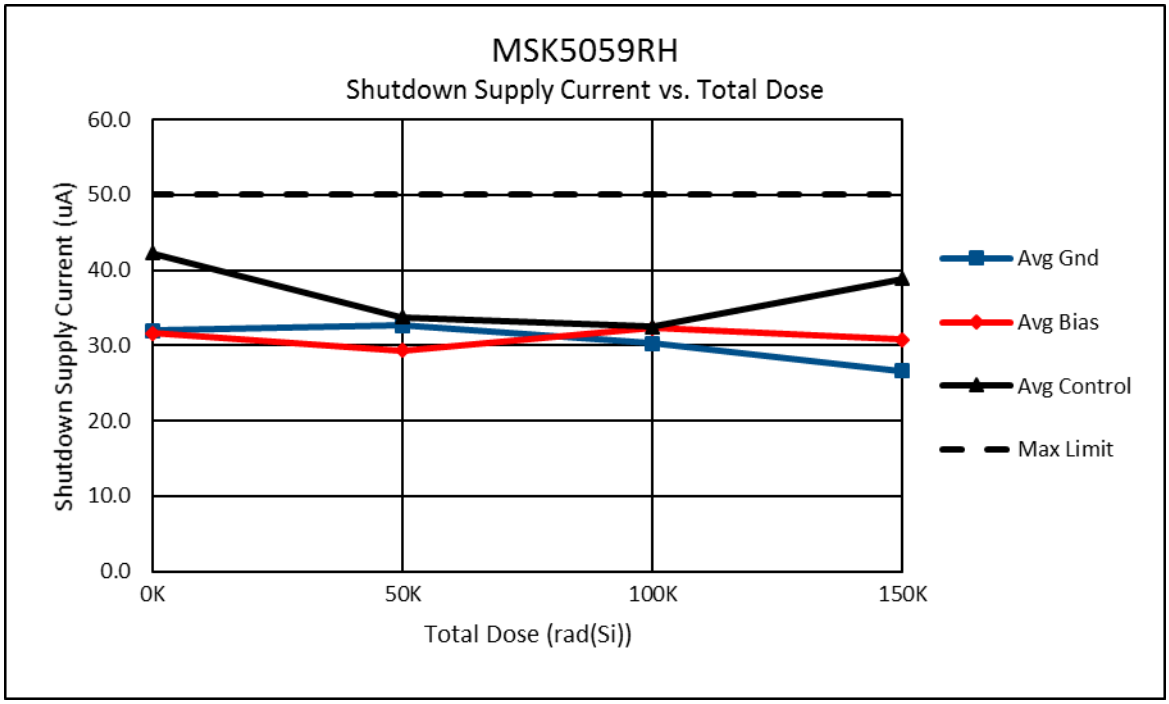
Biased S/N – 1748, 1749, 1750, 1751, 1752

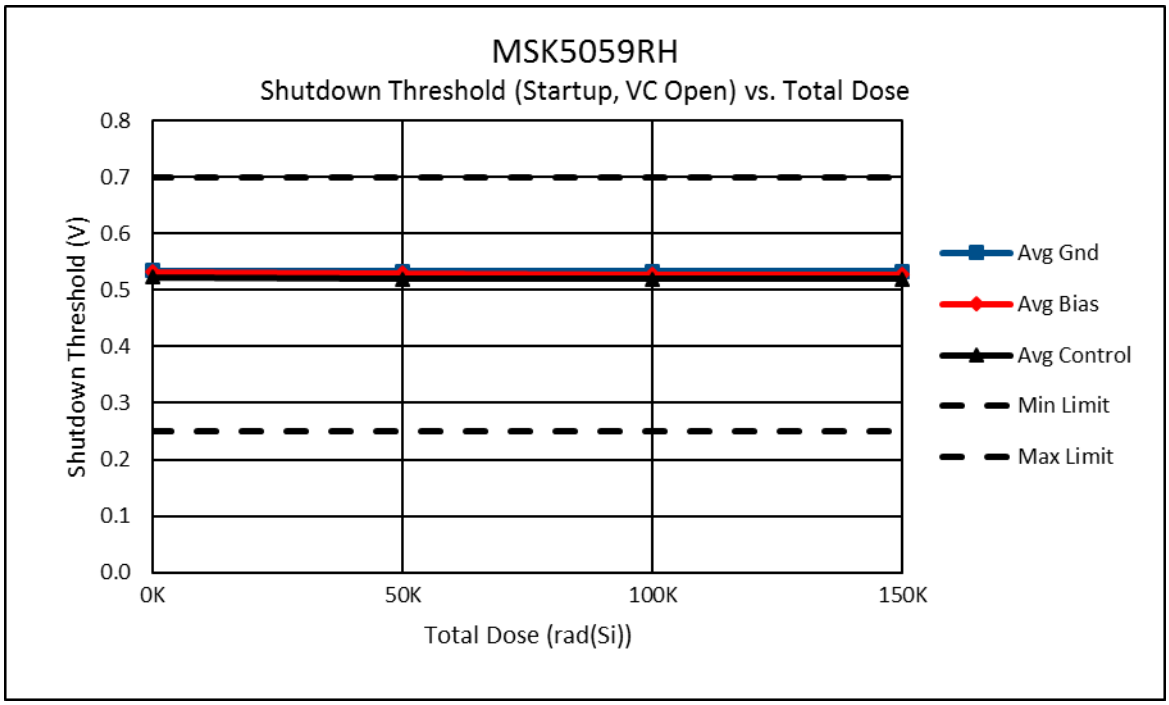
Unbiased S/N – 1753, 1754, 1755, 1756, 1757

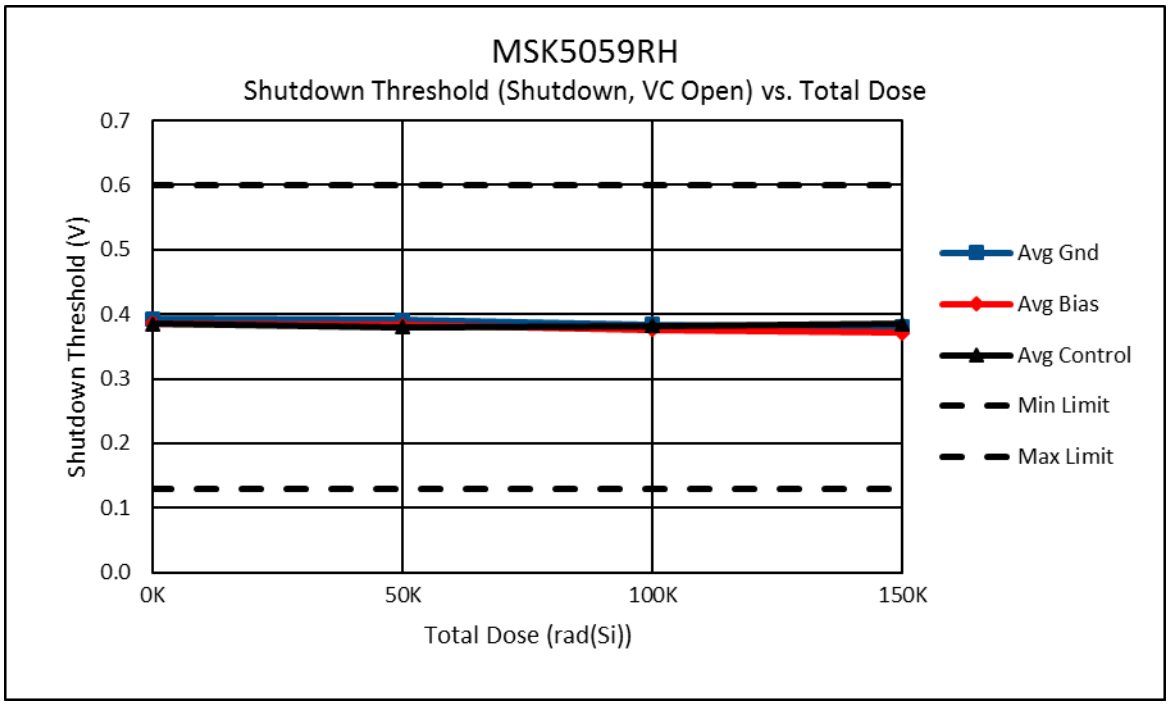
Table 1

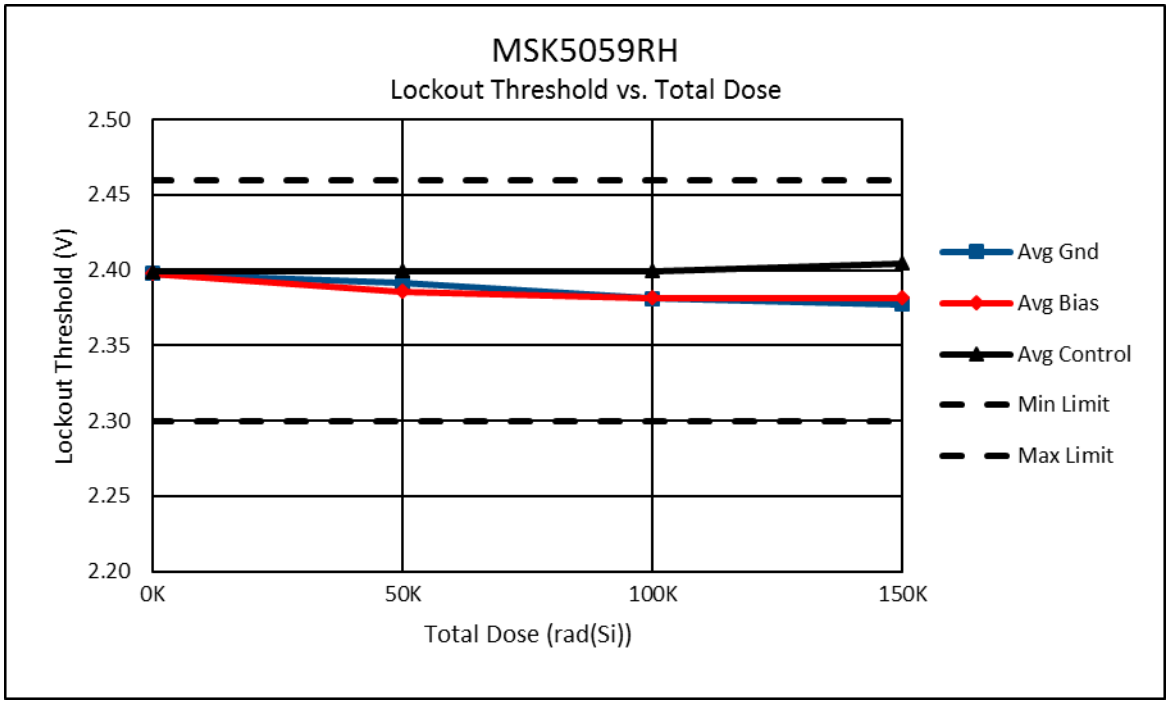
Dose Time, Incremental Dose and Total Cumulative Dose

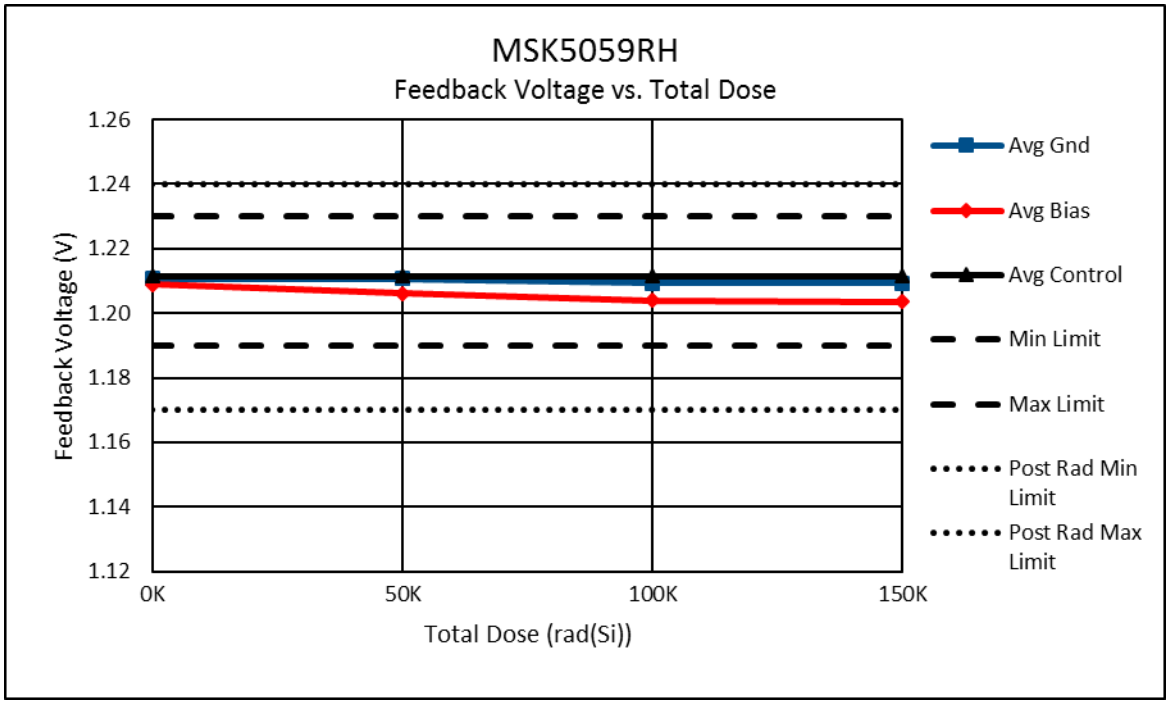

MSK5059RH
Input Supply Current vs. Total Dose
Input Supply Current (mA)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Avg Control
Max Limit

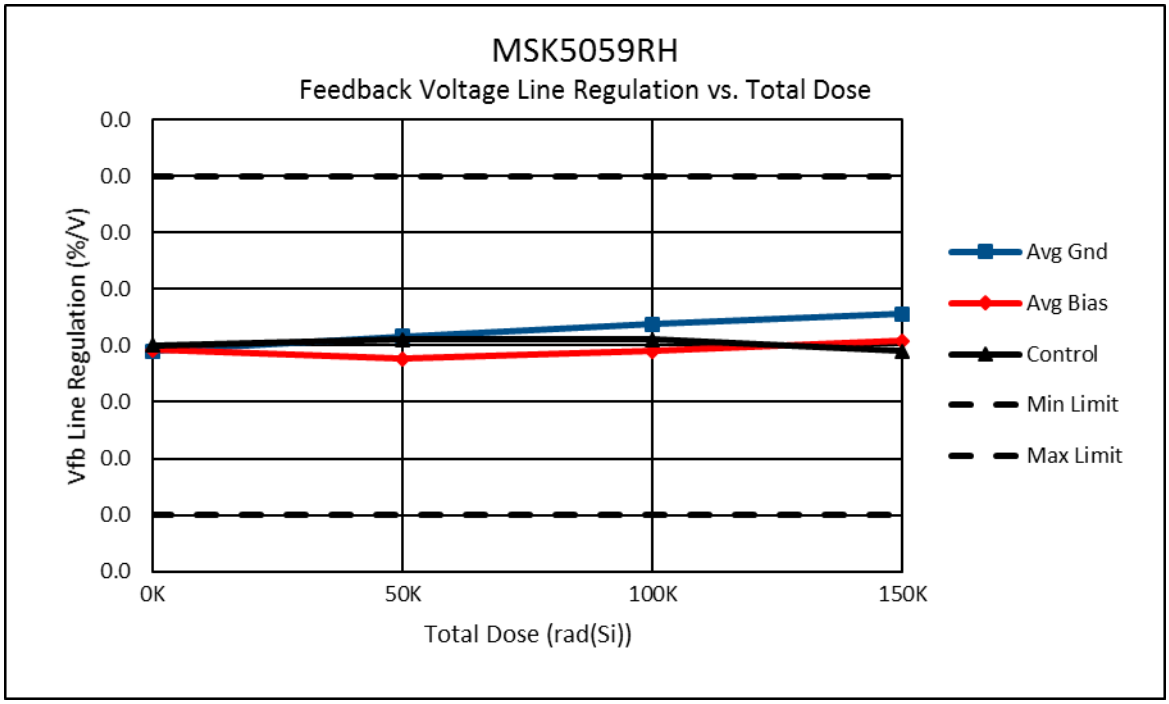

MSK5059RH
Shutdown Supply Current vs. Total Dose
Shutdown Supply Current (uA)
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Avg Control
Max Limit

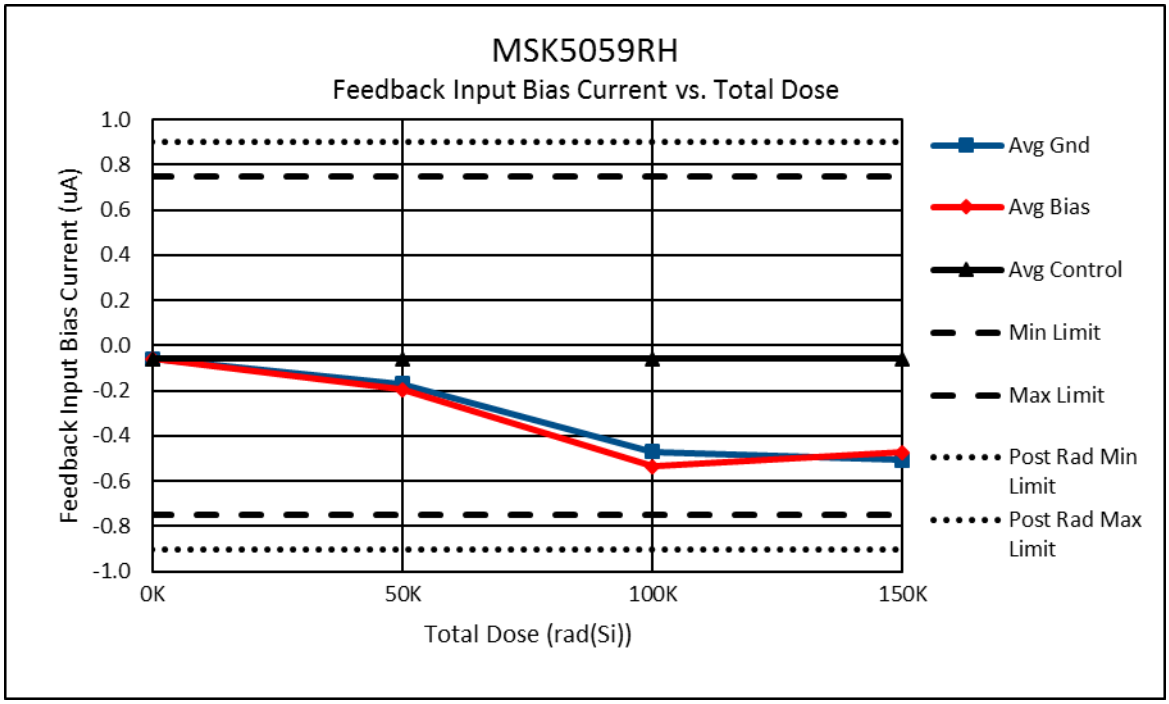

MSK5059RH
Shutdown Threshold (Startup, VC Open) vs. Total Dose
Shutdown Threshold (V)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Avg Control
Min Limit
Max Limit

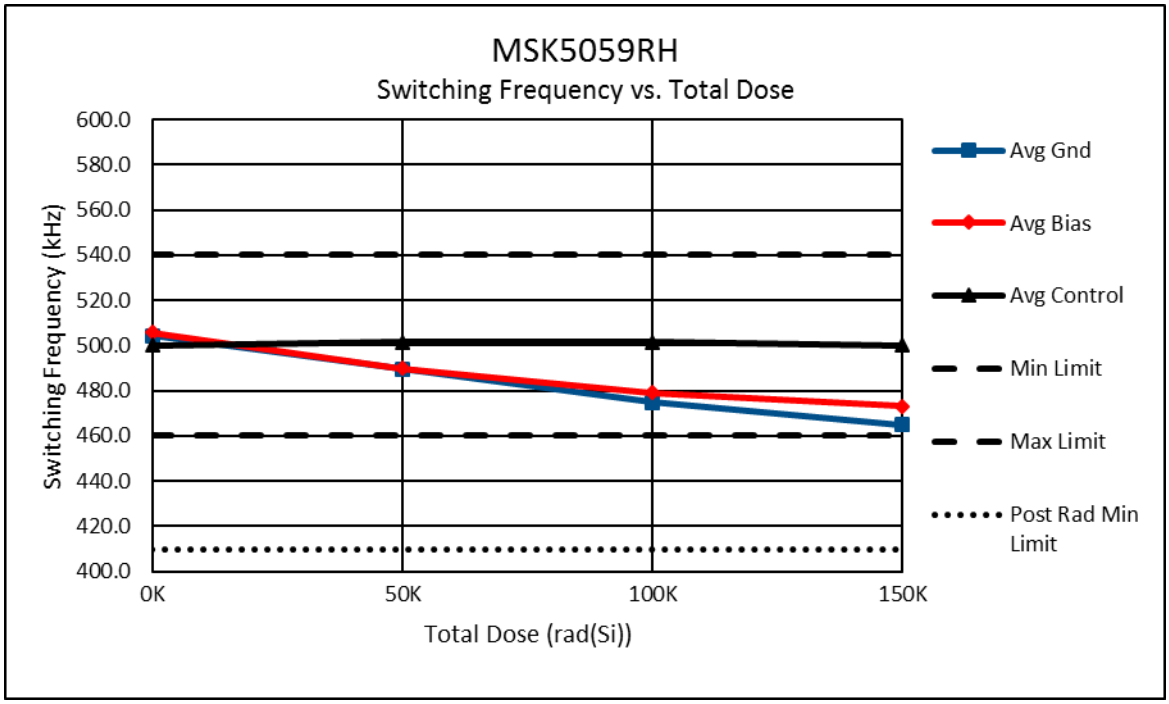

MSK5059RH
Shutdown Threshold (Shutdown, VC Open) vs. Total Dose
Shutdown Threshold (V)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Avg Control
Min Limit
Max Limit

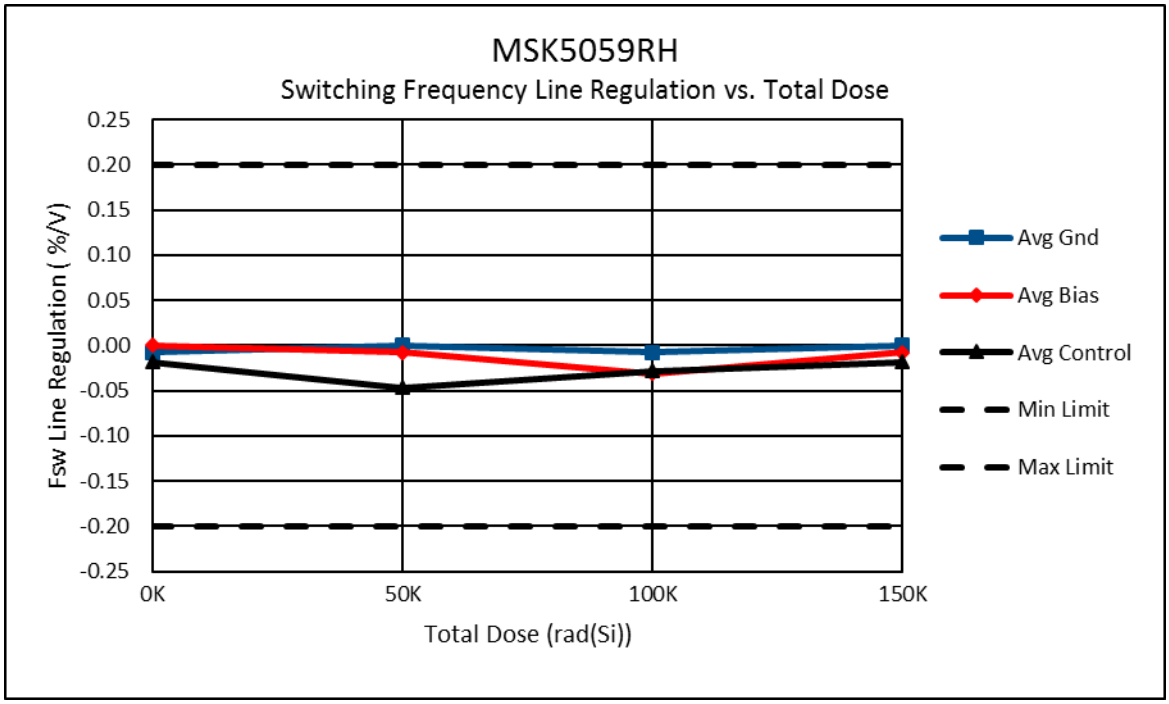

MSK5059RH
Lockout Threshold vs. Total Dose
Lockout Threshold (V)
2.50
2.45
2.40
2.35
2.30
2.25
2.20
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Avg Control
Min Limit
Max Limit

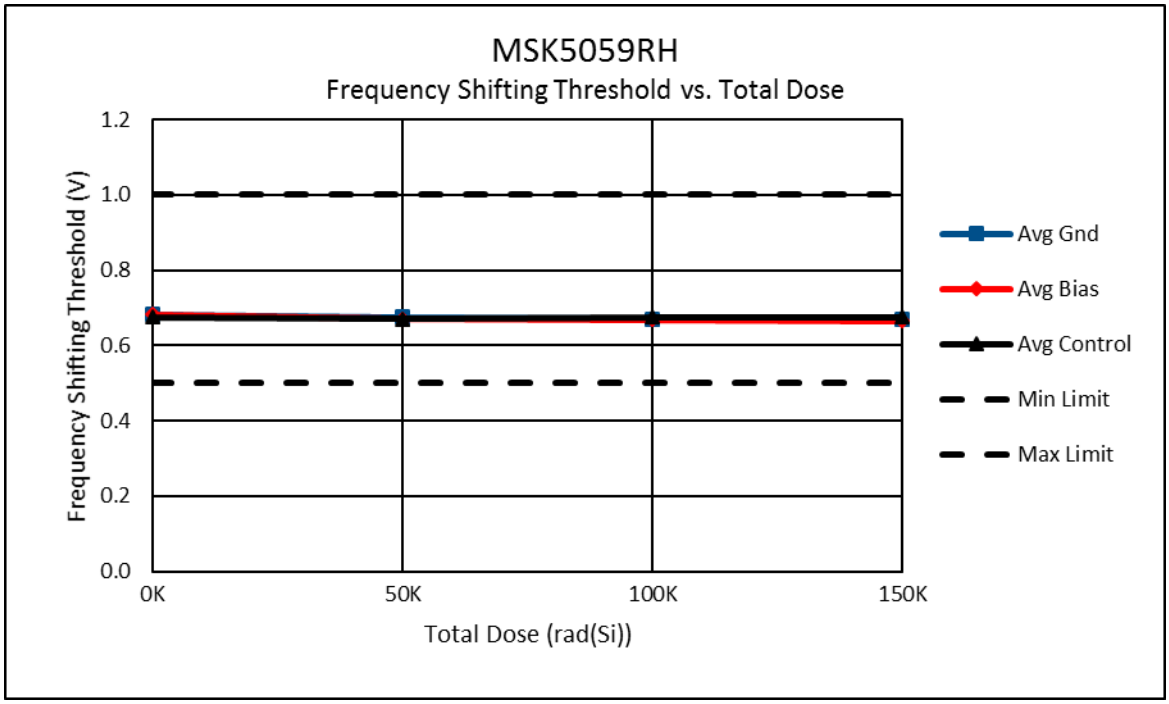

MSK5059RH
Feedback Voltage vs. Total Dose
Feedback Voltage (V)
1.26
1.24
1.22
1.20
1.18
1.16
1.14
1.12
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Avg Control
Min Limit
Max Limit
Post Rad Min Limit
Post Rad Max Limit

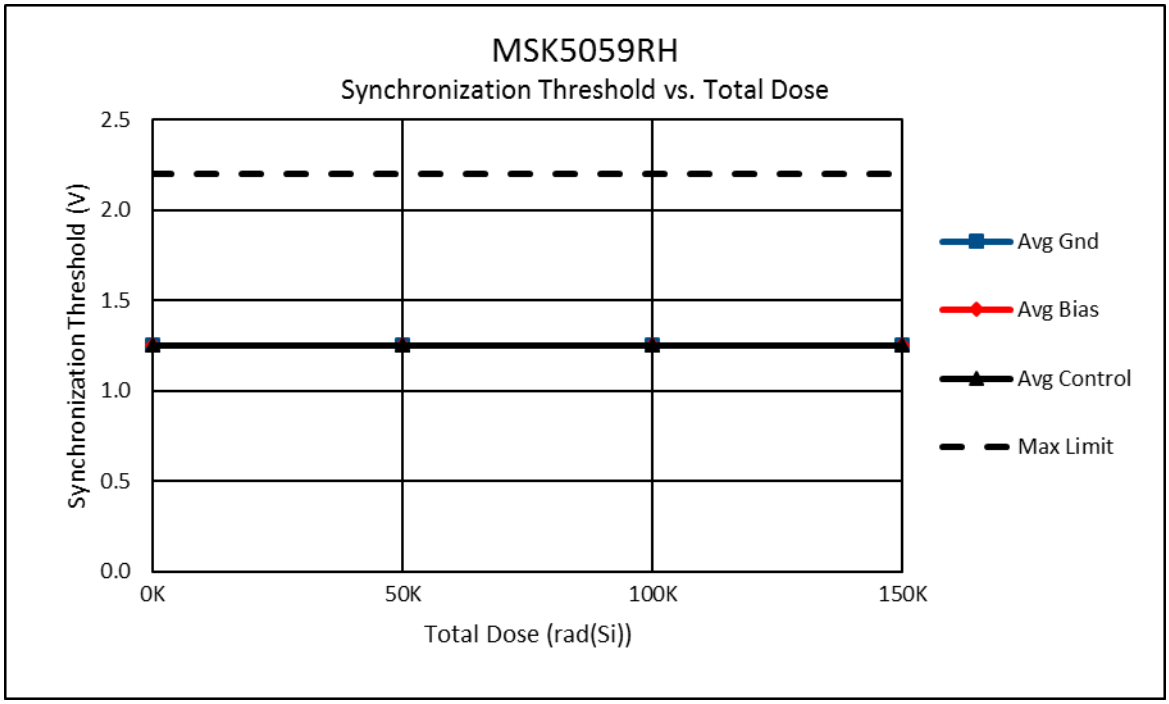

MSK5059RH
Feedback Voltage Line Regulation vs. Total Dose
Vfb Line Regulation (%/V)
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Min Limit
Max Limit

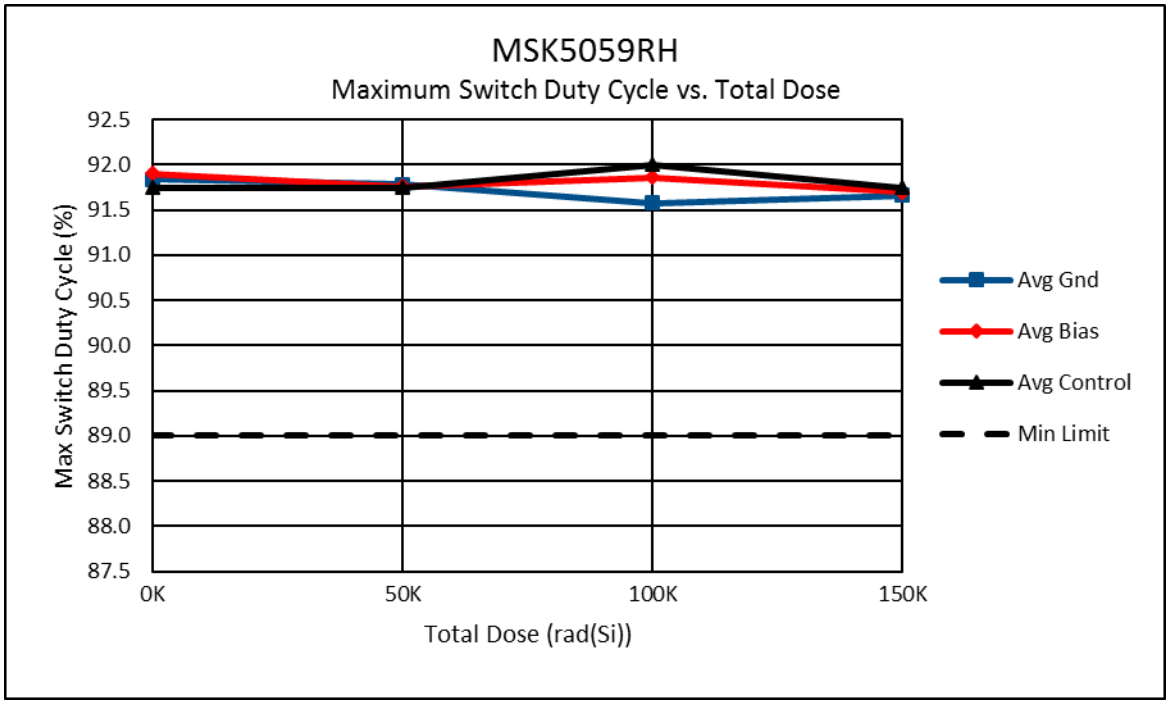

MSK5059RH
Feedback Input Bias Current vs. Total Dose
Feedback Input Bias Current (uA)
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Avg Control
Min Limit
Max Limit
Post Rad Min Limit
Post Rad Max Limit

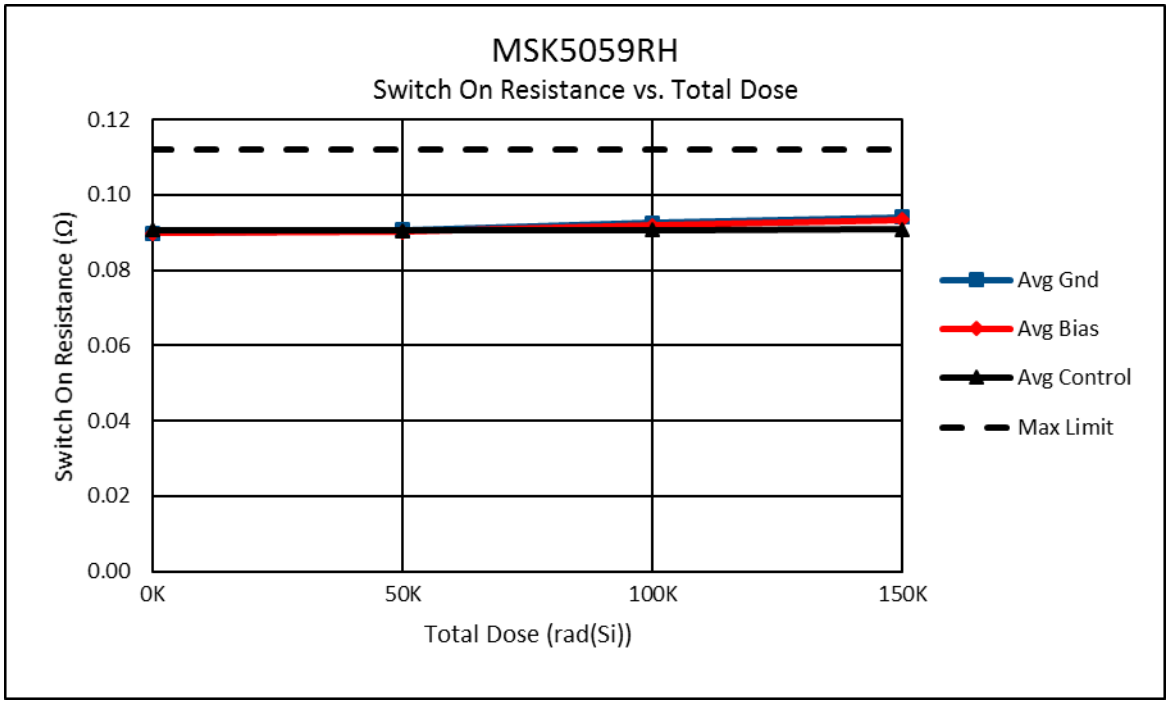

MSK5059RH
Switching Frequency vs. Total Dose
Switching Frequency (kHz)
600.0
580.0
560.0
540.0
520.0
500.0
480.0
460.0
440.0
420.0
400.0
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Avg Control
Min Limit
Max Limit
Post Rad Min Limit

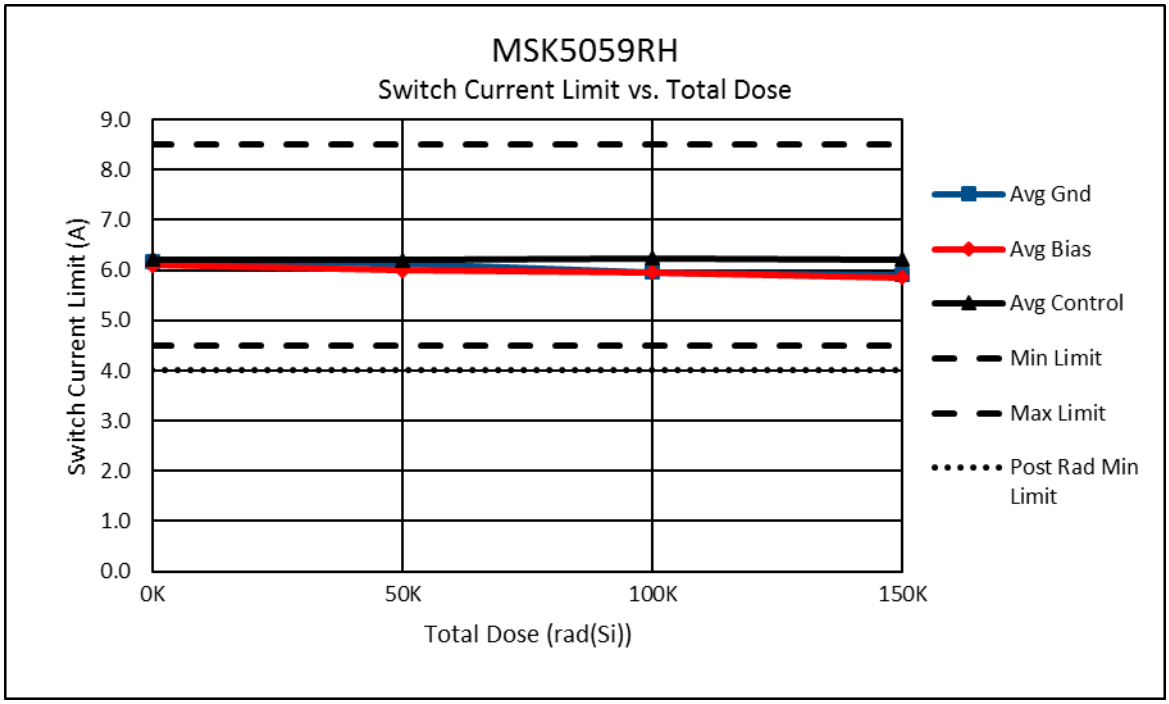

MSK5059RH
Switching Frequency Line Regulation vs. Total Dose
Fsw Line Regulation (%/V)
0.25
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20
-0.25
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Avg Control
Min Limit
Max Limit


MSK5059RH
Frequency Shifting Threshold vs. Total Dose
Frequency Shifting Threshold (V)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Avg Control
Min Limit
Max Limit


MSK5059RH
Synchronization Threshold vs. Total Dose
Synchronization Threshold (V)
2.5
2.0
1.5
1.0
0.5
0.0
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Avg Control
Max Limit


MSK5059RH
Maximum Switch Duty Cycle vs. Total Dose
Max Switch Duty Cycle (%)
92.5
92.0
91.5
91.0
90.5
90.0
89.5
89.0
88.5
88.0
87.5
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Avg Control
Min Limit


MSK5059RH
Switch On Resistance vs. Total Dose
Switch On Resistance (Ω)
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Avg Control
Max Limit


MSK5059RH
Switch Current Limit vs. Total Dose
Switch Current Limit (A)
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Avg Control
Min Limit
Max Limit
Post Rad Min Limit

Total Dose Radiation Test Report

MSK5059RH
RAD Hard 4.5A, 500 KHz Step Down Switching Regulator Controller

November 22, 2010 (TID – First Test)
March 4, 2011 (TID - Updated)
June, 2011 (ELDRS Test)
June 17, 2011 (TID – Second Test)
June 17, 2011 (TID – Third Test)

B. Erwin
C. Salce

M.S. Kennedy Corporation
Liverpool, NY

I. Introduction:

The total dose radiation test plan for the MSK 5059RH was developed to qualify the device as radiation tolerant up to 100 Krad(Si). The testing was performed beyond 100 Krad(Si) to show trends in device performance as a function of total dose. The test does not classify maximum radiation tolerance of the hybrid, but simply offers designers insight to the critical parameter-shifts beyond 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 5059RH.

II. Radiation Source:

Total dose was performed at the University of Massachusetts, Lowell, using a cobalt 60 radiation source. Dosimetry was performed prior to device irradiation and the dose rate was determined to be 123 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 the device data sheet. 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 Pb/Al container during irradiation to minimize dose enhancement effects. Five devices were kept under bias during irradiation. Five devices had all leads grounded during irradiation for the unbiased condition.

After each irradiation, the device leads were shorted together and were 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.

IV. Data:

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

V. Summary:

Total dose irradiation and testing of the MSK 5059RH resulted in most test parameters showing very little change up to 100Krad(Si) and beyond.

Shutdown threshold decreased slightly, but stayed within pre-irradiation limits.

A marked increase in feedback input bias current occurred at 50 Krad(Si), but a slight decrease was seen at 100 Krad(Si). At the final dose level the feedback input bias remained stable.

The switch frequency exhibited a decrease. This decrease was nearly linear throughout the dose points.

In addition, switch current limit also showed a decrease during irradiation. However, this parameter stayed within pre-irradiation limits through all testing to150 Krad(Si).

MSK5059RH Biased/Unbiased Dose Rate Schedule

Dosimetry Equipment
Bruker Biospin # 0141

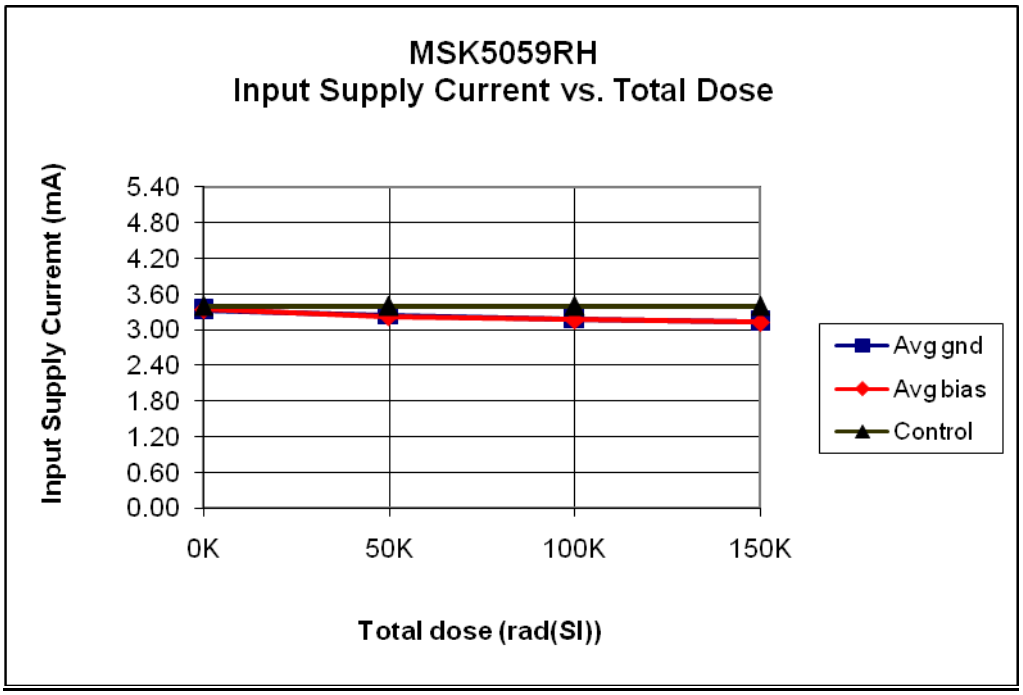
Irradiation Date
6/17/11

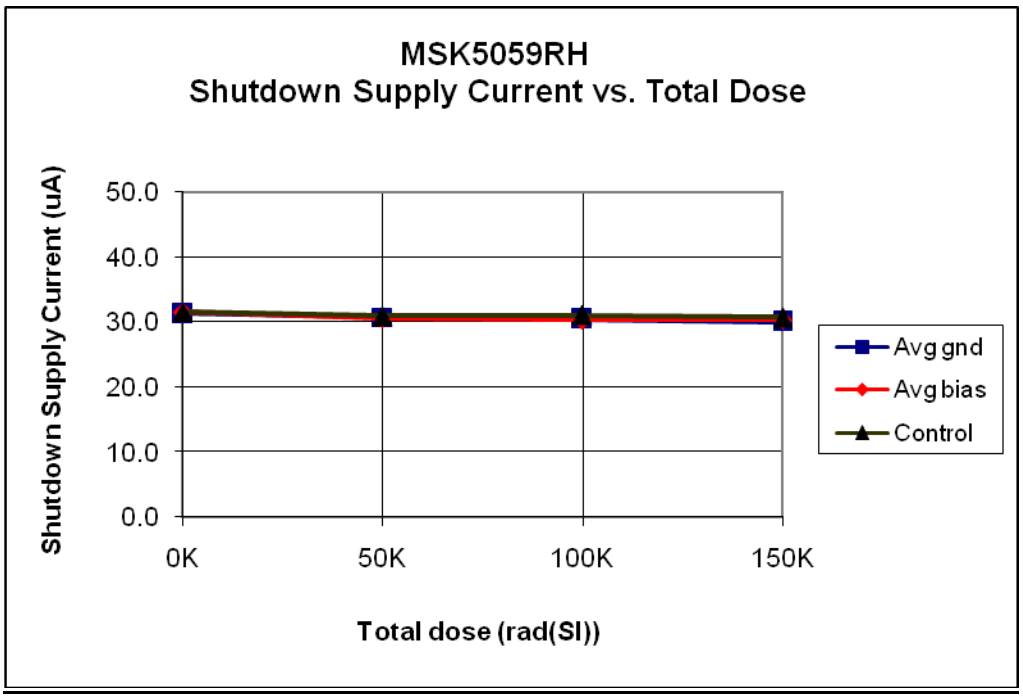
Exposure Length (min:sec)	Incremental Dose rads(Si)	Cumulative Dose rads(Si)
7:00	51,660	51,660
7:00	51,660	103,320
7:00	51,660	154,980

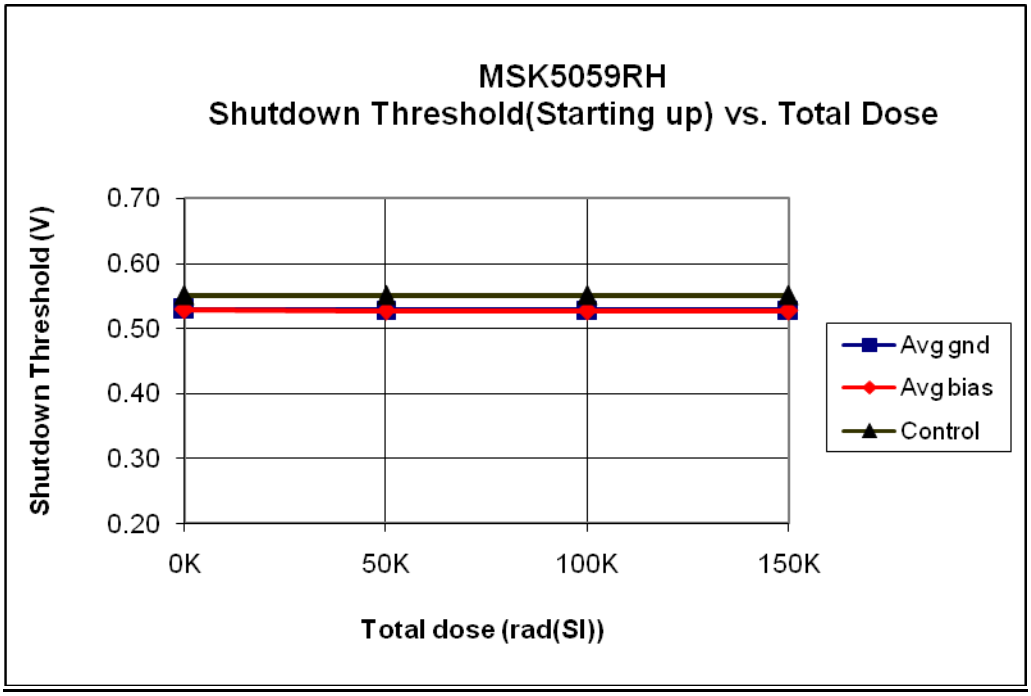
Biased S/N – 0505, 0506, 0507, 05108 0509

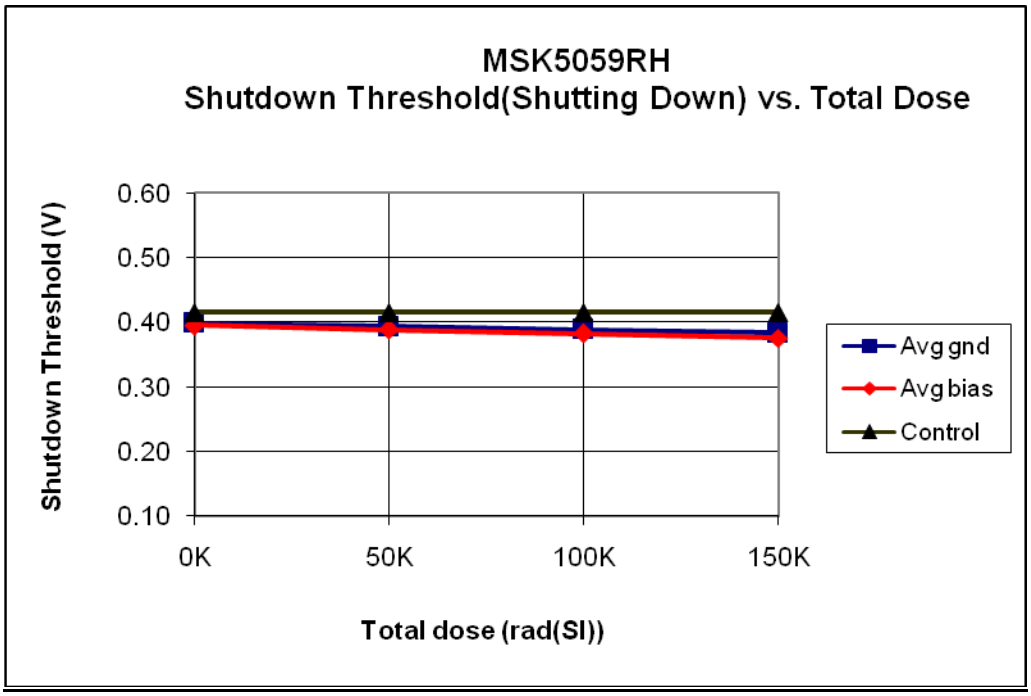
Unbiased S/N – 0510, 0511, 0512, 0513, 0514

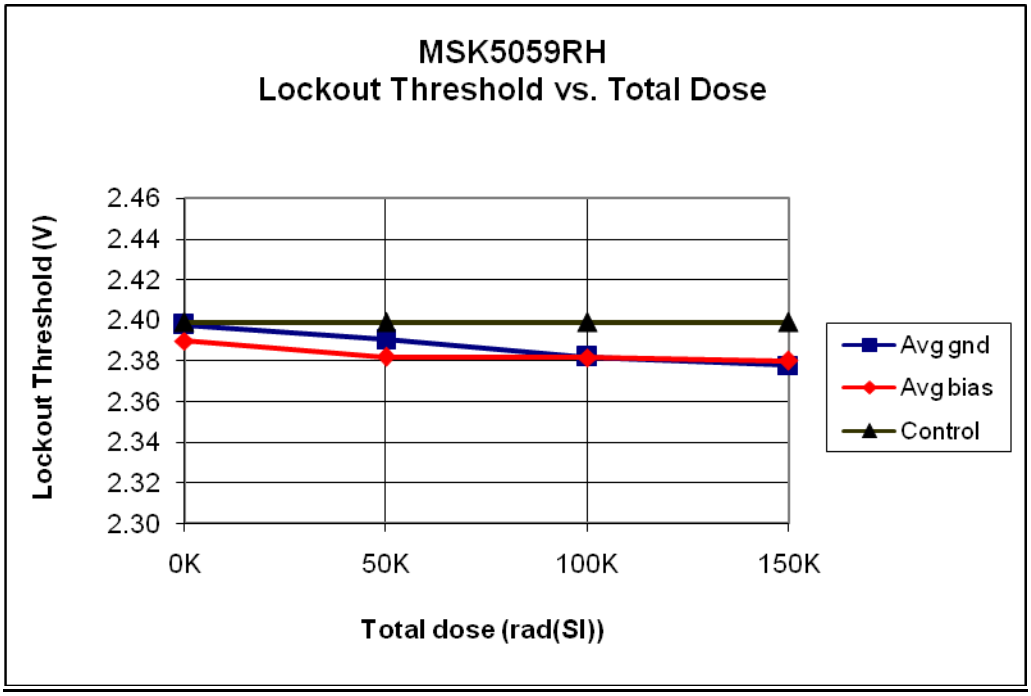
Table 1
Dose Time, Incremental Dose and Total Cumulative Dose

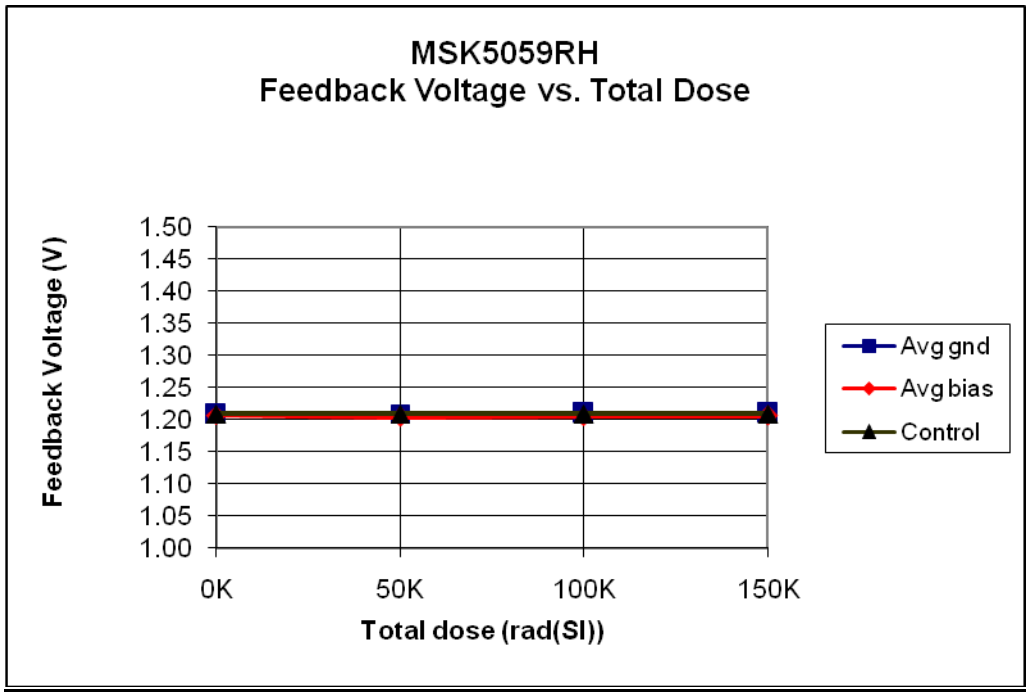

MSK5059RH
Input Supply Current vs. Total Dose
Input Supply Curremt (mA)
5.40
4.80
4.20
3.60
3.00
2.40
1.80
1.20
0.60
0.00
0K
50K
100K
150K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

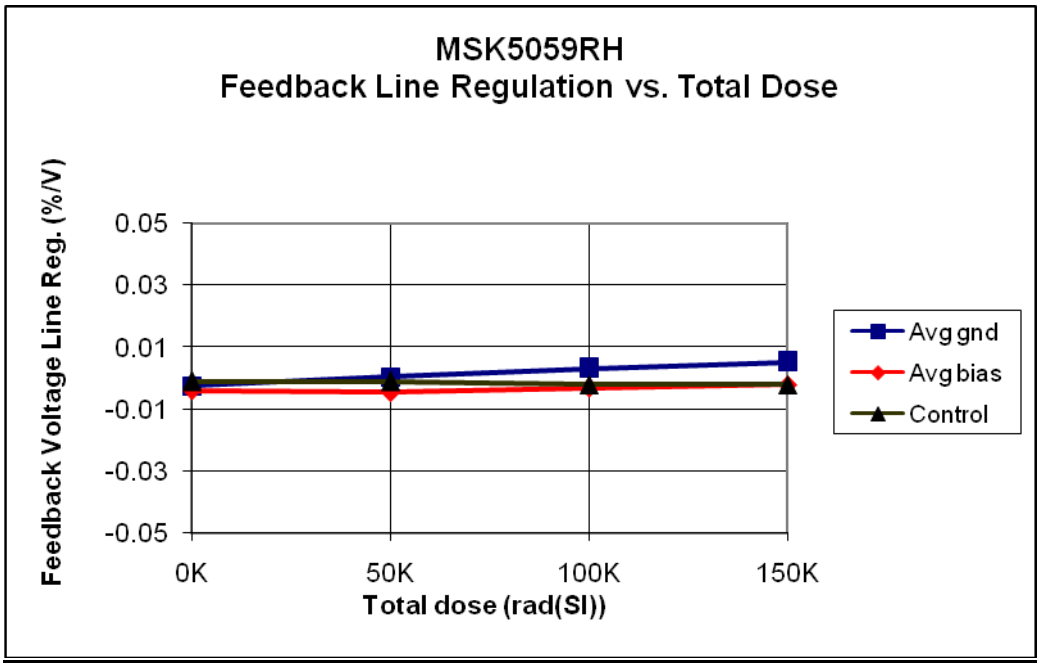

MSK5059RH
Shutdown Supply Current vs. Total Dose
Shutdown Supply Current (uA)
50.0
40.0
30.0
20.0
10.0
0.0
0K
50K
100K
150K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

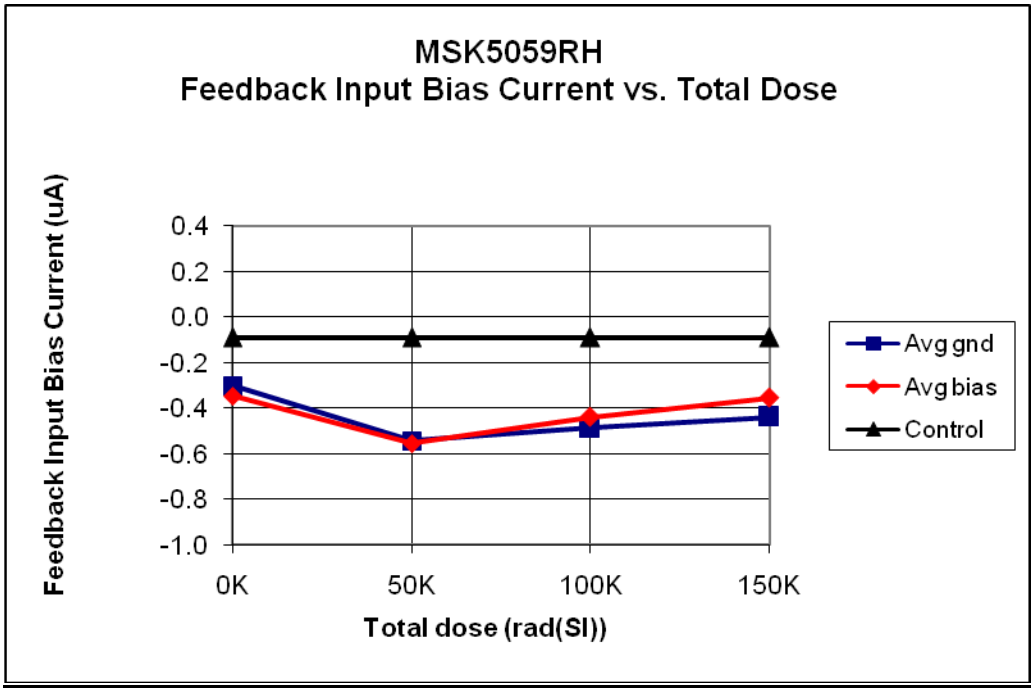

MSK5059RH
Shutdown Threshold(Starting up) vs. Total Dose
Shutdown Threshold (V)
0.70
0.60
0.50
0.40
0.30
0.20
0K
50K
100K
150K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

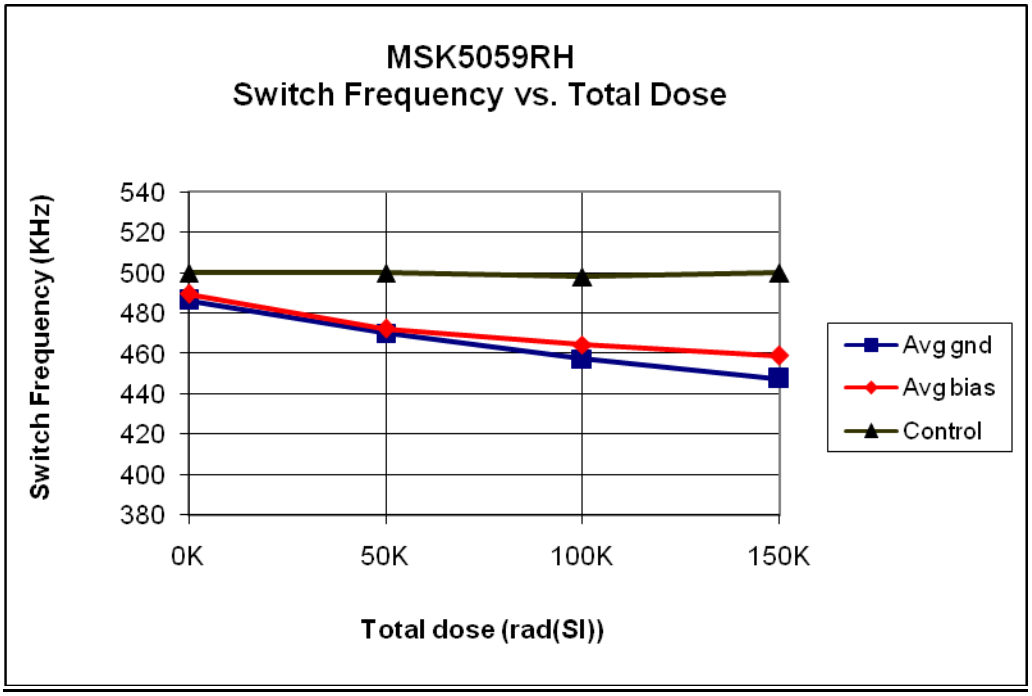

MSK5059RH
Shutdown Threshold(Shutting Down) vs. Total Dose
Shutdown Threshold (V)
0.60
0.50
0.40
0.30
0.20
0.10
0K
50K
100K
150K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

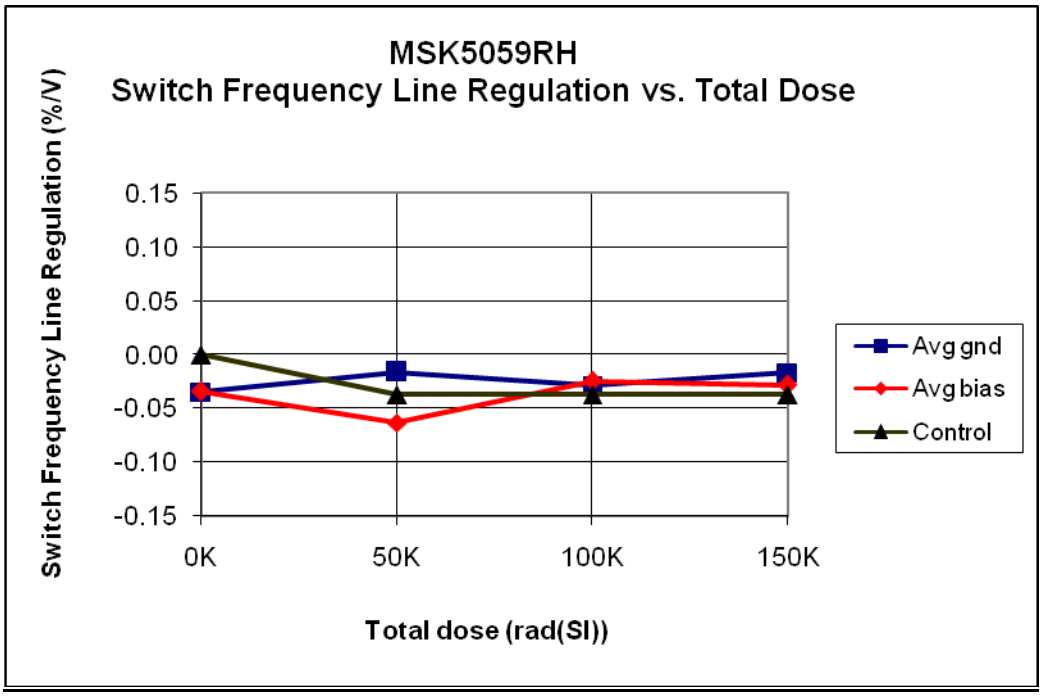

MSK5059RH
Lockout Threshold vs. Total Dose
Lockout Threshold (V)
2.46
2.44
2.42
2.40
2.38
2.36
2.34
2.32
2.30
0K
50K
100K
150K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

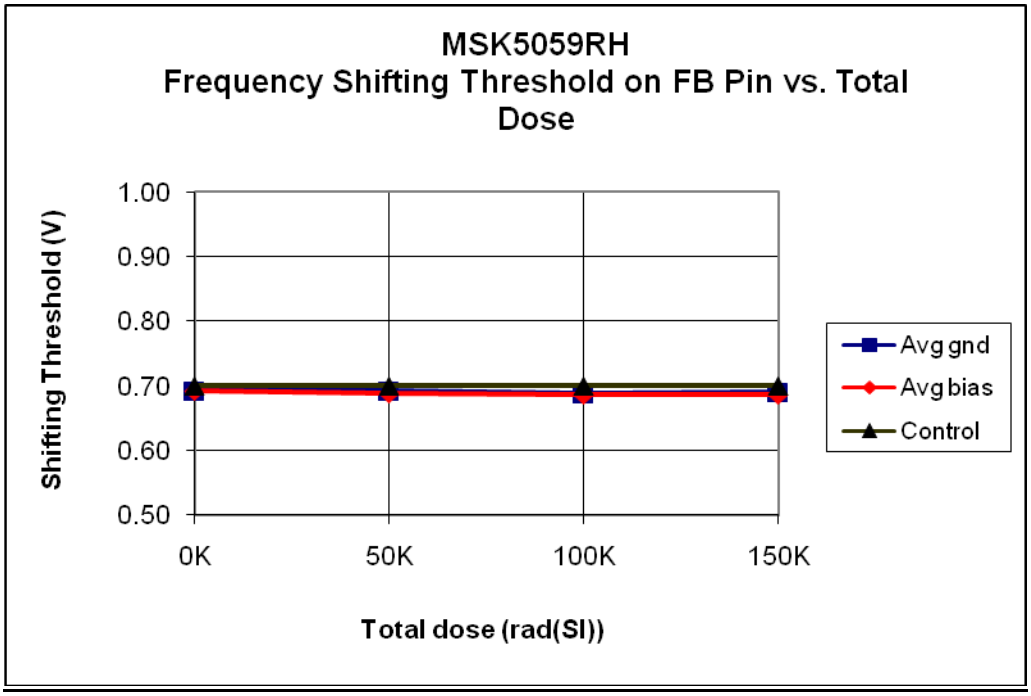

MSK5059RH
Feedback Voltage vs. Total Dose
Feedback Voltage (V)
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
0K
50K
100K
150K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

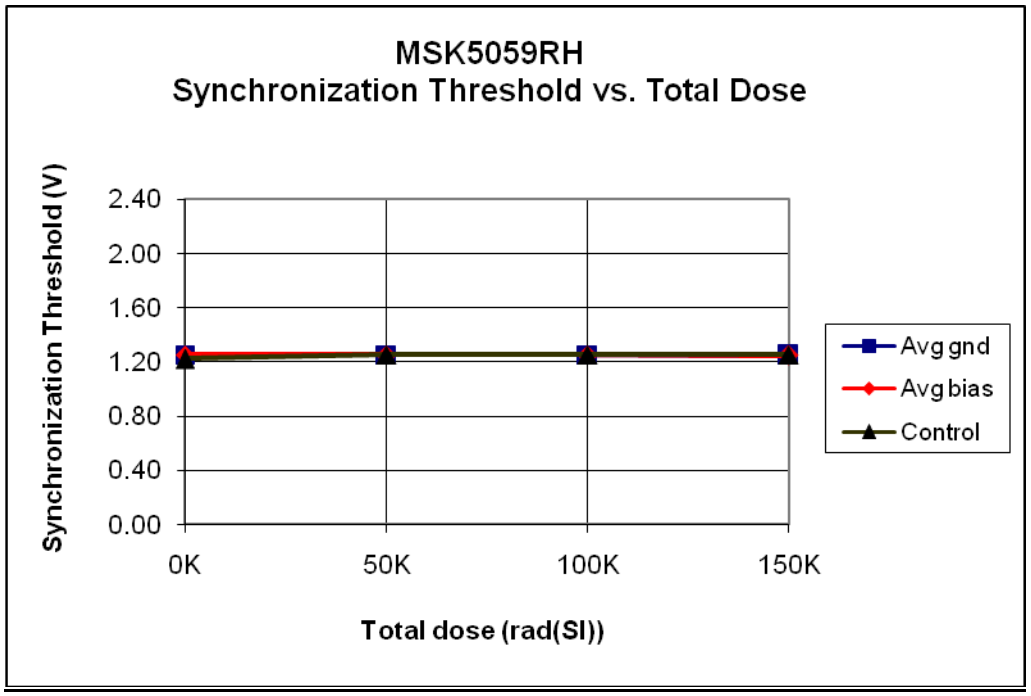

MSK5059RH
Feedback Line Regulation vs. Total Dose
Feedback Voltage Line Reg. (%/V)
0.05
0.03
0.01
-0.01
-0.03
-0.05
0K
50K
100K
150K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

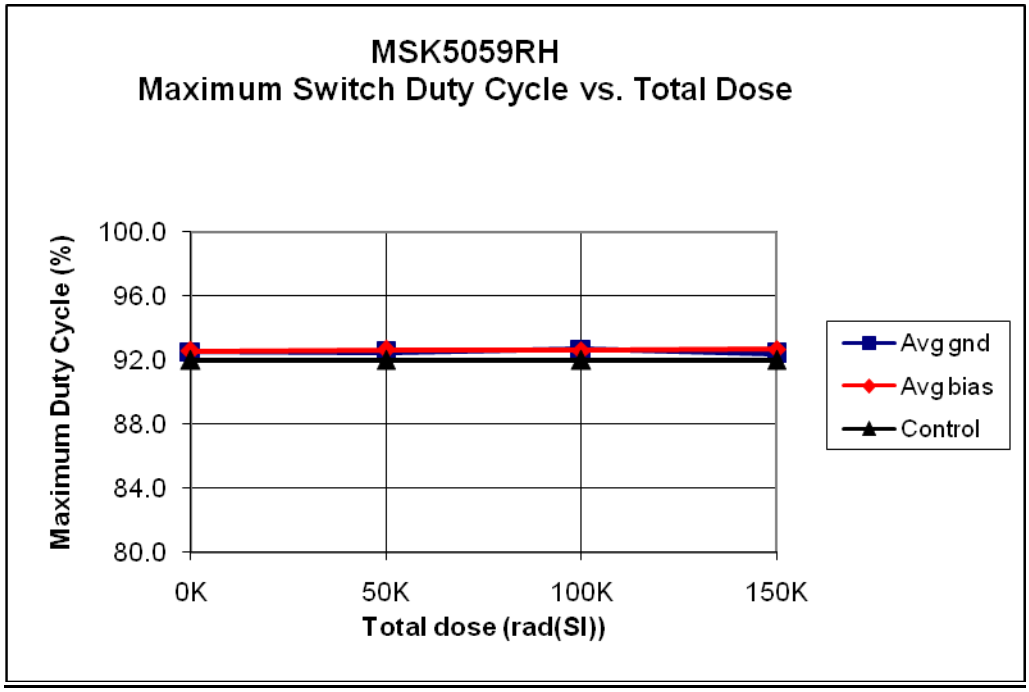

MSK5059RH
Feedback Input Bias Current vs. Total Dose
Feedback Input Bias Current (uA)
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
0K
50K
100K
150K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

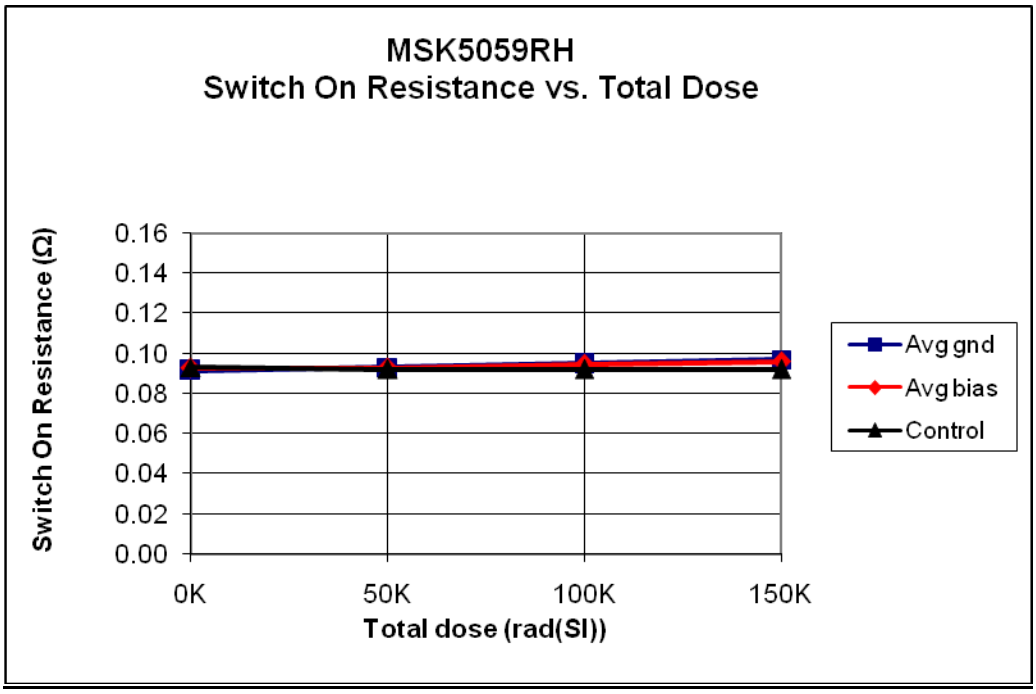

MSK5059RH
Switch Frequency vs. Total Dose
Switch Frequency (KHz)
540
520
500
480
460
440
420
400
380
0K
50K
100K
150K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

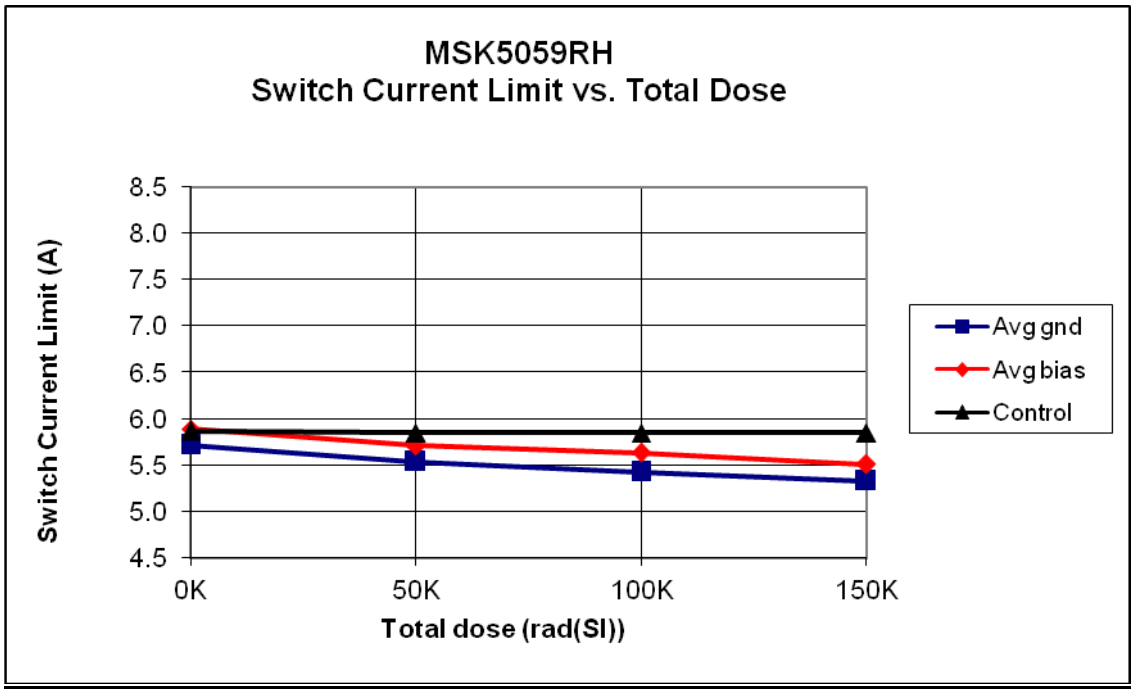

MSK5059RH
Switch Frequency Line Regulation vs. Total Dose
Switch Frequency Line Regulation (%/V)
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
0K
50K
100K
150K
Total dose (rad(Si))
Avg gnd
Avg bias
Control


MSK5059RH
Frequency Shifting Threshold on FB Pin vs. Total Dose
Shifting Threshold (V)
1.00
0.90
0.80
0.70
0.60
0.50
0K
50K
100K
150K
Total dose (rad(Si))
Avg gnd
Avg bias
Control


MSK5059RH
Synchronization Threshold vs. Total Dose
Synchronization Threshold (V)
2.40
2.00
1.60
1.20
0.80
0.40
0.00
0K
50K
100K
150K
Total dose (rad(Si))
Avg gnd
Avg bias
Control


MSK5059RH
Maximum Switch Duty Cycle vs. Total Dose
Maximum Duty Cycle (%)
100.0
96.0
92.0
88.0
84.0
80.0
0K
50K
100K
150K
Total dose (rad(Si))
Avg gnd
Avg bias
Control


MSK5059RH
Switch On Resistance vs. Total Dose
Switch On Resistance (Ω)
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0K
50K
100K
150K
Total dose (rad(Si))
Avg gnd
Avg bias
Control


MSK5059RH
Switch Current Limit vs. Total Dose
Switch Current Limit (A)
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
0K
50K
100K
150K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

Total Dose Radiation Test Report

MSK5059RH
RAD Hard 4.5A, 500 KHz Step Down Switching Regulator Controller

November 22, 2010 (TID – First Test)
March 4, 2011 (TID - Updated)
June, 2011 (ELDRS Test)
June 17, 2011 (TID – Second Test)

B. Erwin
C. Salce

M.S. Kennedy Corporation
Liverpool, NY

I. Introduction:

The total dose radiation test plan for the MSK 5059RH was developed to qualify the device as radiation tolerant up to 100 Krad(Si). The testing was performed beyond 100 Krad(Si) to show trends in device performance as a function of total dose. The test does not classify maximum radiation tolerance of the hybrid, but simply offers designers insight to the critical parameter-shifts beyond 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 5059RH.

II. Radiation Source:

Total dose was performed at the University of Massachusetts, Lowell, using a cobalt 60 radiation source. Dosimetry was performed prior to device irradiation and the dose rate was determined to be 123 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 the device data sheet. 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 Pb/Al container during irradiation to minimize dose enhancement effects. Five devices were kept under bias during irradiation. Five devices had all leads grounded during irradiation for the unbiased condition.

After each irradiation, the device leads were shorted together and were 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.

IV. Data:

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

V. Summary:

Total dose irradiation and testing of the MSK 5059RH resulted in most test parameters showing very little change up to 100Krad(Si) and beyond.

Shutdown threshold decreased slightly, but stayed within pre-irradiation limits.

A marked increase in feedback input bias current occurred at 50 Krad(Si), but a slight decrease was seen at 100 Krad(Si). At the final dose level the feedback input bias remained stable.

The switch frequency exhibited a decrease. This decrease was nearly linear throughout the dose points.

In addition, switch current limit also showed a decrease during irradiation. However, this parameter stayed within pre-irradiation limits through all testing to 150 Krad(Si).

MSK5059RH Biased/Unbiased Dose Rate Schedule

Dosimetry Equipment
Bruker Biospin # 0141

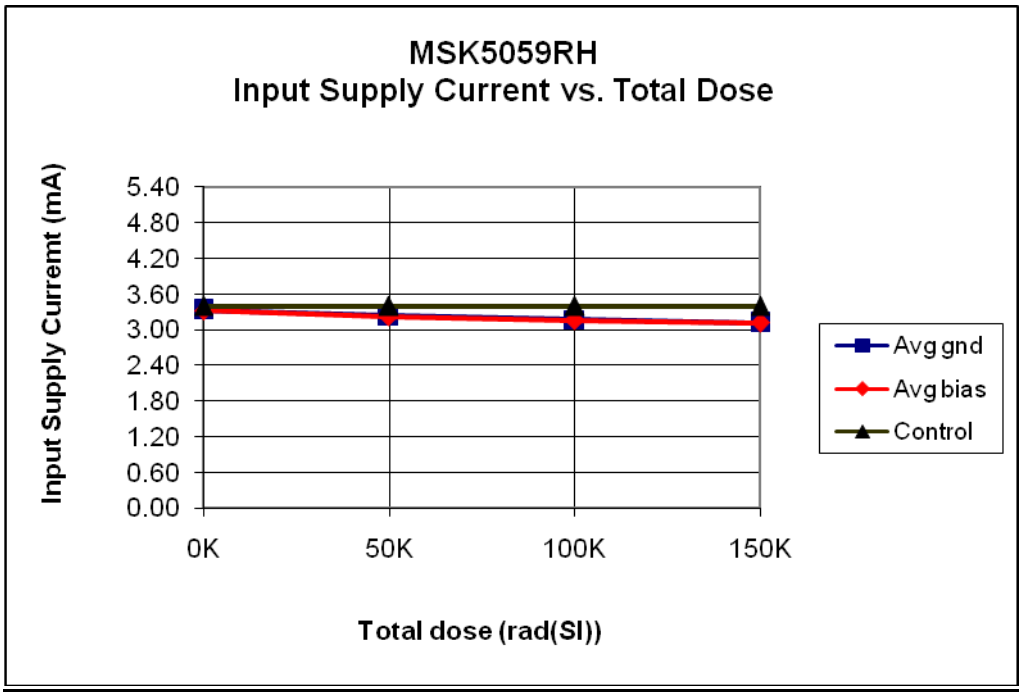
Irradiation Date
6/17/11

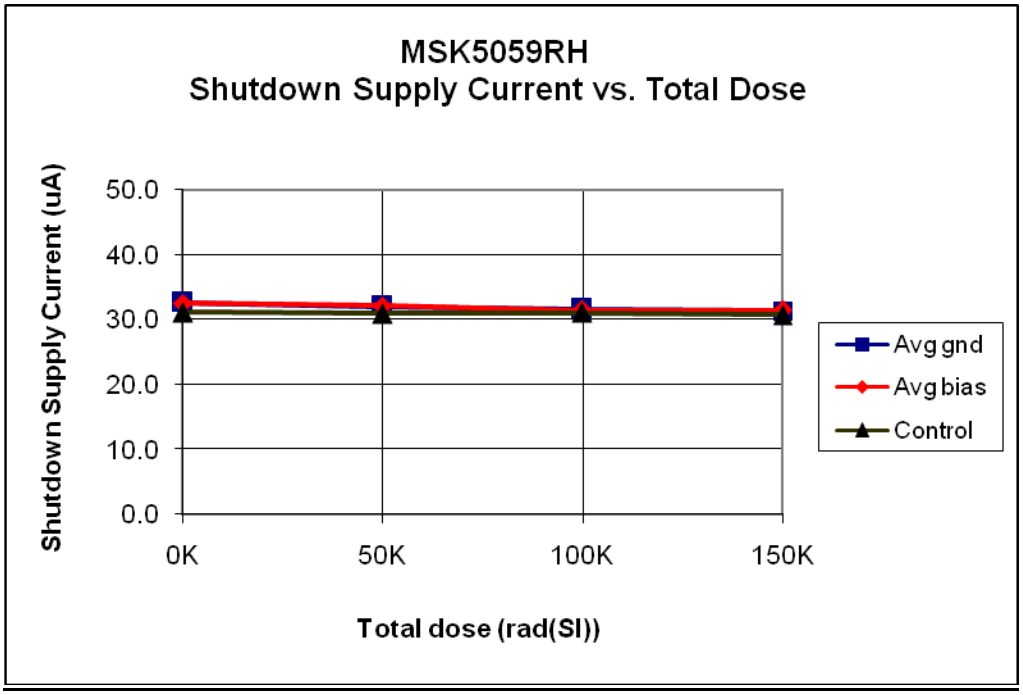
Exposure Length (min:sec)	Incremental Dose rads(Si)	Cumulative Dose rads(Si)
7:00	51,660	51,660
7:00	51,660	103,320
7:00	51,660	154,980

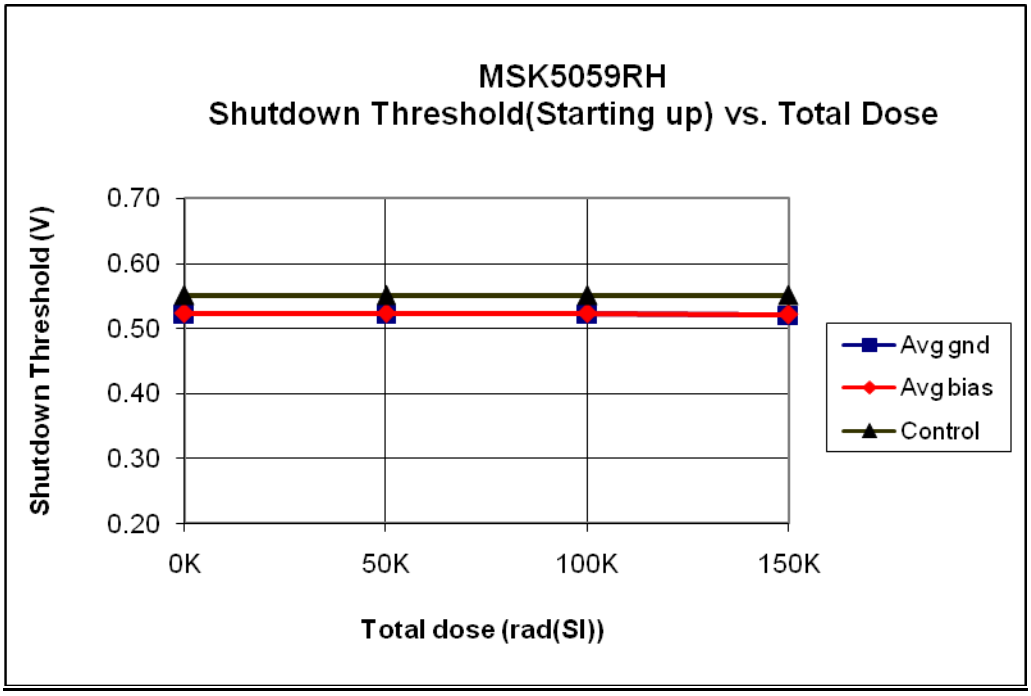
Biased S/N – 0407, 0408, 0409, 0410, 0411

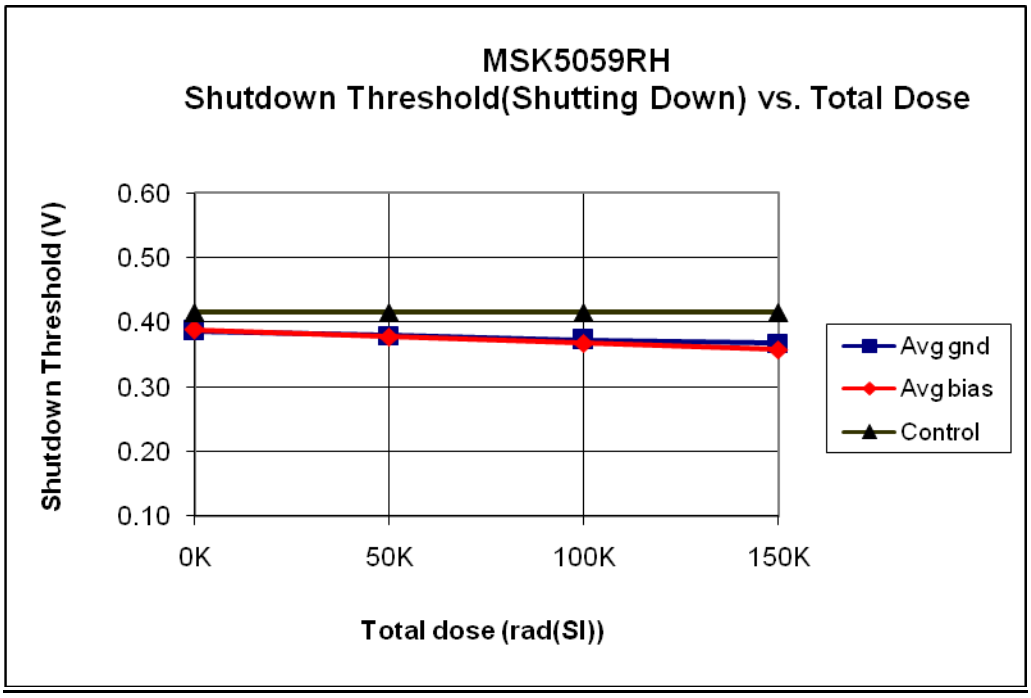
Unbiased S/N – 0412, 0413, 0414, 0415, 0416

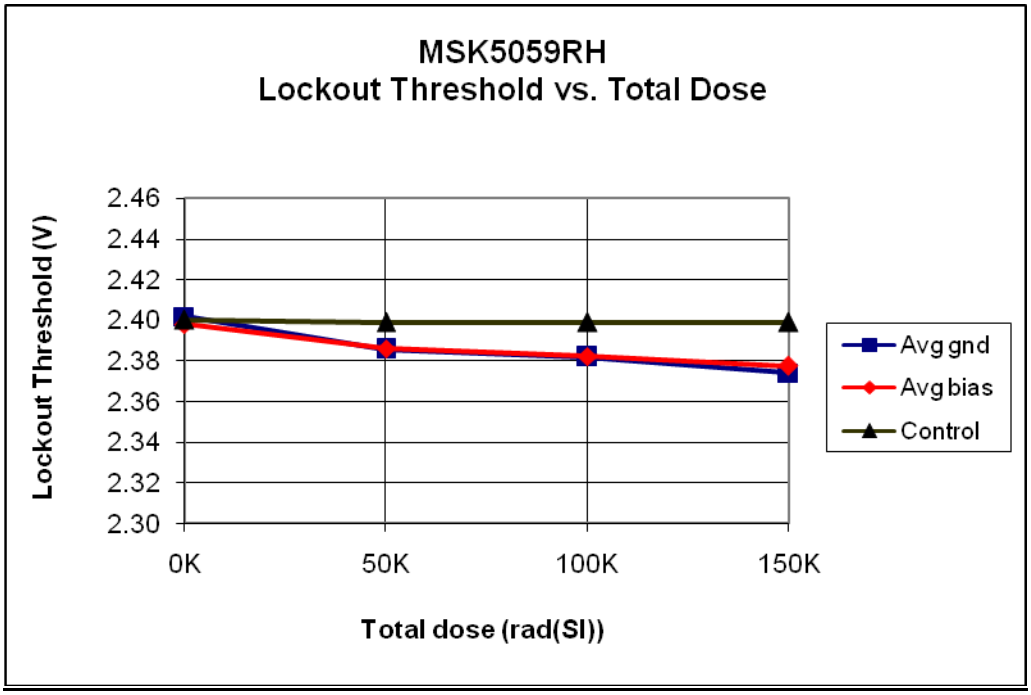
Table 1
Dose Time, Incremental Dose and Total Cumulative Dose

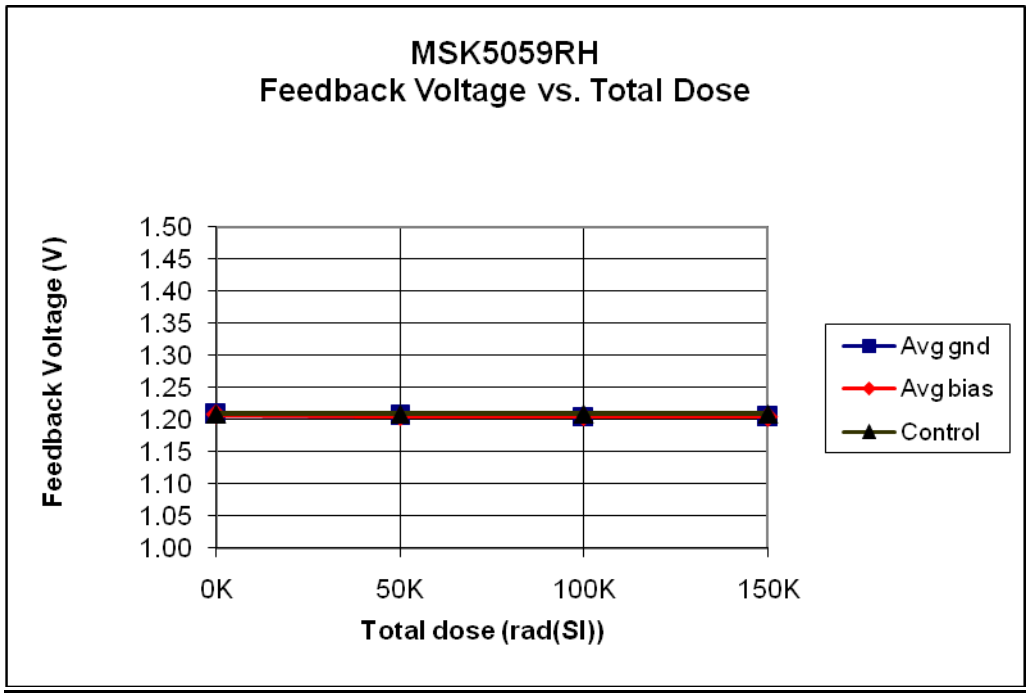

MSK5059RH
Input Supply Current vs. Total Dose
Input Supply Curremt (mA)
5.40
4.80
4.20
3.60
3.00
2.40
1.80
1.20
0.60
0.00
0K
50K
100K
150K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

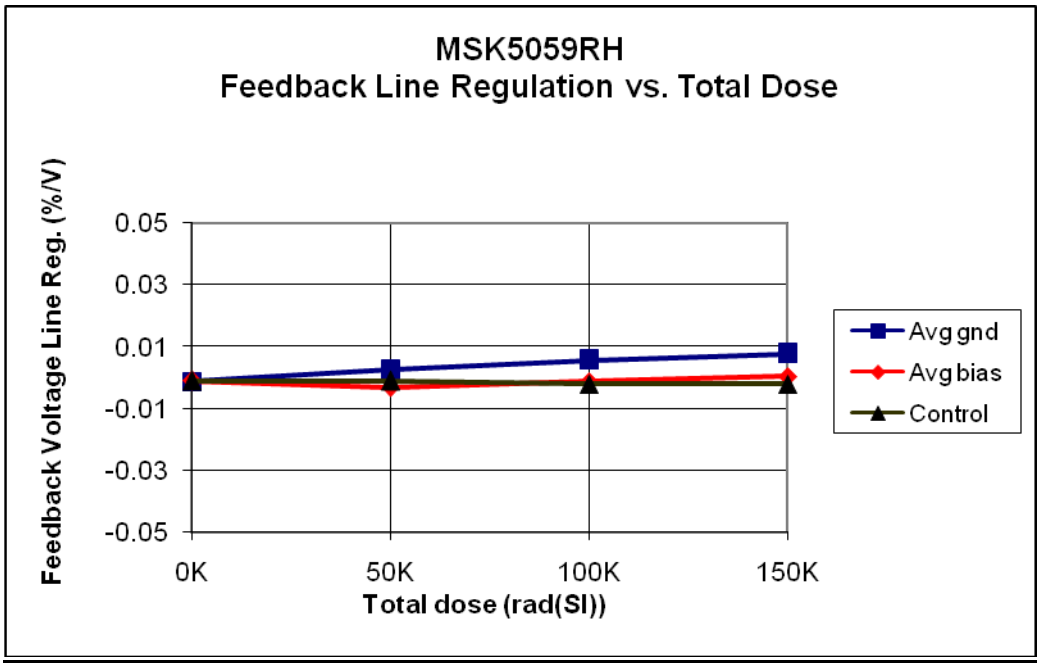

MSK5059RH
Shutdown Supply Current vs. Total Dose
Shutdown Supply Current (uA)
50.0
40.0
30.0
20.0
10.0
0.0
0K
50K
100K
150K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

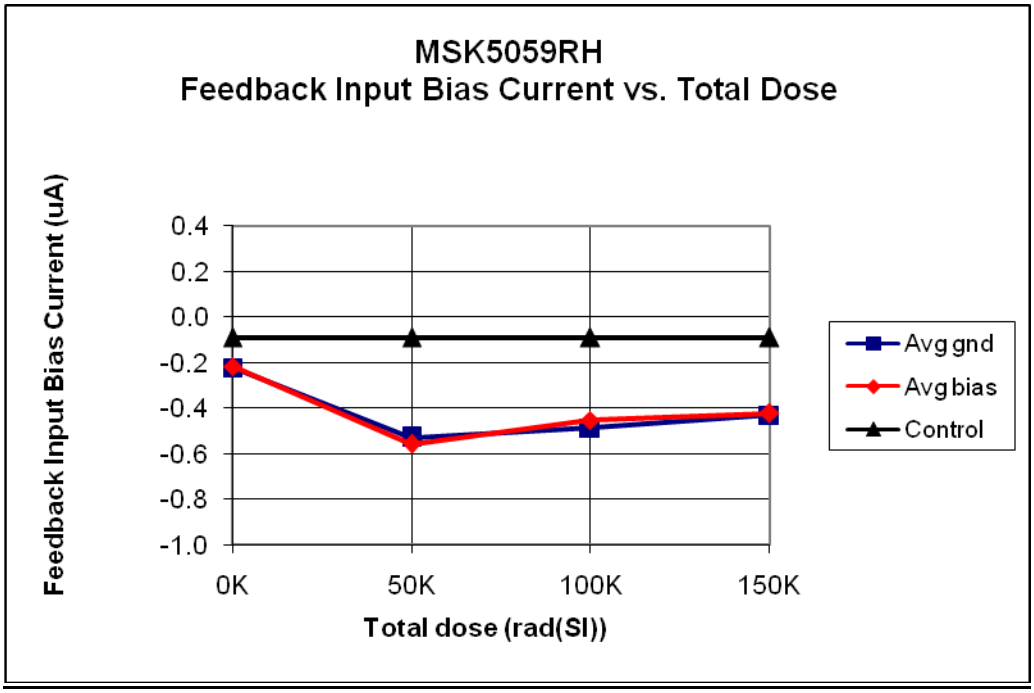

MSK5059RH
Shutdown Threshold(Starting up) vs. Total Dose
Shutdown Threshold (V)
0.70
0.60
0.50
0.40
0.30
0.20
0K
50K
100K
150K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

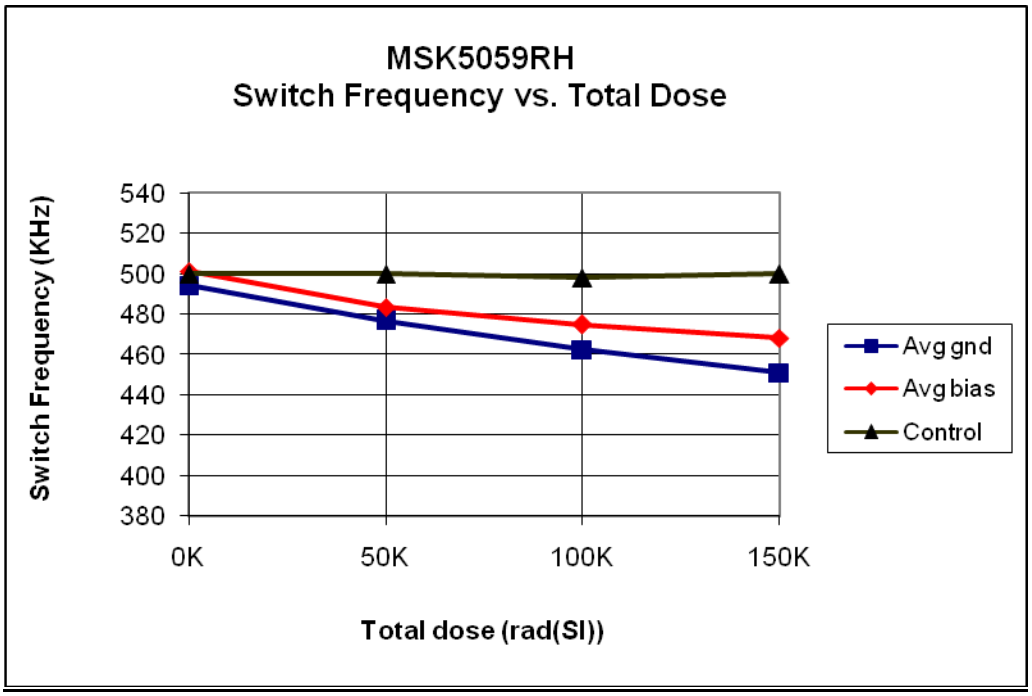

MSK5059RH
Shutdown Threshold(Shutting Down) vs. Total Dose
Shutdown Threshold (V)
0.60
0.50
0.40
0.30
0.20
0.10
0K
50K
100K
150K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

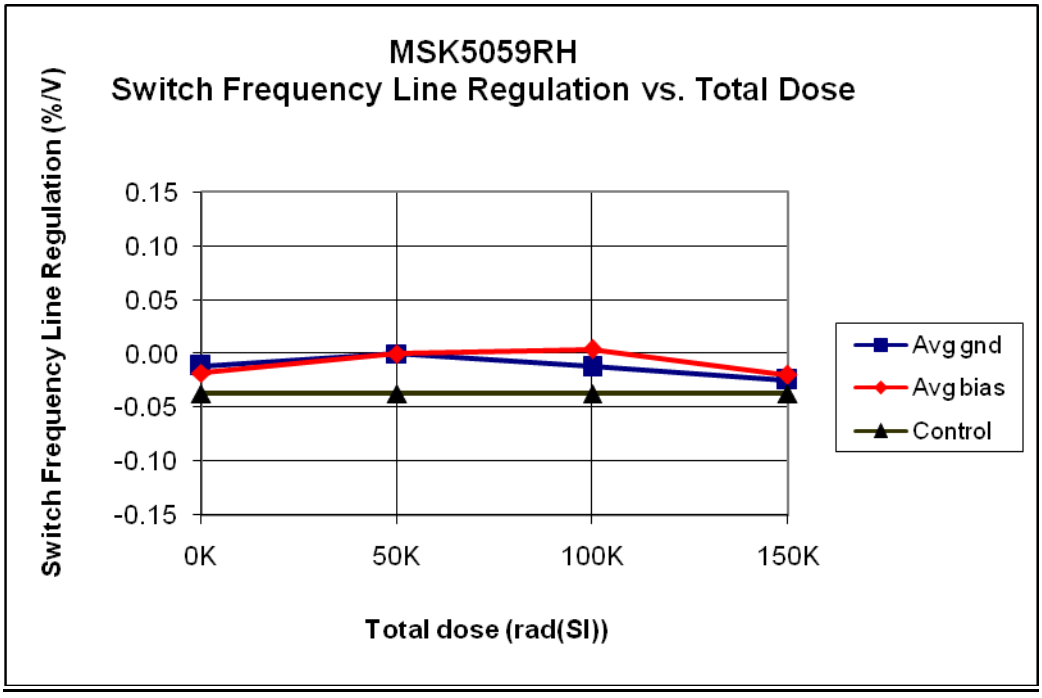

MSK5059RH
Lockout Threshold vs. Total Dose
Lockout Threshold (V)
2.46
2.44
2.42
2.40
2.38
2.36
2.34
2.32
2.30
0K
50K
100K
150K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

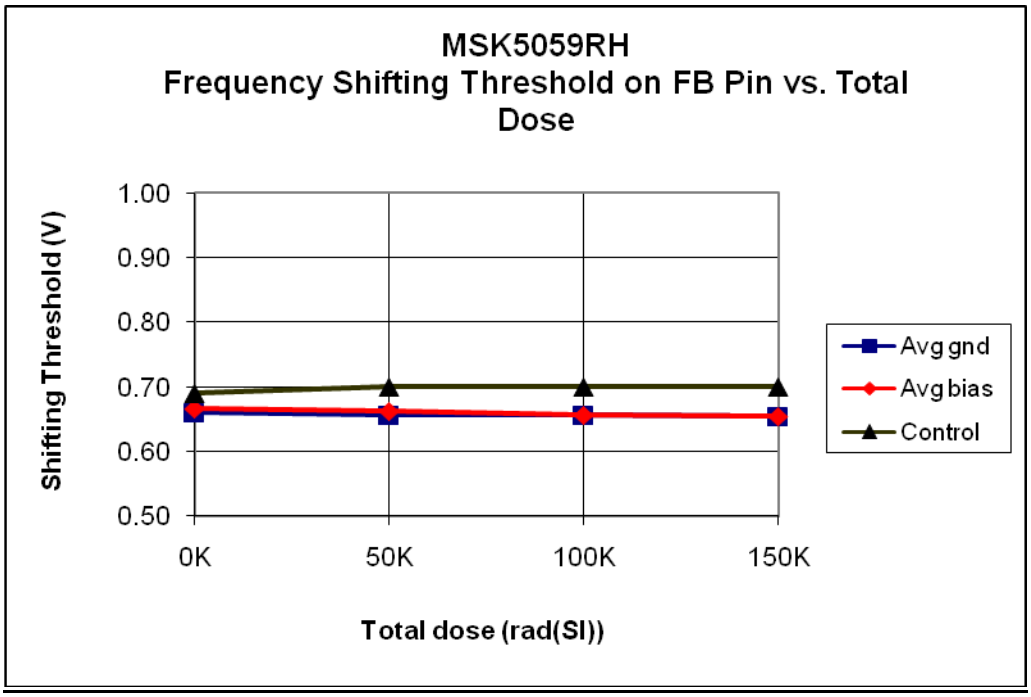

MSK5059RH
Feedback Voltage vs. Total Dose
Feedback Voltage (V)
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
0K
50K
100K
150K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

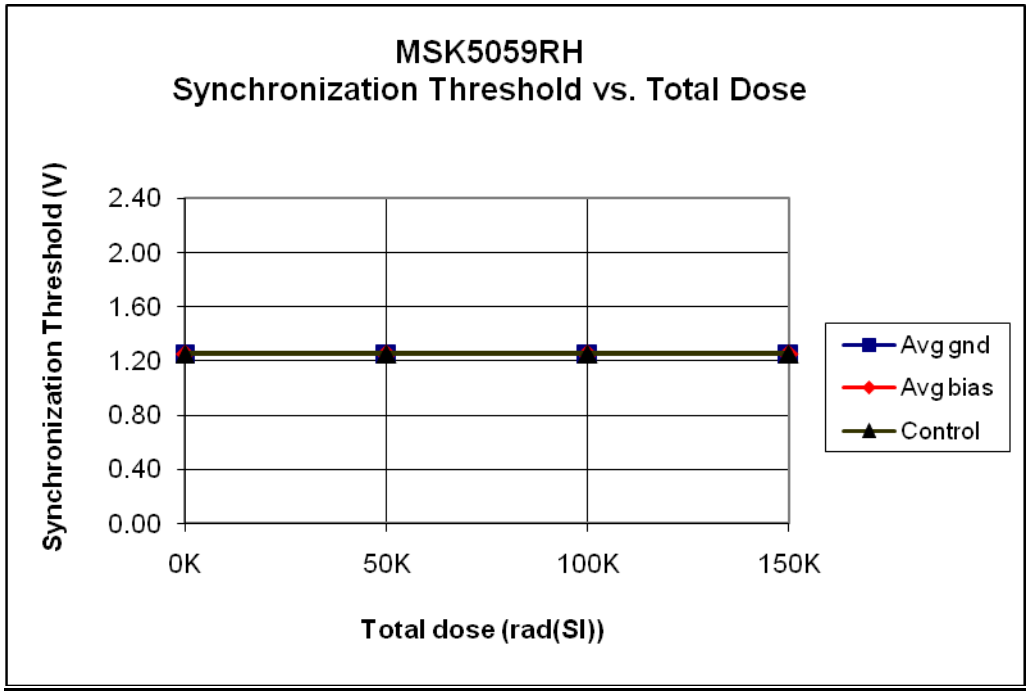

MSK5059RH
Feedback Line Regulation vs. Total Dose
Feedback Voltage Line Reg. (%/V)
0.05
0.03
0.01
-0.01
-0.03
-0.05
0K
50K
100K
150K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

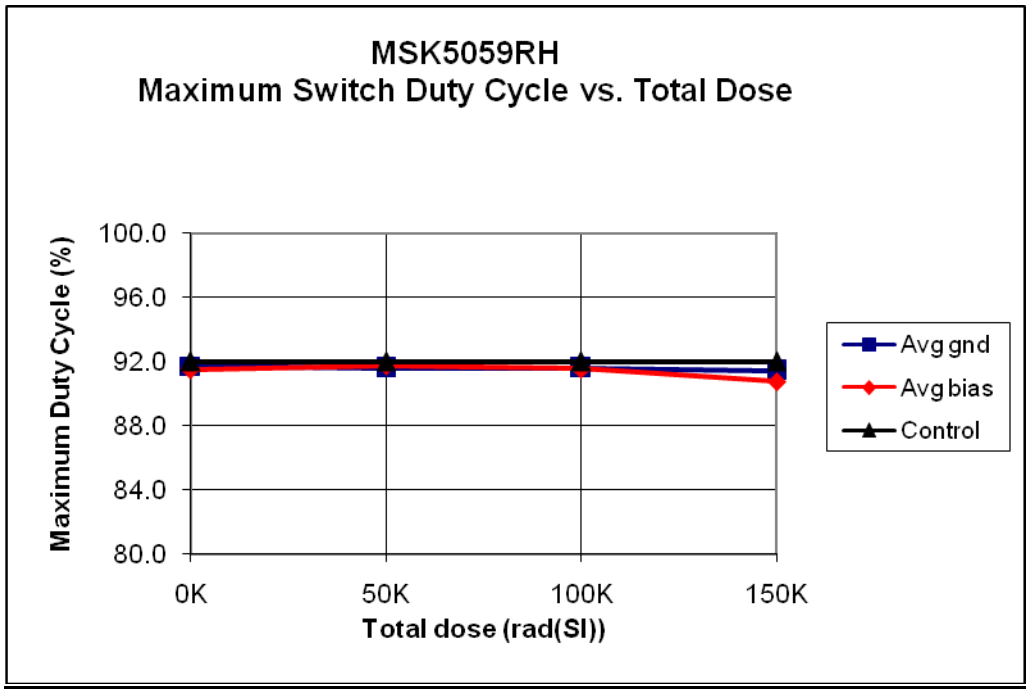

MSK5059RH
Feedback Input Bias Current vs. Total Dose
Feedback Input Bias Current (uA)
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
0K
50K
100K
150K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

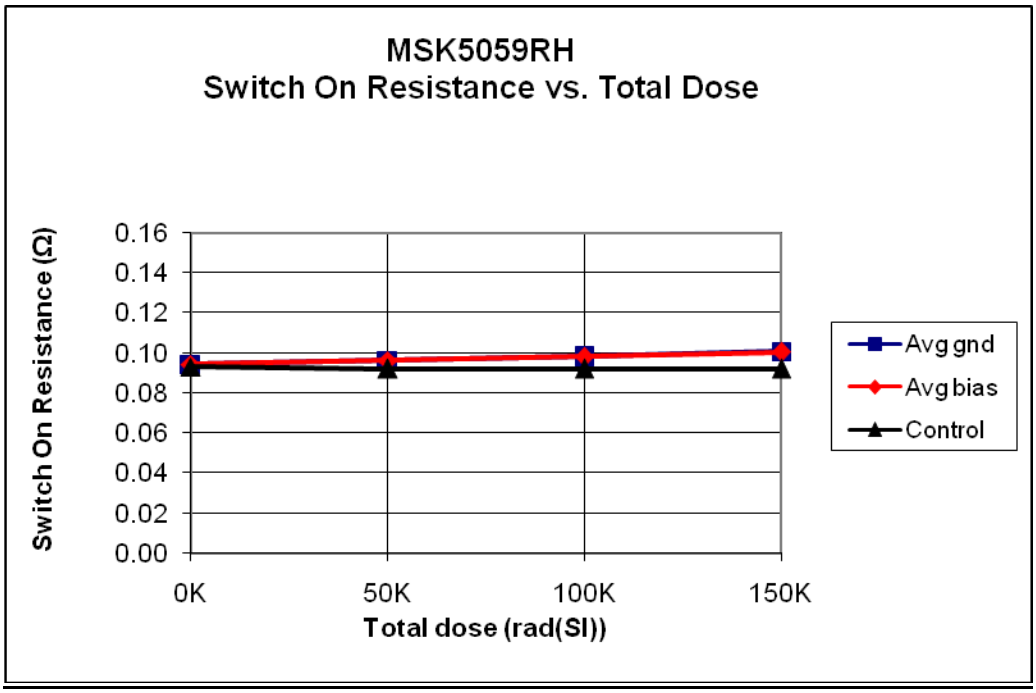

MSK5059RH
Switch Frequency vs. Total Dose
Switch Frequency (KHz)
540
520
500
480
460
440
420
400
380
0K
50K
100K
150K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

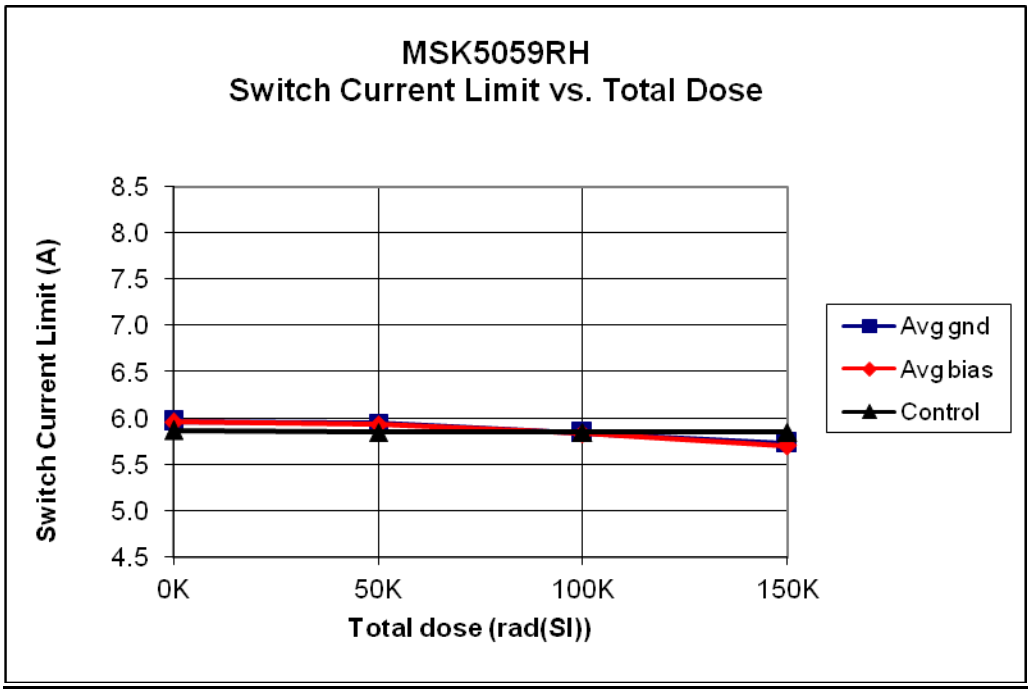

MSK5059RH
Switch Frequency Line Regulation vs. Total Dose
Switch Frequency Line Regulation (%/V)
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
0K
50K
100K
150K
Total dose (rad(Si))
Avg gnd
Avg bias
Control


MSK5059RH
Frequency Shifting Threshold on FB Pin vs. Total Dose
Shifting Threshold (V)
1.00
0.90
0.80
0.70
0.60
0.50
0K
50K
100K
150K
Total dose (rad(Si))
Avg gnd
Avg bias
Control


MSK5059RH
Synchronization Threshold vs. Total Dose
Synchronization Threshold (V)
2.40
2.00
1.60
1.20
0.80
0.40
0.00
0K
50K
100K
150K
Total dose (rad(Si))
Avg gnd
Avg bias
Control


MSK5059RH
Maximum Switch Duty Cycle vs. Total Dose
Maximum Duty Cycle (%)
100.0
96.0
92.0
88.0
84.0
80.0
0K
50K
100K
150K
Total dose (rad(Si))
Avg gnd
Avg bias
Control


MSK5059RH
Switch On Resistance vs. Total Dose
Switch On Resistance (Ω)
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0K
50K
100K
150K
Total dose (rad(Si))
Avg gnd
Avg bias
Control


MSK5059RH
Switch Current Limit vs. Total Dose
Switch Current Limit (A)
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
0K
50K
100K
150K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

TID and ELDRS Radiation Test Report

MSK5059RH

MFG Lot/ Wafer: WP004619 WF#2,
WP004844 WF#1,
W0950586.1 WF#1

November 22, 2010 (TID – First Test)
March 4, 2011 (TID - Updated)
June, 2011 (ELDRS Test)

B. Erwin
B. Horton

M.S. Kennedy Corporation
Liverpool, NY

I. Introduction:

The ELDRS radiation test plan for the MSK5059RH was developed to characterize Enhanced Low Dose Rate Sensitivity. ELDRS testing was performed to 50Krad(Si) accumulated dose.

MIL-STD-883 Method 1019.8 Condition D and ASTM F1892-06 were used as guidelines in the development and implementation of the ELDRS test plan for the MSK 5059RH.

II. Radiation Source:

ELDRS test was performed at the University of Massachusetts, Lowell, using a cobalt 60 radiation source. Dosimetry was performed prior to device irradiation and the dose rate was determined to be 0.01 rads(Si)/sec. The ELDRS 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 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 in the University of Massachusetts ELDRS facility, chamber #2. Fifteen devices (five from each lot) were kept under bias during irradiation. The maximum recommended operating voltage of +15 Volts was used for bias. Fifteen devices (Five from each lot) had all leads grounded during irradiation for the unbiased condition.

Electrical testing was performed on the irradiated devices, as well as the control device, at each total dose level. After the first and second irradiation steps, the device leads were shorted together and then transported to the MSK automatic electrical test platform for test In accordance with the MSK5059RH data sheet. The devices were returned to the irradiation field within 120 hours of removal from the radiation source per MIL-STD-883 Method 1019.8 Condition D. After the final irradiation the devices were packaged with dry ice for shipment, and shipped overnight to the MSK facility. Electrical testing IAW the MSK5059RH data sheet was performed within 72 hours from the removal of the radiation source. To prove that the device temperature did not exceed the irradiation chamber temperature, it was verified that dry ice remained in the insulated shipping container during the shipping process.

IV. Data:

All performance curves are averaged from the combined three lot test results of the biased and unbiased devices.

V. Summary:

Low dose rate irradiation and testing of the MSK5059RH resulted in most test parameters showing very little change up to 50Krad(Si) total dose.

Shutdown threshold decreased slightly, but stayed within pre-irradiation limits.

.

A marked increase in feedback input bias current occurred at 14 Krad(Si), but a slight decrease was seen at 30 Krad(Si). At the final dose level the feedback input bias remained stable.

The switch frequency exhibited a decrease. This decrease was nearly linear throughout the dose points.

In addition, switch current limit also showed a decrease during irradiation. However, this parameter stayed within pre-irradiation limits through all testing to 50 Krad(Si).

MSK 5059RH Biased/Unbiased Dose Rate Schedule

Dosimetry Equipment
Bruker Biospin # 0162

Irradiation Date
6/1/2011 – 8/3/2011

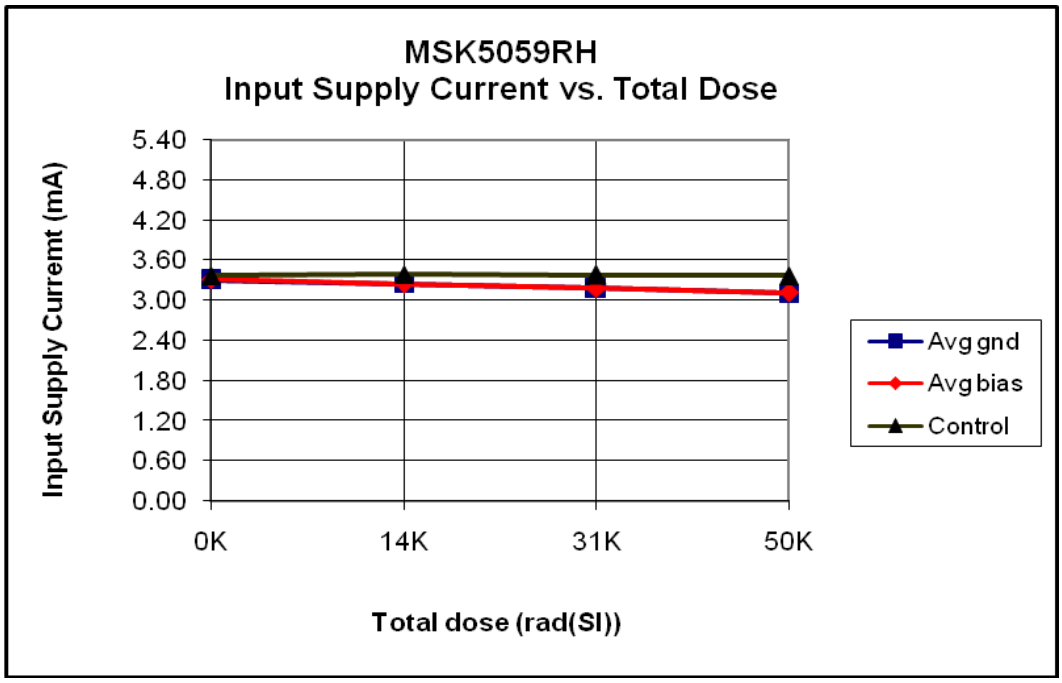
Exposure Length (hr:min:sec)	Incremental Dose rads(Si)	Cumulative Dose rads(Si)
379:55:00	13,600	13,600
473:49:00	16,900	30,500
591:01:00	20,900	51,400

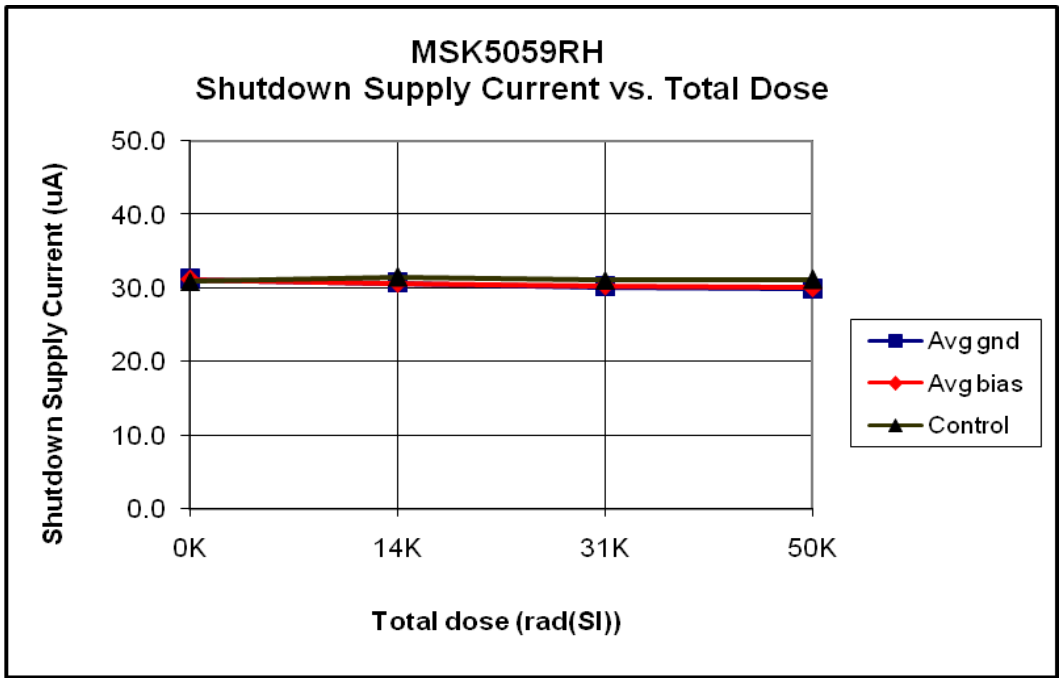
Biased S/N – 0204, 0205, 0206, 0207, 0208, 0495, 0496, 0497, 0498, 0499, 0395, 0397, 0398, 0400, 0401

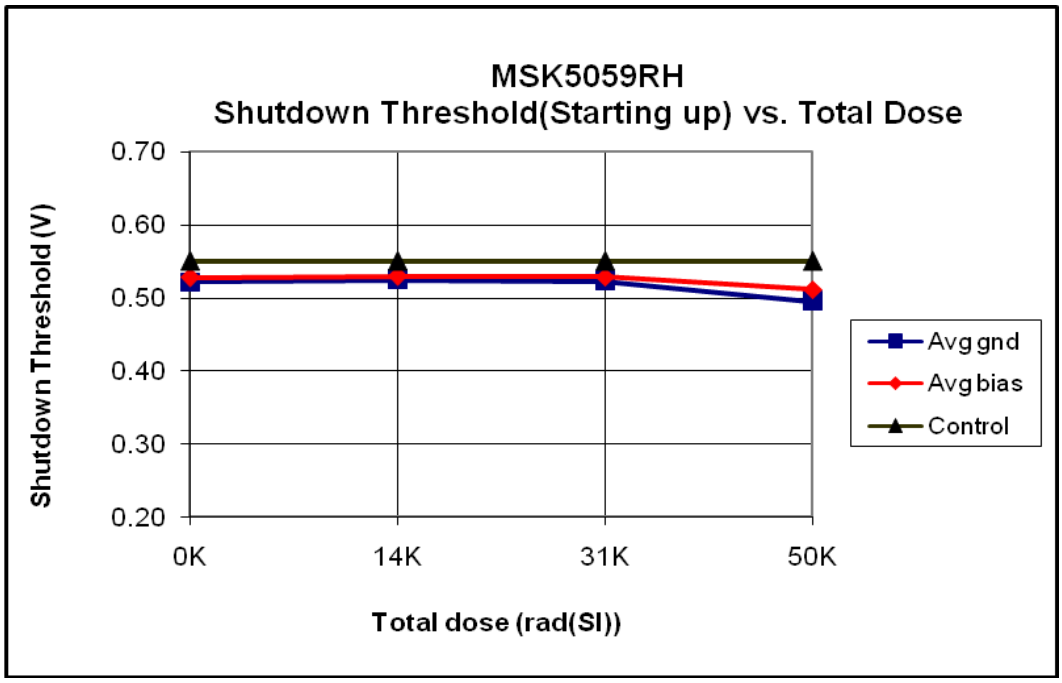
Unbiased S/N – 0209, 0210, 0211, 0212, 0213, 0500, 0501, 0502, 0503, 0504, 0402, 0403, 0404, 0405, 0406

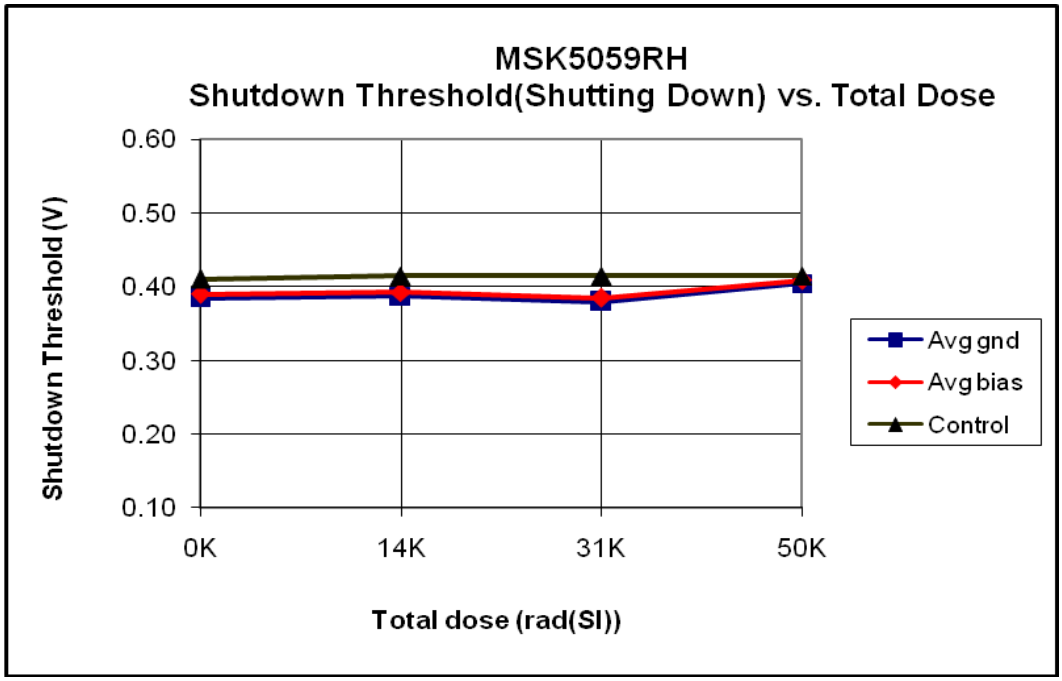
Table 1

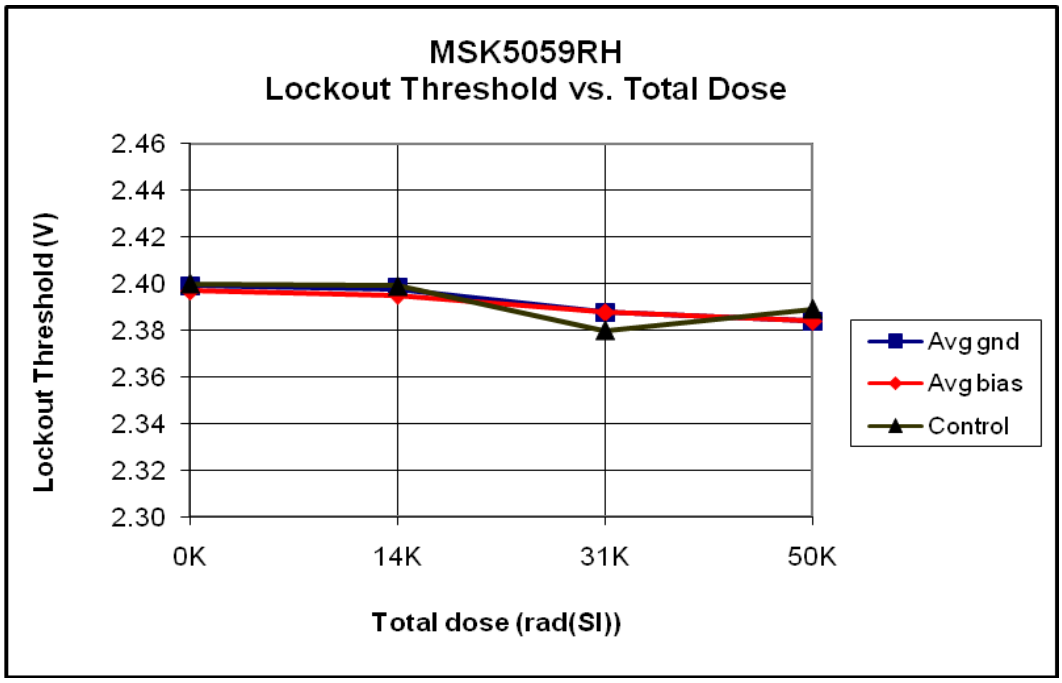
Dose Time, Incremental Dose and Total Cumulative Dose

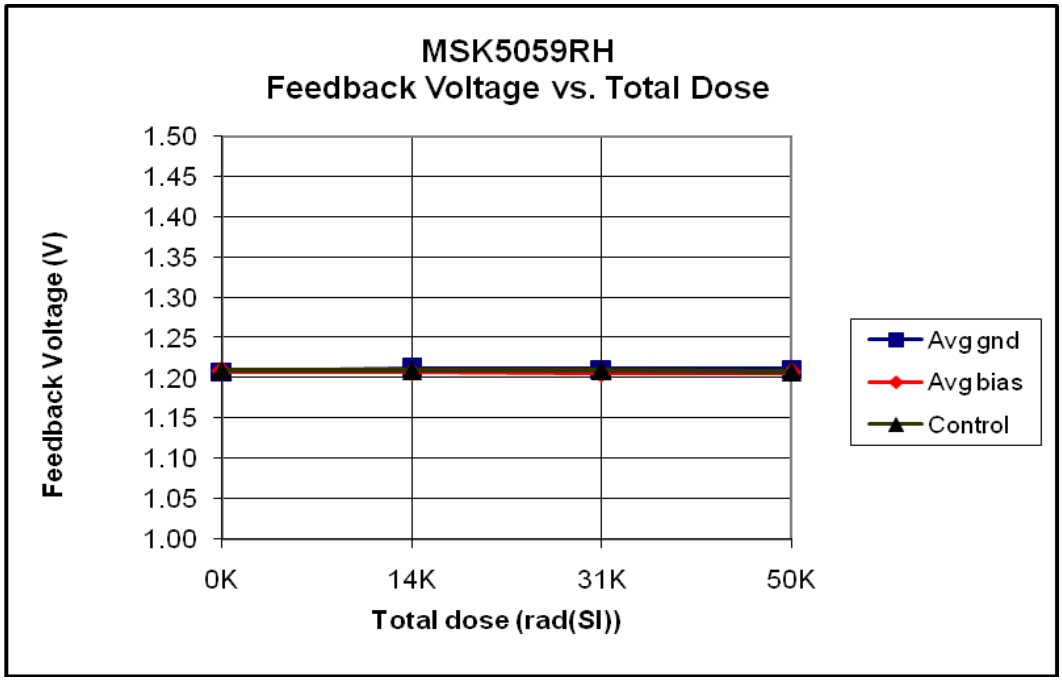

MSK5059RH
Input Supply Current vs. Total Dose
Input Supply Curremt (mA)
5.40
4.80
4.20
3.60
3.00
2.40
1.80
1.20
0.60
0.00
0K
14K
31K
50K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

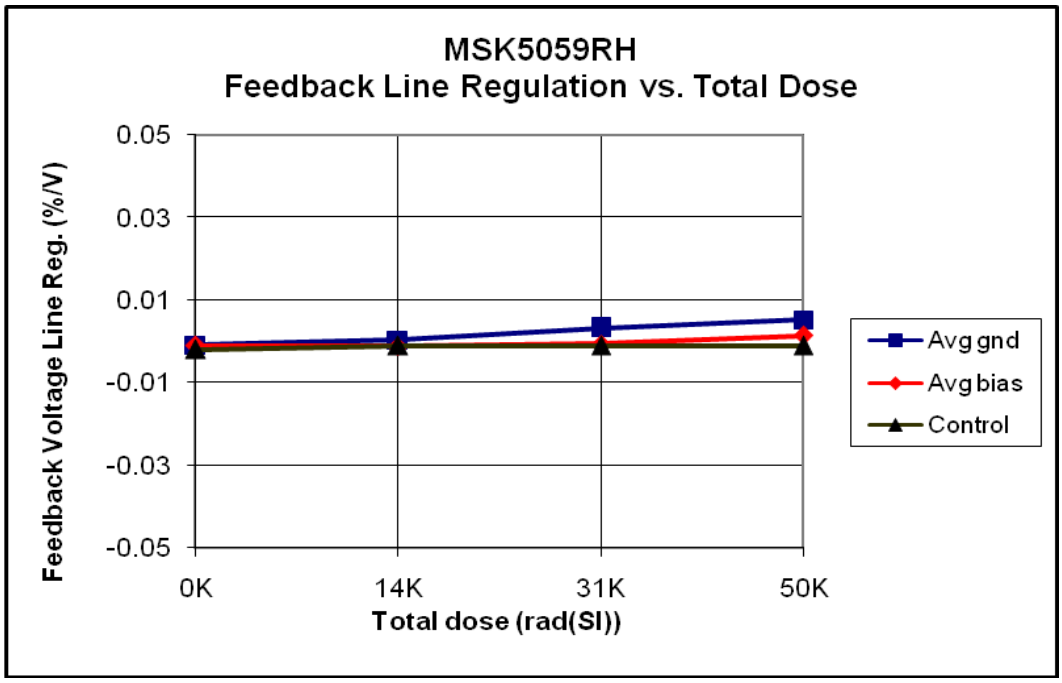

MSK5059RH
Shutdown Supply Current vs. Total Dose
Shutdown Supply Current (uA)
50.0
40.0
30.0
20.0
10.0
0.0
0K
14K
31K
50K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

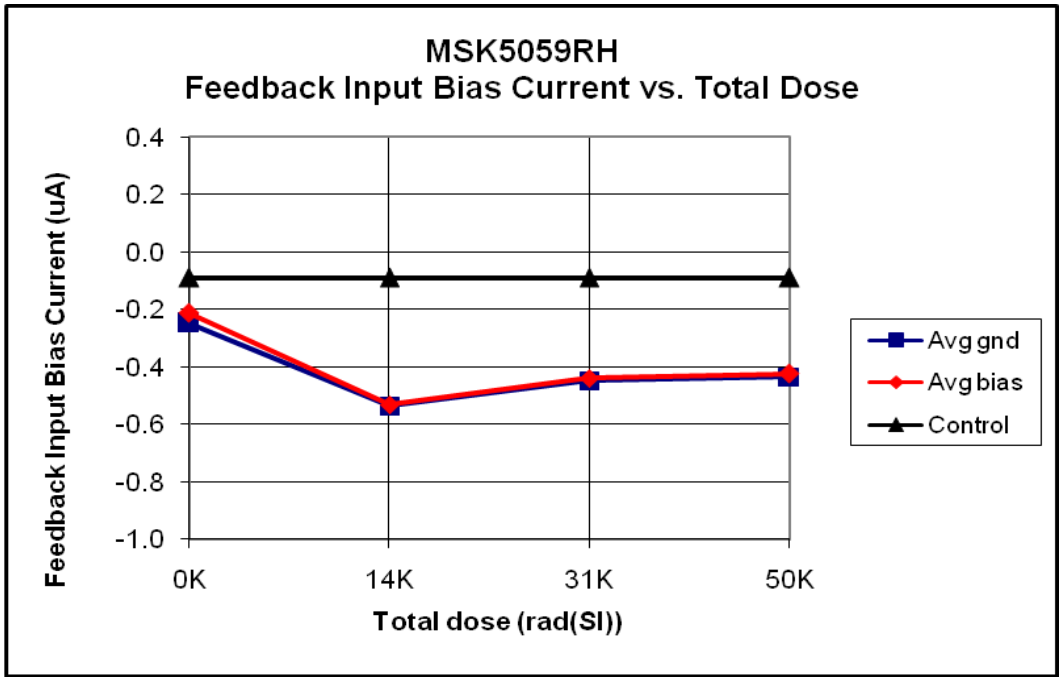

MSK5059RH
Shutdown Threshold(Starting up) vs. Total Dose
Shutdown Threshold (V)
0.70
0.60
0.50
0.40
0.30
0.20
0K
14K
31K
50K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

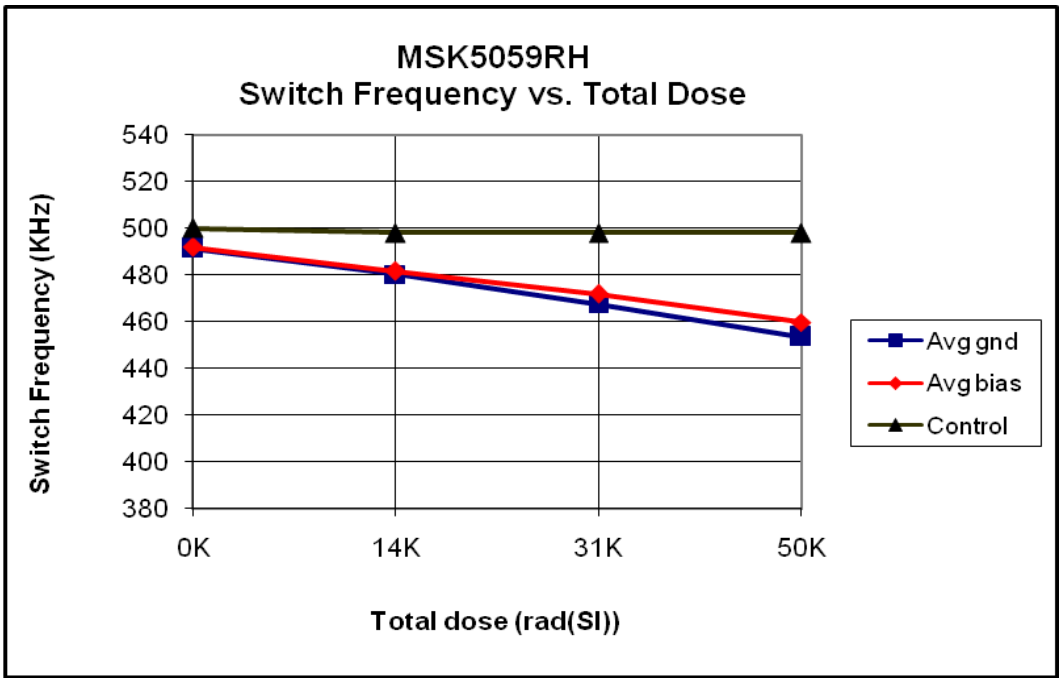

MSK5059RH
Shutdown Threshold(Shutting Down) vs. Total Dose
Shutdown Threshold (V)
0.60
0.50
0.40
0.30
0.20
0.10
0K
14K
31K
50K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

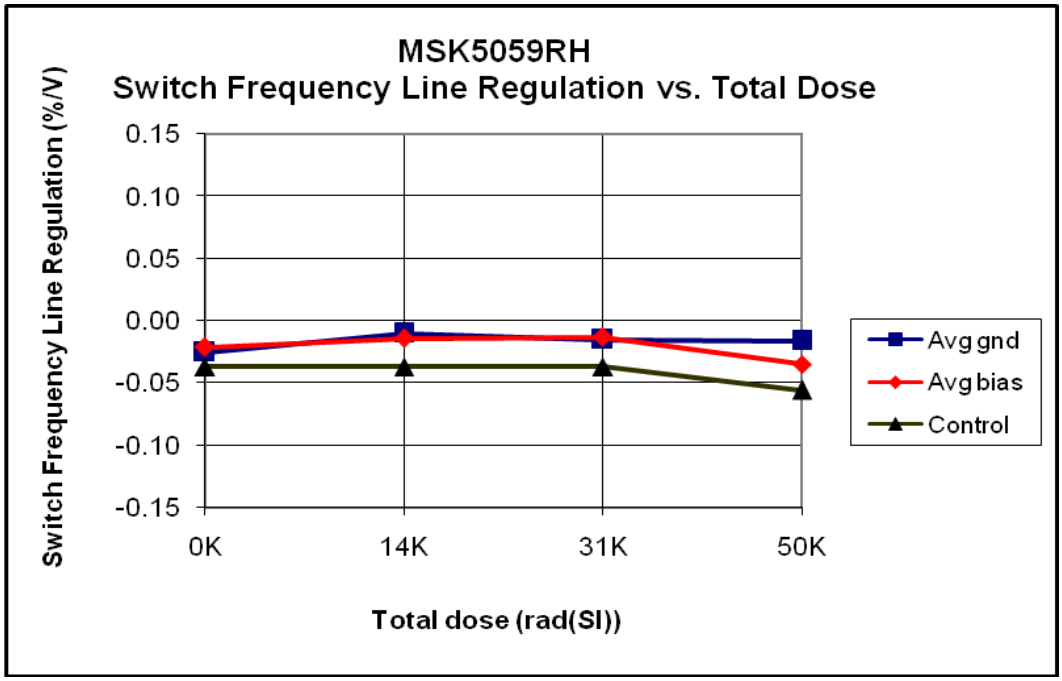

MSK5059RH
Lockout Threshold vs. Total Dose
Lockout Threshold (V)
2.46
2.44
2.42
2.40
2.38
2.36
2.34
2.32
2.30
0K
14K
31K
50K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

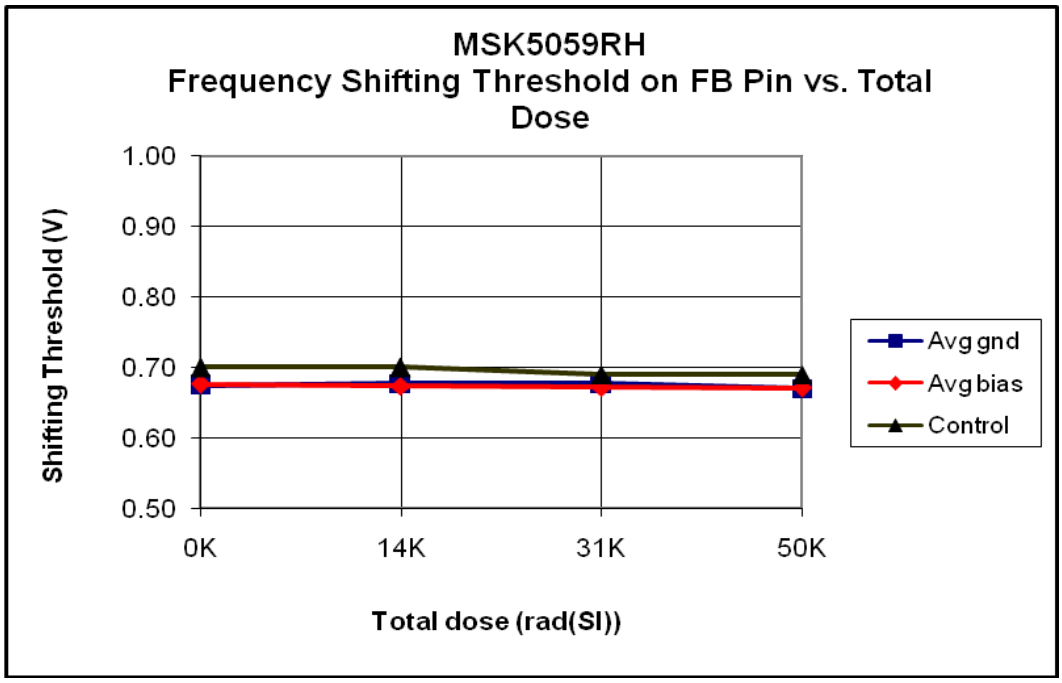

MSK5059RH
Feedback Voltage vs. Total Dose
Feedback Voltage (V)
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
0K
14K
31K
50K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

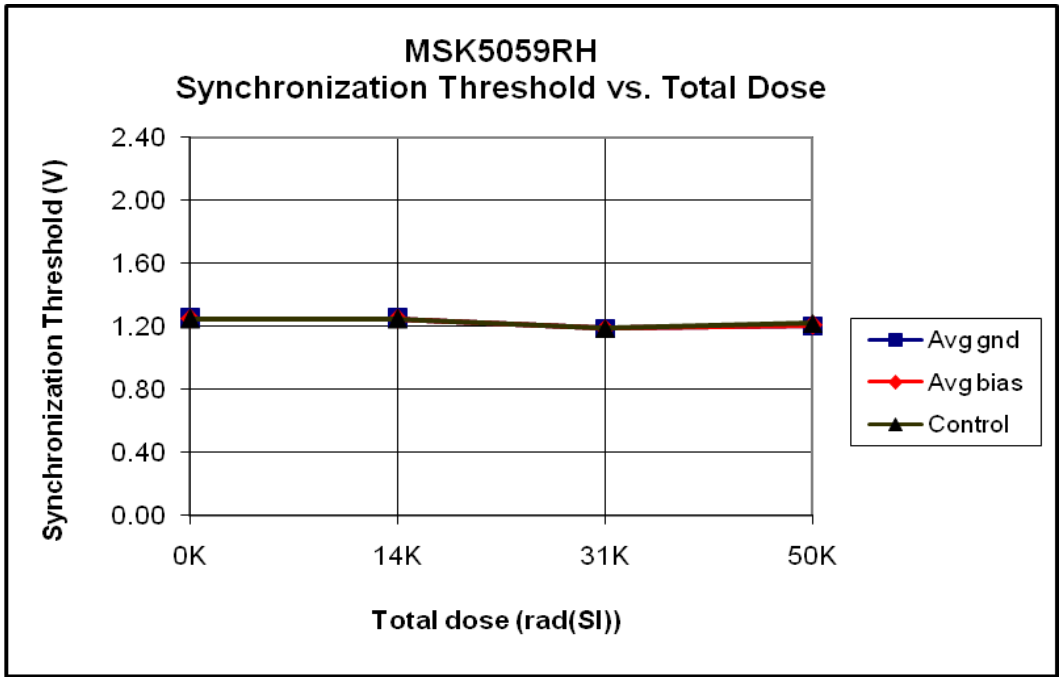

MSK5059RH
Feedback Line Regulation vs. Total Dose
Feedback Voltage Line Reg. (%/V)
0.05
0.03
0.01
-0.01
-0.03
-0.05
0K
14K
31K
50K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

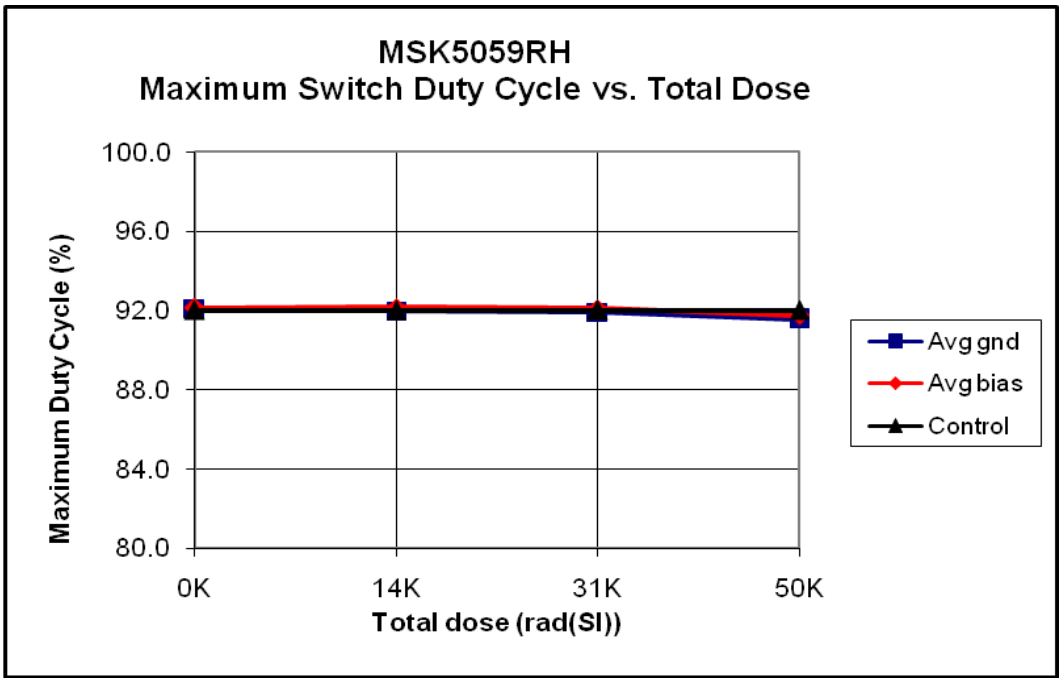

MSK5059RH
Feedback Input Bias Current vs. Total Dose
Feedback Input Bias Current (uA)
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
0K
14K
31K
50K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

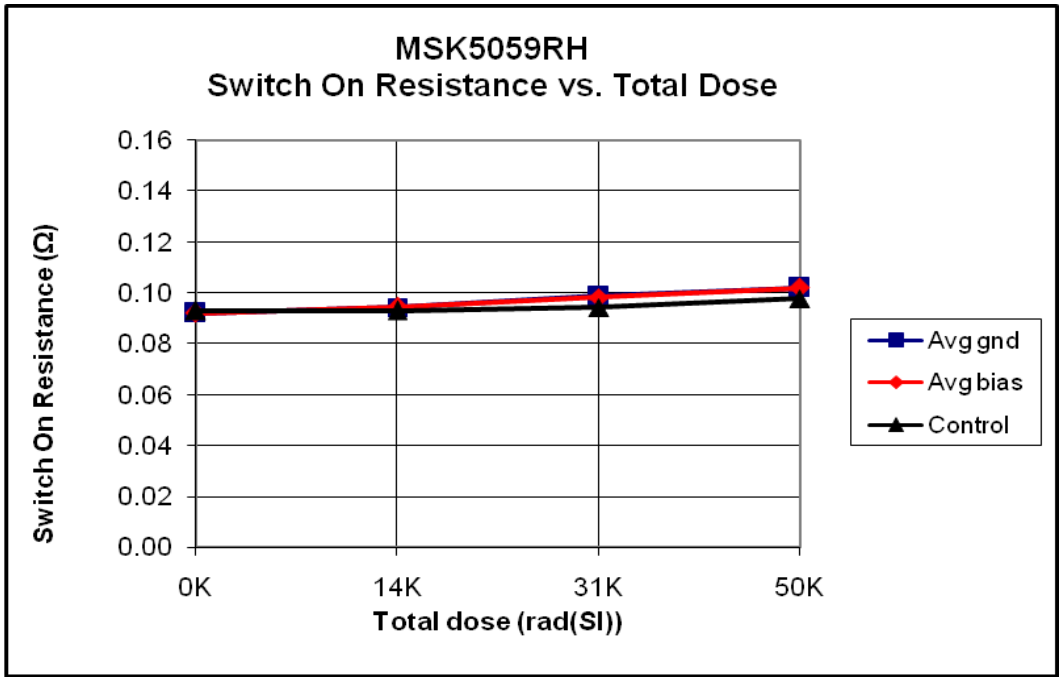

MSK5059RH
Switch Frequency vs. Total Dose
Switch Frequency (KHz)
540
520
500
480
460
440
420
400
380
0K
14K
31K
50K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

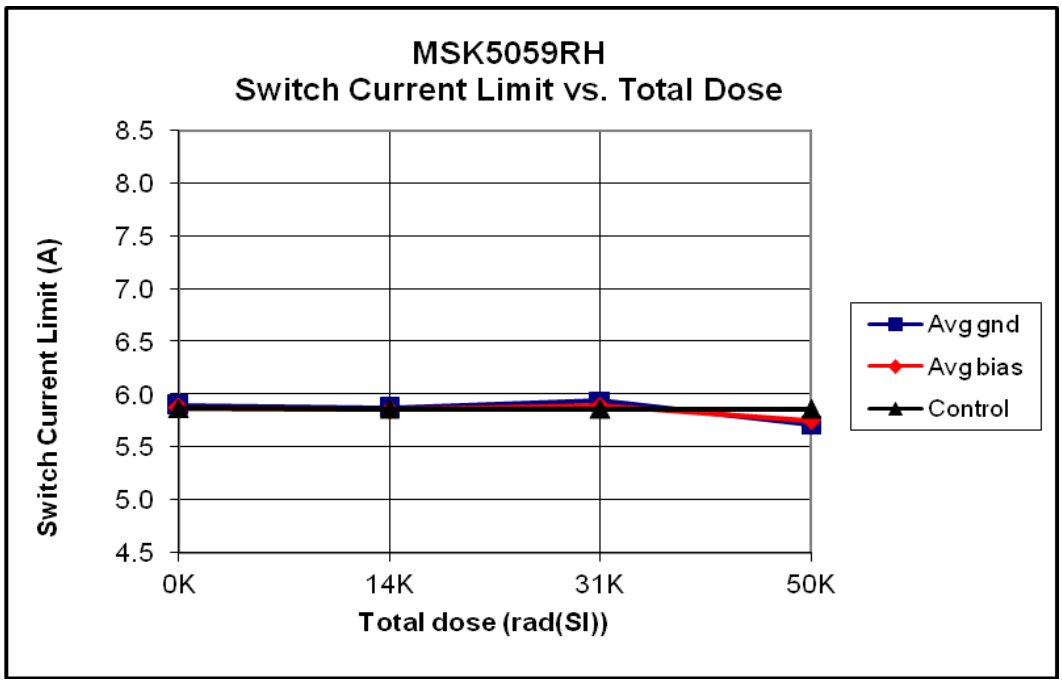

MSK5059RH
Switch Frequency Line Regulation vs. Total Dose
Switch Frequency Line Regulation (%/V)
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
0K
14K
31K
50K
Total dose (rad(Si))
Avg gnd
Avg bias
Control


MSK5059RH
Frequency Shifting Threshold on FB Pin vs. Total Dose
Shifting Threshold (V)
1.00
0.90
0.80
0.70
0.60
0.50
0K
14K
31K
50K
Total dose (rad(Si))
Avg gnd
Avg bias
Control


MSK5059RH
Synchronization Threshold vs. Total Dose
Synchronization Threshold (V)
2.40
2.00
1.60
1.20
0.80
0.40
0.00
0K
14K
31K
50K
Total dose (rad(Si))
Avg gnd
Avg bias
Control


MSK5059RH
Maximum Switch Duty Cycle vs. Total Dose
Maximum Duty Cycle (%)
100.0
96.0
92.0
88.0
84.0
80.0
0K
14K
31K
50K
Total dose (rad(Si))
Avg gnd
Avg bias
Control


MSK5059RH
Switch On Resistance vs. Total Dose
Switch On Resistance (Ω)
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0K
14K
31K
50K
Total dose (rad(Si))
Avg gnd
Avg bias
Control


MSK5059RH
Switch Current Limit vs. Total Dose
Switch Current Limit (A)
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
0K
14K
31K
50K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

Total Dose Radiation Test Report

MSK5059RH
RAD Hard 4.5A, 500 KHz Step Down Switching Regulator Controller

November 22, 2010 (MSK5059RH – First Test)
March 4, 2011 (Updated)

M. Bilecki
B. Erwin

M.S. Kennedy Corporation
Liverpool, NY

I. Introduction:

The total dose radiation test plan for the MSK 5059RH was developed to qualify the device as radiation tolerant up to 100 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 hybrid, but simply offers designers insight to the critical parameter-shifts beyond 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 5059RH.

II. Radiation Source:

Total dose was performed at the University of Massachusetts, Lowell, using a cobalt 60 radiation source. Dosimetry was performed prior to device irradiation and the dose rate was determined to be 130 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 the device data sheet. 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 Pb/Al container during irradiation to minimize dose enhancement effects. Five devices were kept under bias during irradiation. Five devices had all leads grounded during irradiation for the unbiased condition.

After each irradiation, the device leads were shorted together and were 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.

IV. Data:

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

V. Summary:

Total dose irradiation and testing of the MSK 5059RH resulted in most test parameters showing very little change up to 300Krad(Si) and beyond.

A significant increase in feedback input bias current occurred at 50 Krad(Si), but a slight decrease was seen at 100 Krad(Si). At subsequent dose levels the feedback input bias remained stable.

The switch frequency exhibited a marked decrease of approximately 6.5% at 100 Krad(Si). The change in the frequency was nearly linear throughout the dose points.

In addition, switch current limit also showed a 5 % decrease at 100 Krad(Si). However, this parameter stayed within pre-irradiation limits through all testing up to 450 Krad(Si).

MSK5059RH Biased/Unbiased Dose Rate Schedule

Dosimetry Equipment
Bruker Biospin # 0141

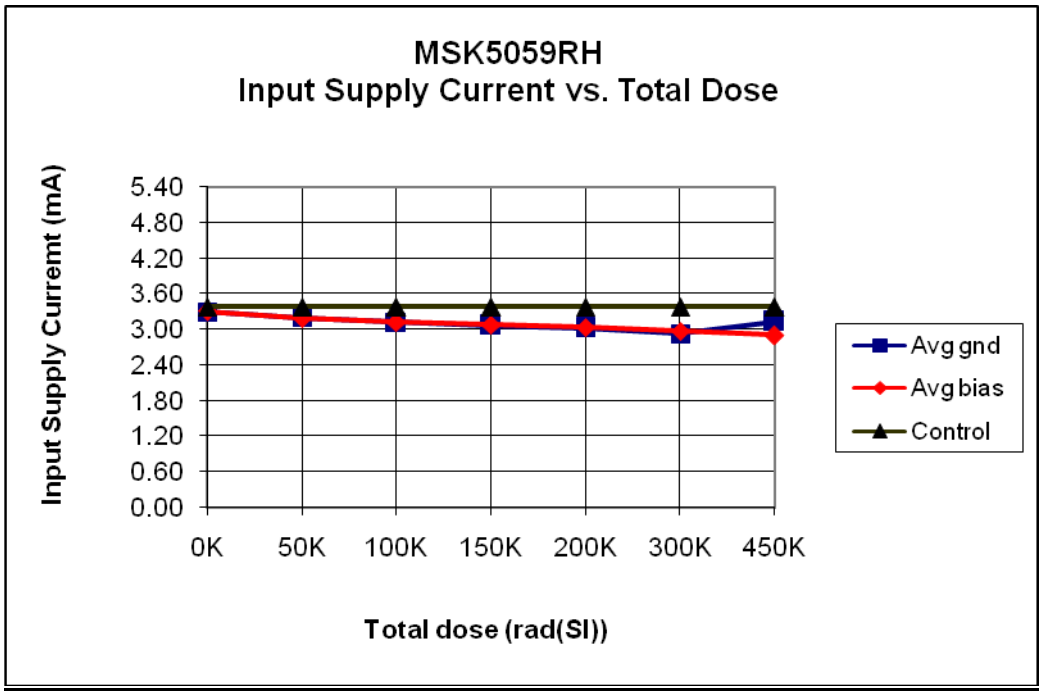
Irradiation Date
11/12/2010

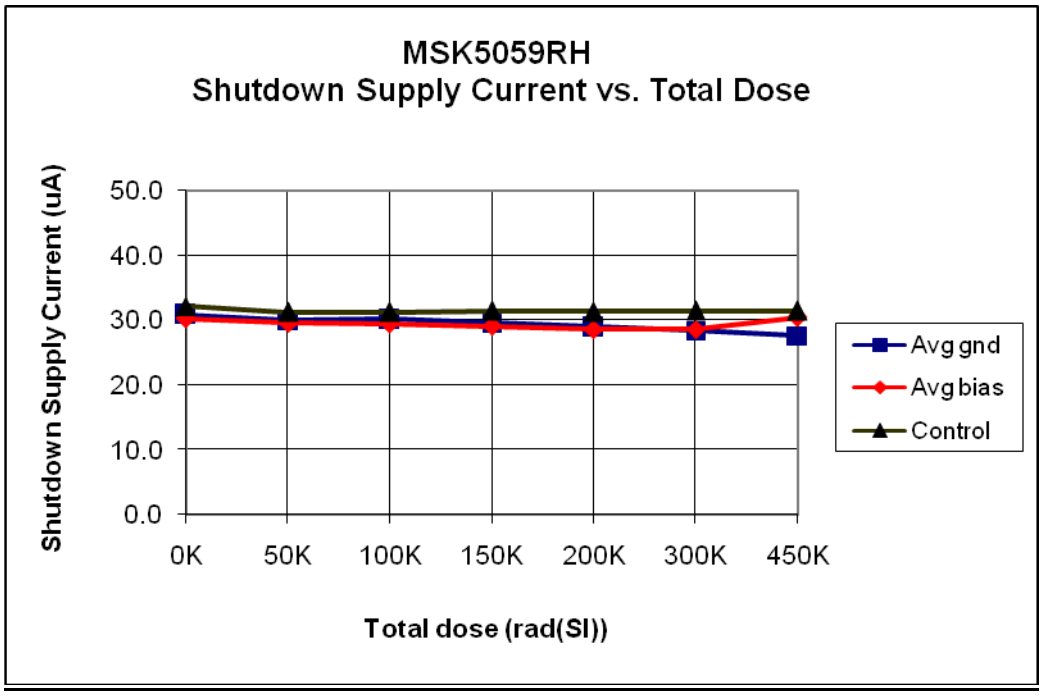
Exposure Length (min:sec)	Incremental Dose rads(Si)	Cumulative Dose rads(Si)
6:36	51,480	51,480
6:36	51,480	102,960
6:36	51,480	154,440
6:36	51,480	205,920
13:12	102,960	308,880
19:48	154,440	463,320

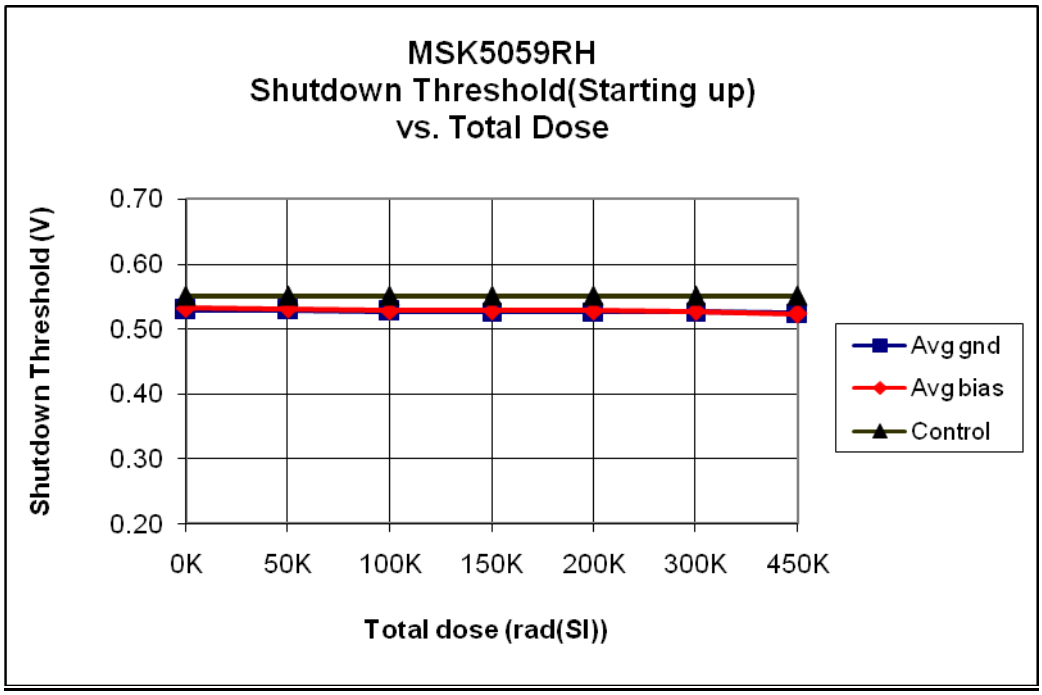
Biased S/N – 0079, 0080, 0081, 0082, 0083

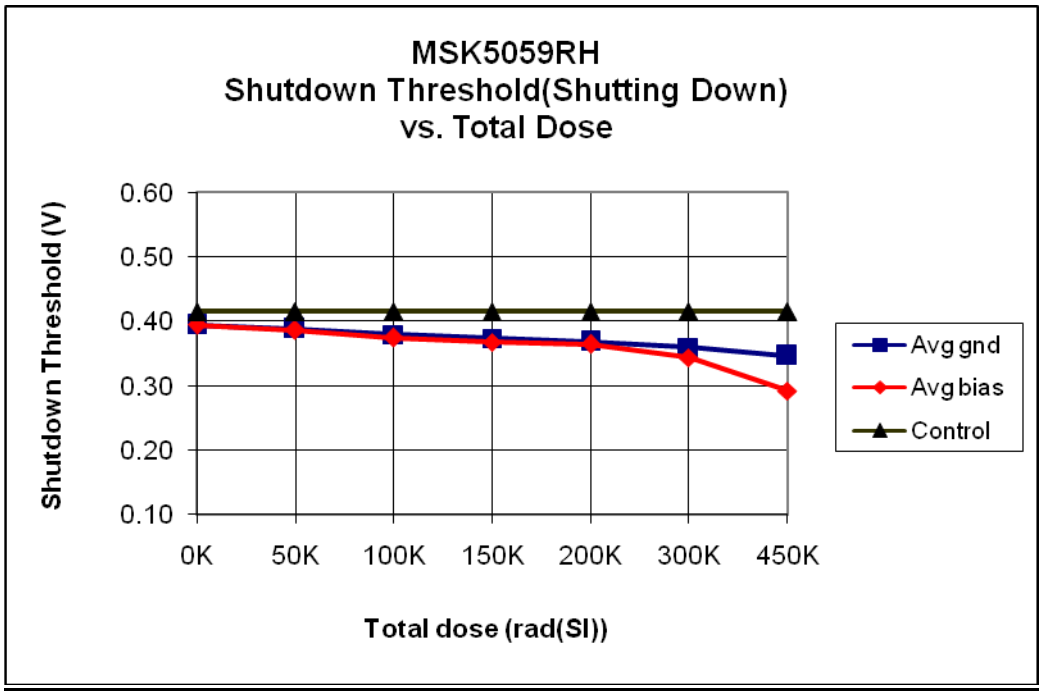
Unbiased S/N – 0084, 0085, 0086, 0087, 0088

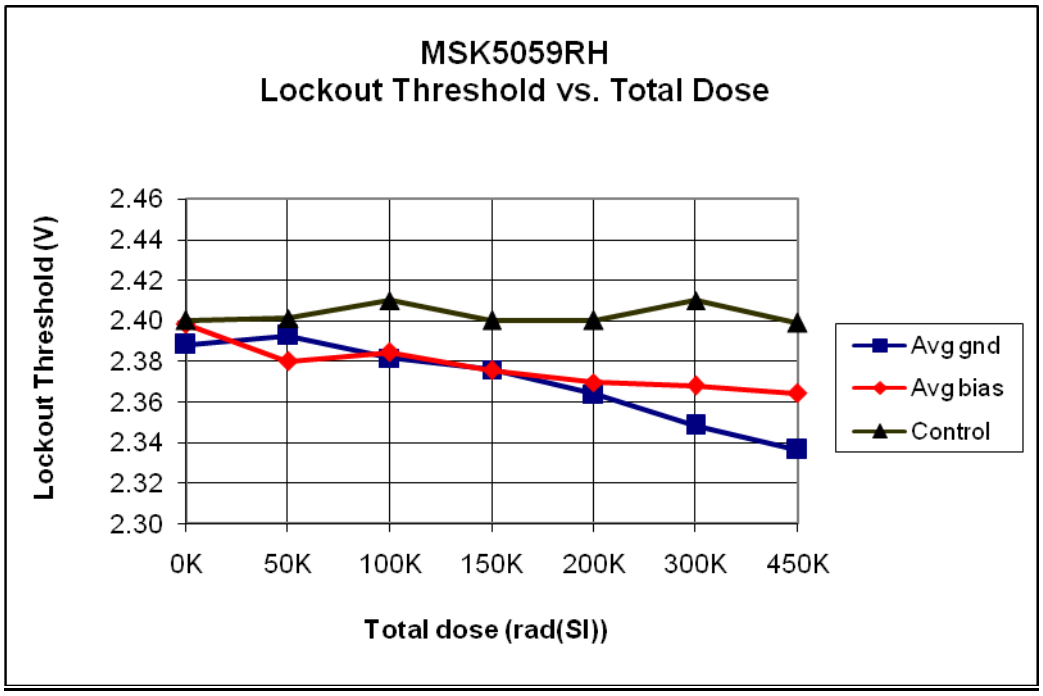
Table 1
Dose Time, Incremental Dose and Total Cumulative Dose

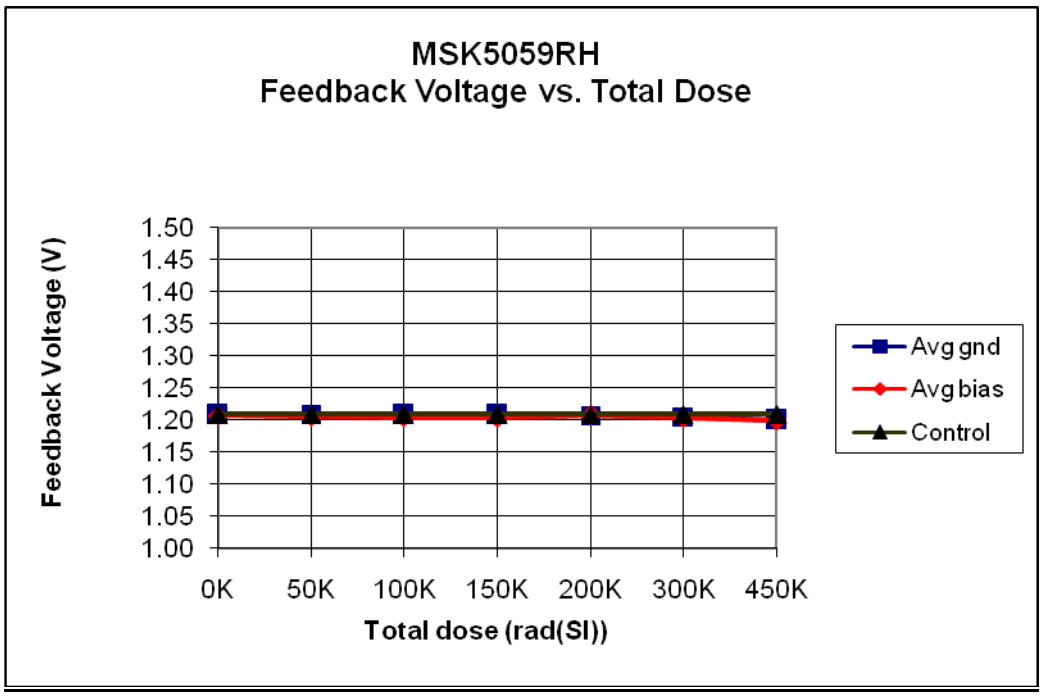

MSK5059RH
Input Supply Current vs. Total Dose
Input Supply Curremt (mA)
5.40
4.80
4.20
3.60
3.00
2.40
1.80
1.20
0.60
0.00
0K
50K
100K
150K
200K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

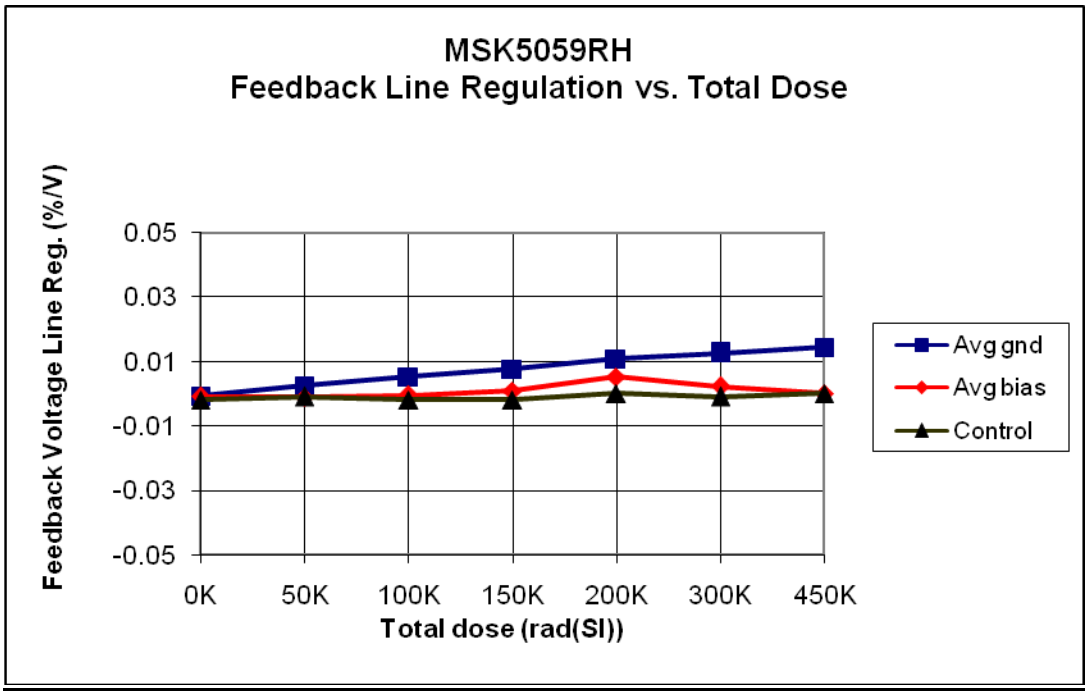

MSK5059RH
Shutdown Supply Current vs. Total Dose
Shutdown Supply Current (uA)
50.0
40.0
30.0
20.0
10.0
0.0
0K
50K
100K
150K
200K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

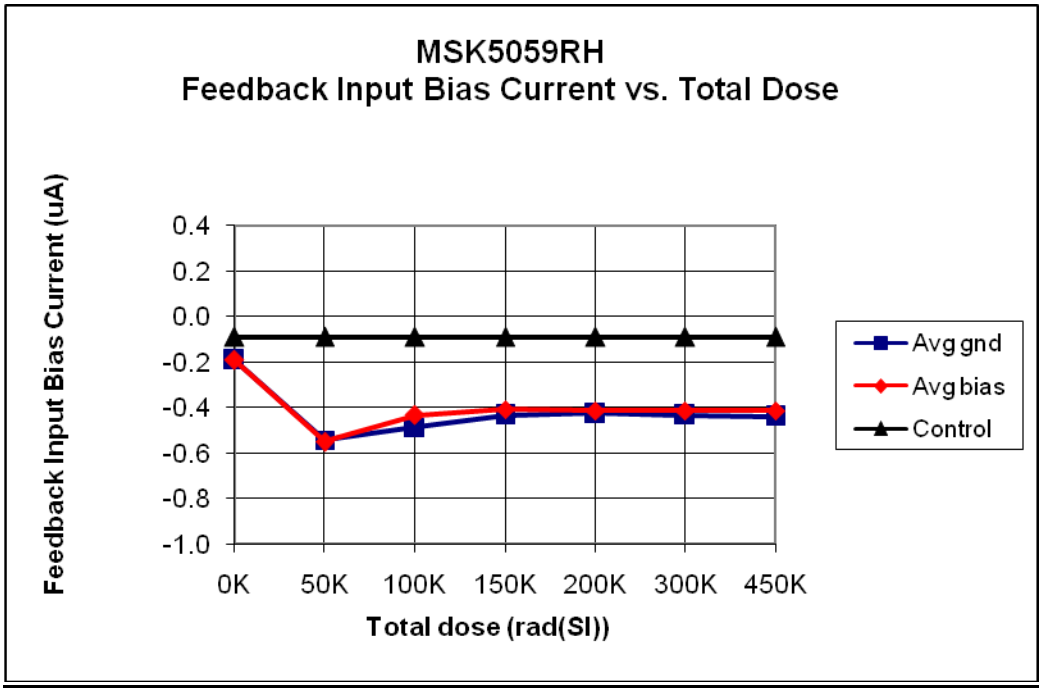

MSK5059RH
Shutdown Threshold(Starting up)
vs. Total Dose
Shutdown Threshold (V)
0.70
0.60
0.50
0.40
0.30
0.20
0K
50K
100K
150K
200K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

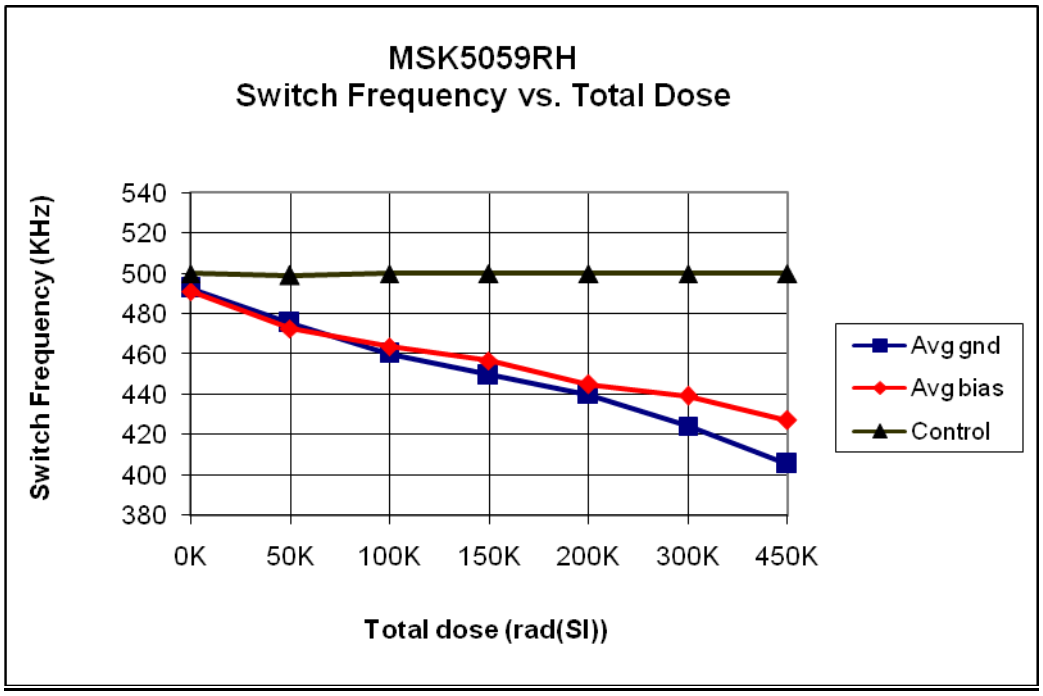

MSK5059RH
Shutdown Threshold(Shutting Down)
vs. Total Dose
Shutdown Threshold (V)
0.60
0.50
0.40
0.30
0.20
0.10
0K
50K
100K
150K
200K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

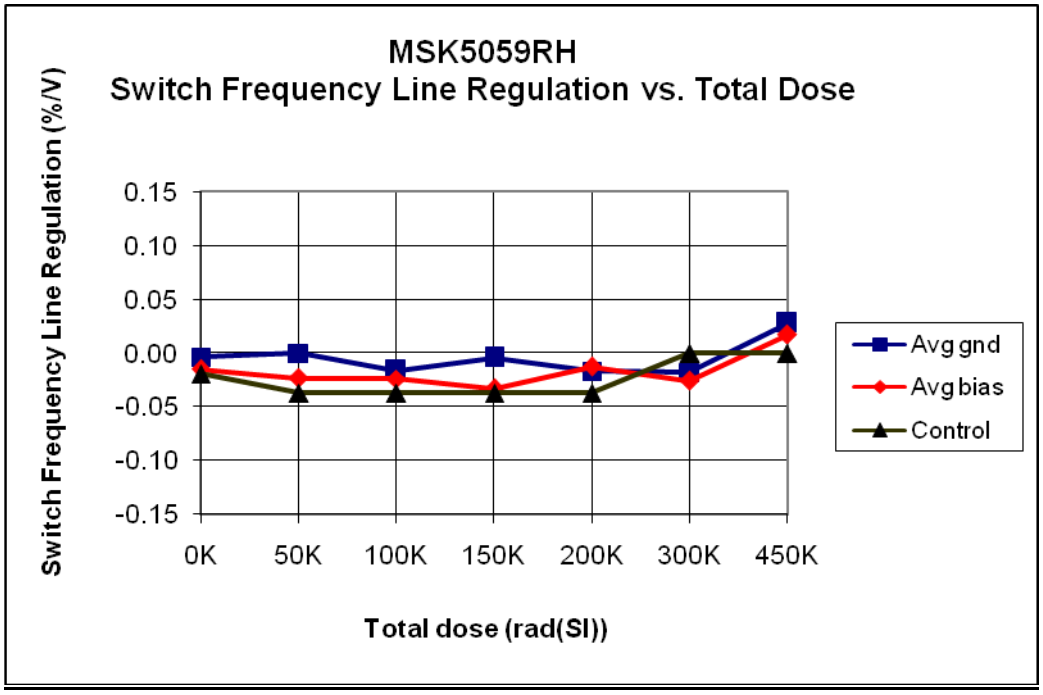

MSK5059RH
Lockout Threshold vs. Total Dose
Lockout Threshold (V)
2.46
2.44
2.42
2.40
2.38
2.36
2.34
2.32
2.30
0K
50K
100K
150K
200K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

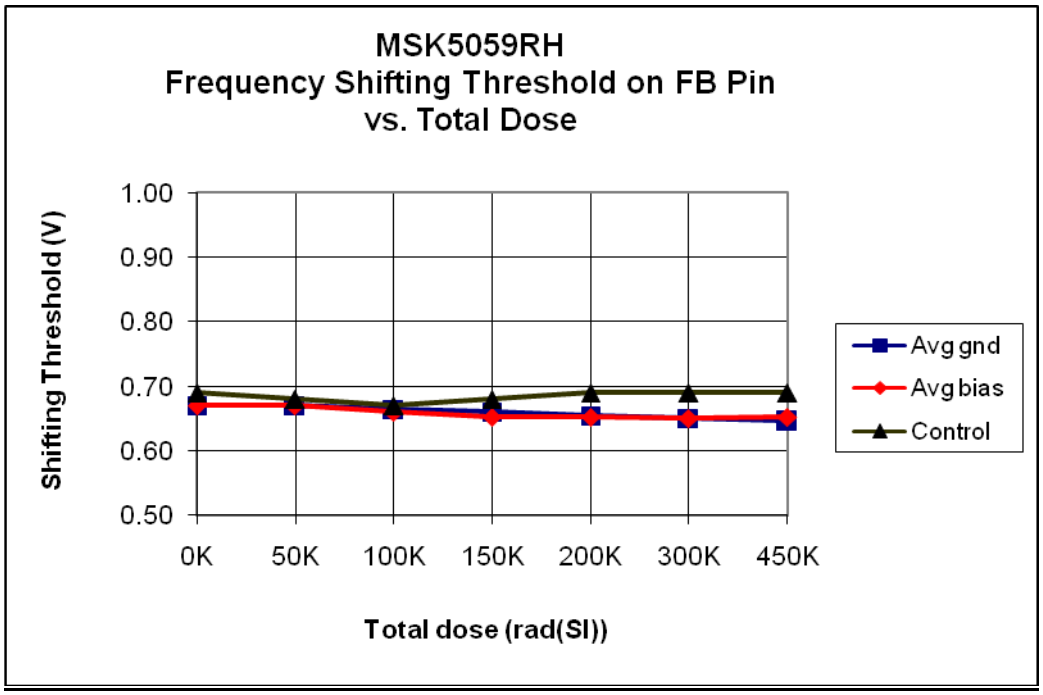

MSK5059RH
Feedback Voltage vs. Total Dose
Feedback Voltage (V)
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
0K
50K
100K
150K
200K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

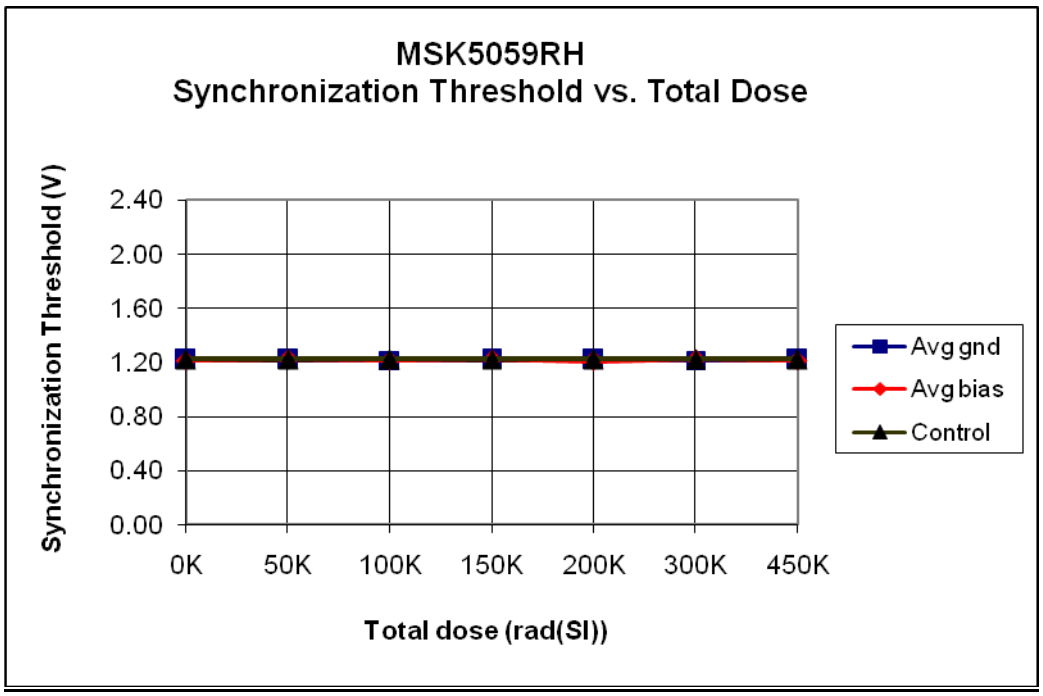

MSK5059RH
Feedback Line Regulation vs. Total Dose
Feedback Voltage Line Reg. (%/V)
0.05
0.03
0.01
-0.01
-0.03
-0.05
0K
50K
100K
150K
200K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

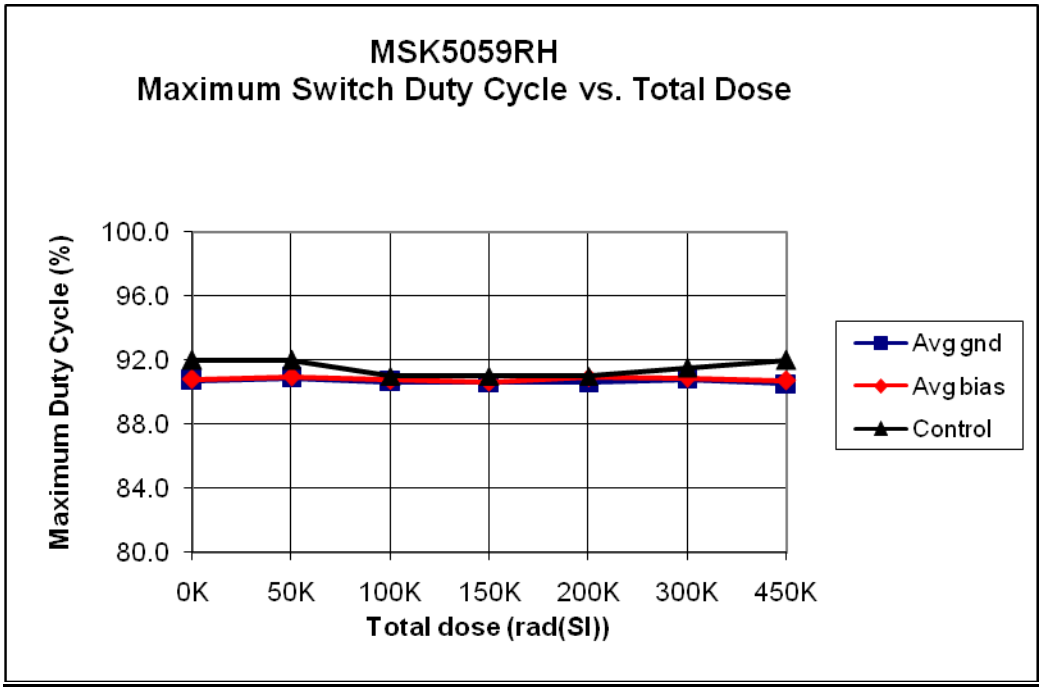

MSK5059RH
Feedback Input Bias Current vs. Total Dose
Feedback Input Bias Current (uA)
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
0K
50K
100K
150K
200K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

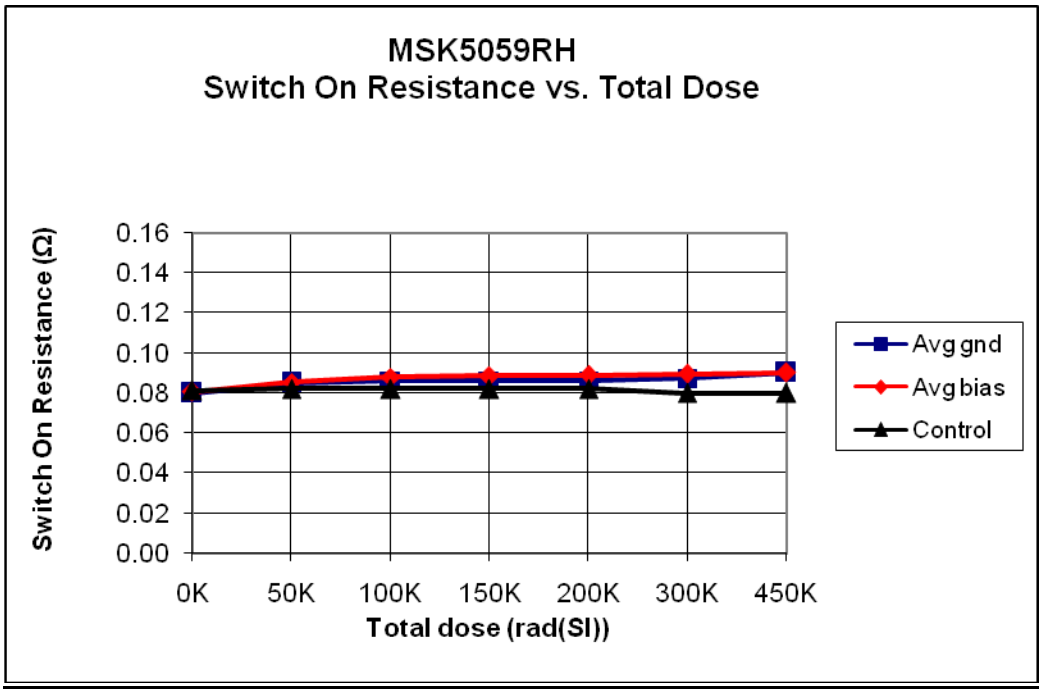

MSK5059RH
Switch Frequency vs. Total Dose
Switch Frequency (KHz)
540
520
500
480
460
440
420
400
380
0K
50K
100K
150K
200K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

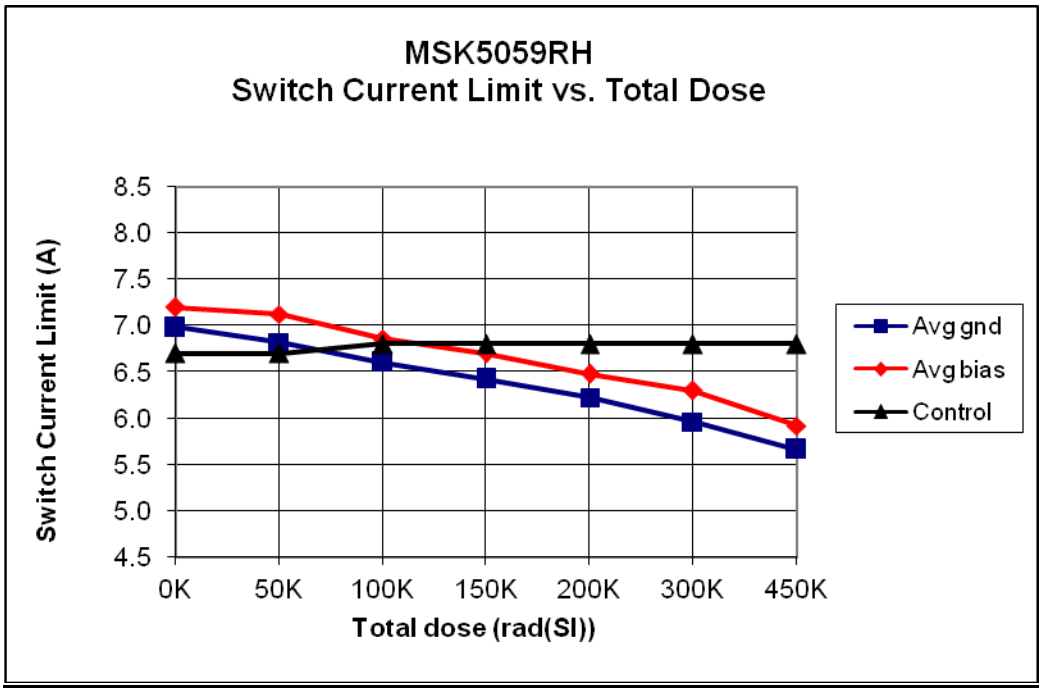

MSK5059RH
Switch Frequency Line Regulation vs. Total Dose
Switch Frequency Line Regulation (%/V)
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
0K
50K
100K
150K
200K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control


MSK5059RH
Frequency Shifting Threshold on FB Pin
vs. Total Dose
Shifting Threshold (V)
1.00
0.90
0.80
0.70
0.60
0.50
0K
50K
100K
150K
200K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control


MSK5059RH
Synchronization Threshold vs. Total Dose
Synchronization Threshold (V)
2.40
2.00
1.60
1.20
0.80
0.40
0.00
0K
50K
100K
150K
200K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control


MSK5059RH
Maximum Switch Duty Cycle vs. Total Dose
Maximum Duty Cycle (%)
100.0
96.0
92.0
88.0
84.0
80.0
0K
50K
100K
150K
200K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control


MSK5059RH
Switch On Resistance vs. Total Dose
Switch On Resistance (Ω)
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0K
50K
100K
150K
200K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control


MSK5059RH
Switch Current Limit vs. Total Dose
Switch Current Limit (A)
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
0K
50K
100K
150K
200K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

Total Dose Radiation Test Report

MSK5059RH
RAD Hard 4.5A, 500 KHz Step Down Switching Regulator Controller

November 22, 2010 (MSK5059RH – First Test)

M. Bilecki
B. Erwin

M.S. Kennedy Corporation
Liverpool, NY

I. Introduction:

The total dose radiation test plan for the MSK 5059RH was developed to qualify the device as radiation tolerant up to 100 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 hybrid, but simply offers designers insight to the critical parameter-shifts beyond 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 5059RH.

Testing was performed on two separate lots on this date. For comparison refer to the MSK 5059RH Total Dose Radiation Test Report – Group #1.

II. Radiation Source:

Total dose was performed at the University of Massachusetts, Lowell, using a cobalt 60 radiation source. Dosimetry was performed prior to device irradiation and the dose rate was determined to be 130 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 the device data sheet. 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 Pb/Al container during irradiation to minimize dose enhancement effects. Five devices were kept under bias during irradiation. Five devices had all leads grounded during irradiation for the unbiased condition.

After each irradiation, the device leads were shorted together and were 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.

IV. Data:

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

V. Summary:

Total dose irradiation and testing of the MSK 5059RH resulted in most test parameters showing very little change up to 300Krad(Si) and beyond.

A significant increase in feedback input bias current occurred at 50 Krad(Si), but a slight decrease was seen at 100 Krad(Si). At subsequent dose levels the feedback input bias remained stable.

The switch frequency exhibited a marked decrease of approximately 6.5% at 100 Krad(Si). The change in the frequency was nearly linear throughout the dose points.

In addition, switch current limit also showed a 5 % decrease at 100 Krad(Si). However, this parameter stayed within pre-irradiation limits through all testing up to 450 Krad(Si).

MSK119RH Biased/Unbiased Dose Rate Schedule

Dosimetry Equipment
Bruker Biospin # 0141

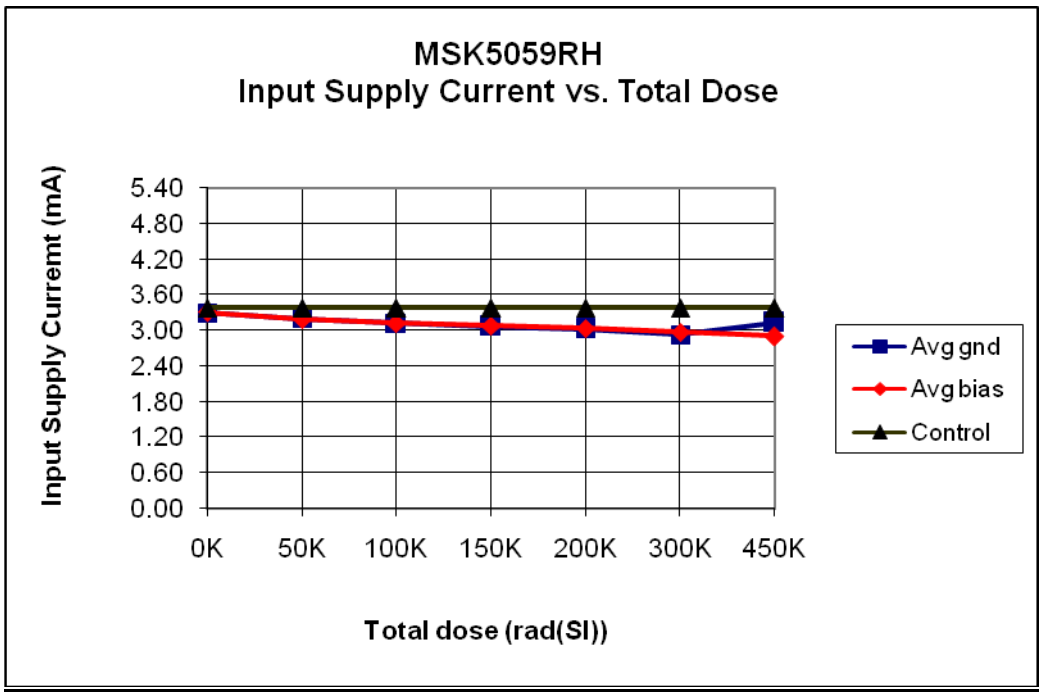
Irradiation Date
5/21/2010

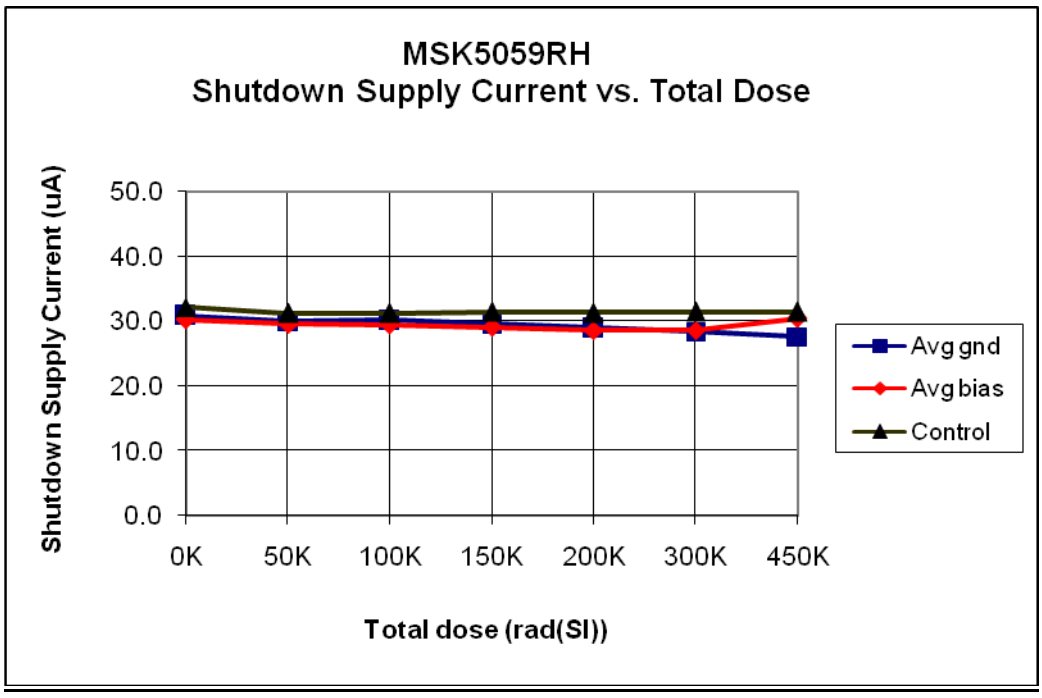
Exposure Length (min:sec)	Incremental Dose rads(Si)	Cumulative Dose rads(Si)
6:36	51,480	51,480
6:36	51,480	102,960
6:36	51,480	154,440
6:36	51,480	205,920
13:12	102,960	308,880
19:48	154,440	463,320

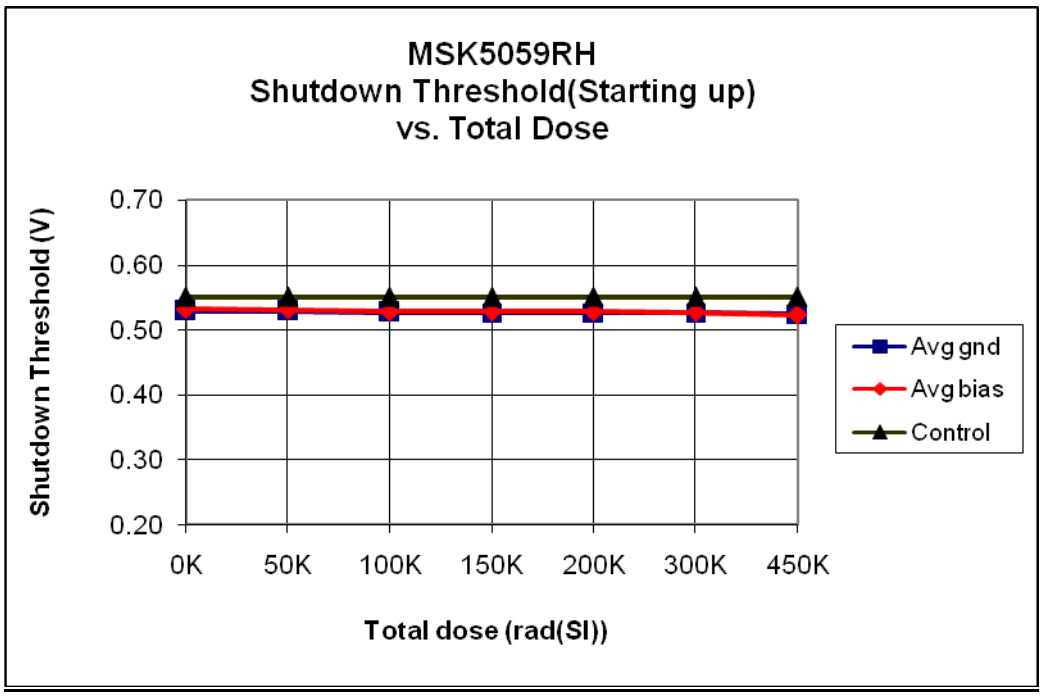
Biased S/N – 0079, 0080, 0081, 0082, 0083

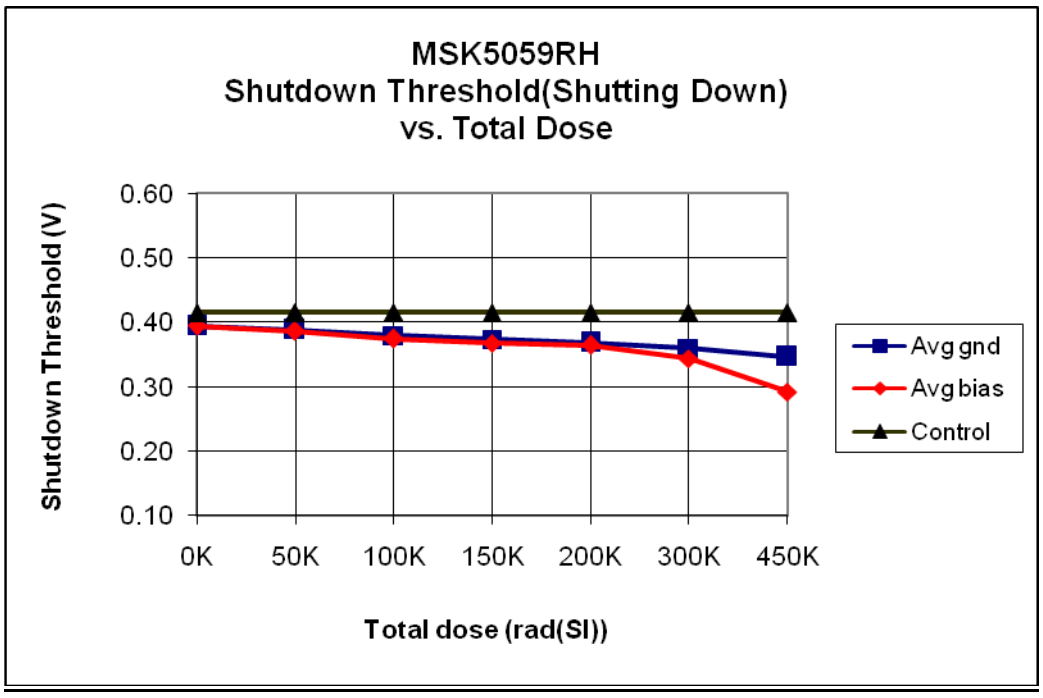
Unbiased S/N – 0084, 0085, 0086, 0087, 0088

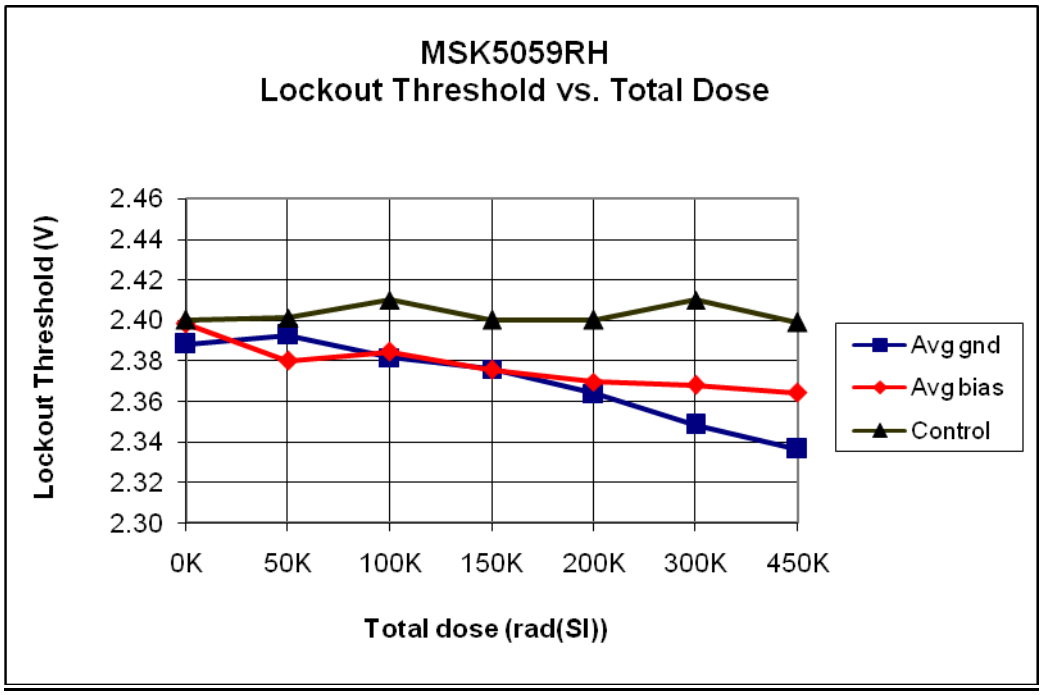
Table 1
Dose Time, Incremental Dose and Total Cumulative Dose

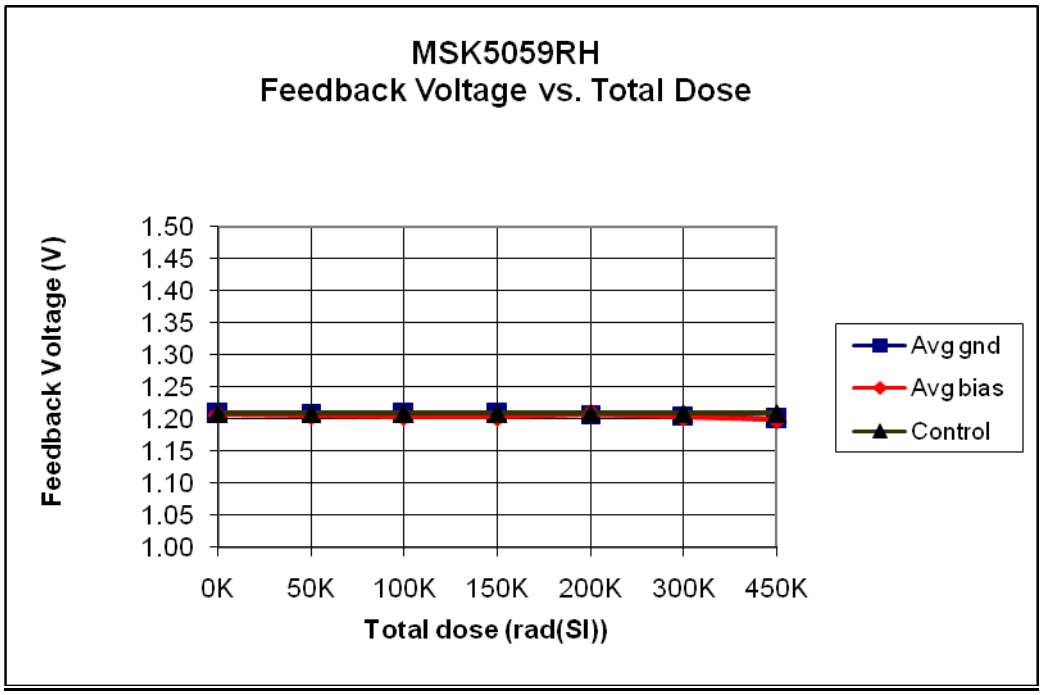

MSK5059RH
Input Supply Current vs. Total Dose
Input Supply Curremt (mA)
5.40
4.80
4.20
3.60
3.00
2.40
1.80
1.20
0.60
0.00
0K
50K
100K
150K
200K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

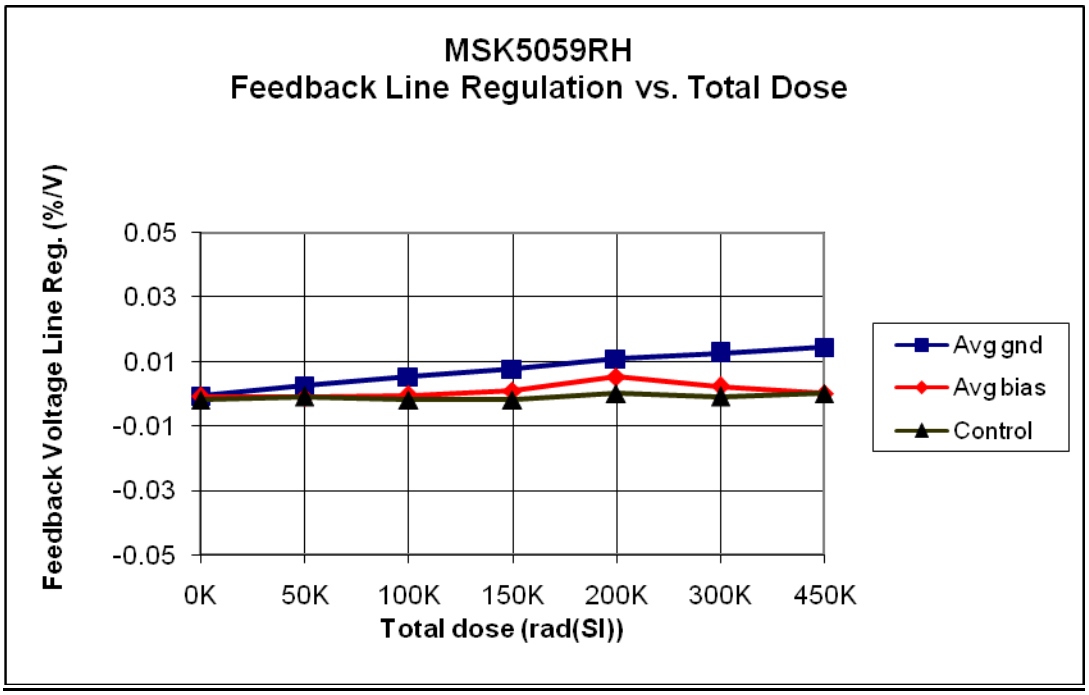

MSK5059RH
Shutdown Supply Current vs. Total Dose
Shutdown Supply Current (uA)
50.0
40.0
30.0
20.0
10.0
0.0
0K
50K
100K
150K
200K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

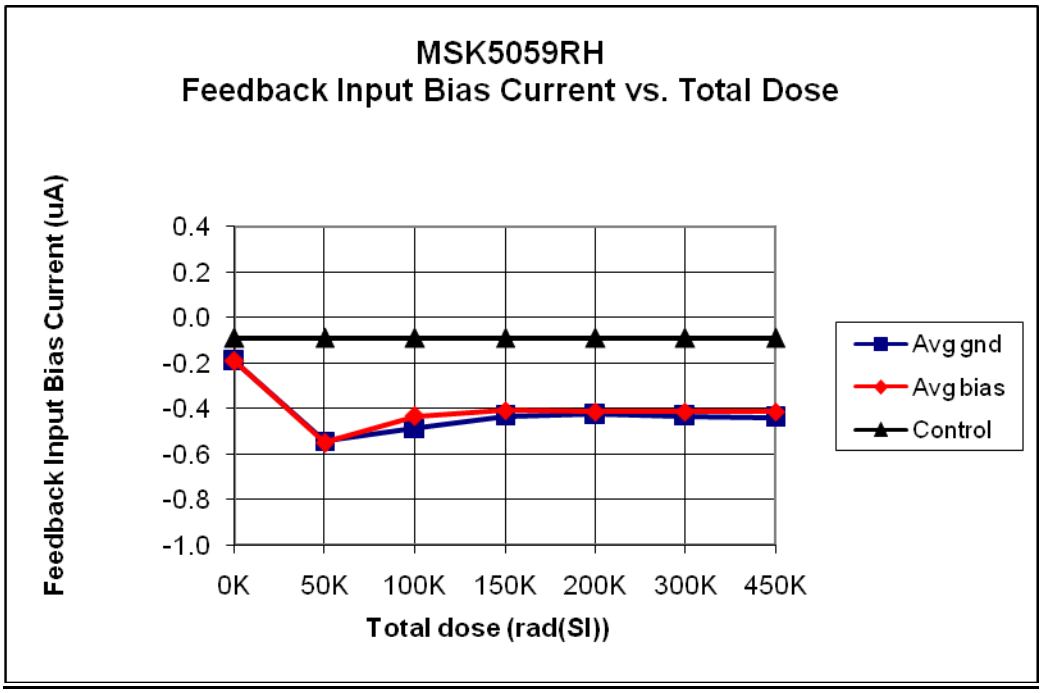

MSK5059RH
Shutdown Threshold(Starting up)
vs. Total Dose
Shutdown Threshold (V)
0.70
0.60
0.50
0.40
0.30
0.20
0K
50K
100K
150K
200K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

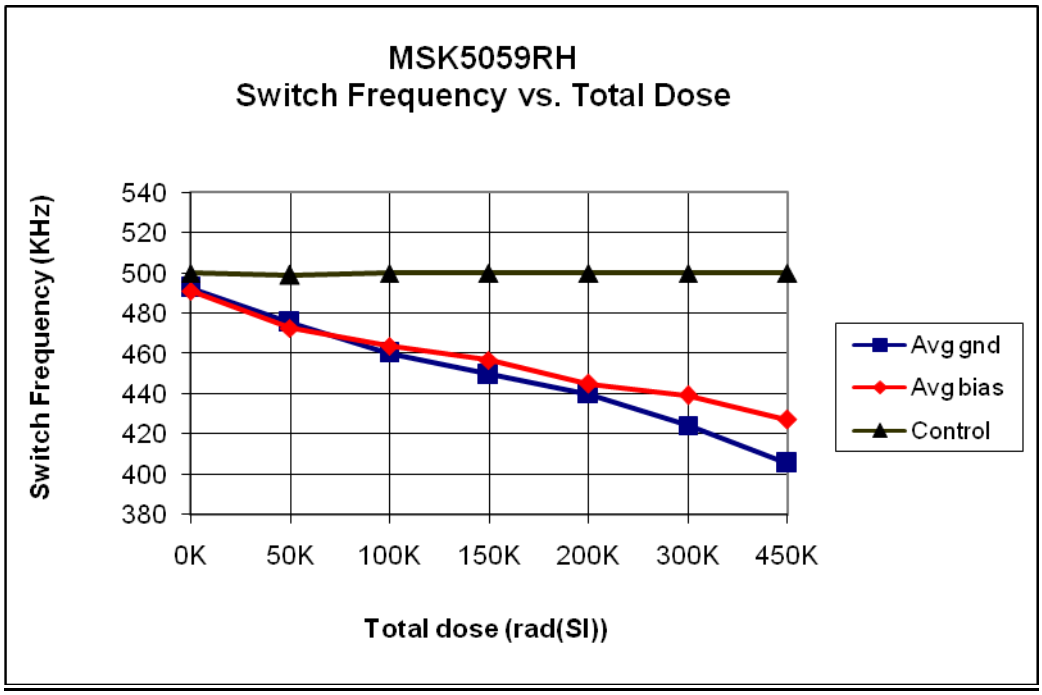

MSK5059RH
Shutdown Threshold(Shutting Down)
vs. Total Dose
Shutdown Threshold (V)
0.60
0.50
0.40
0.30
0.20
0.10
0K
50K
100K
150K
200K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

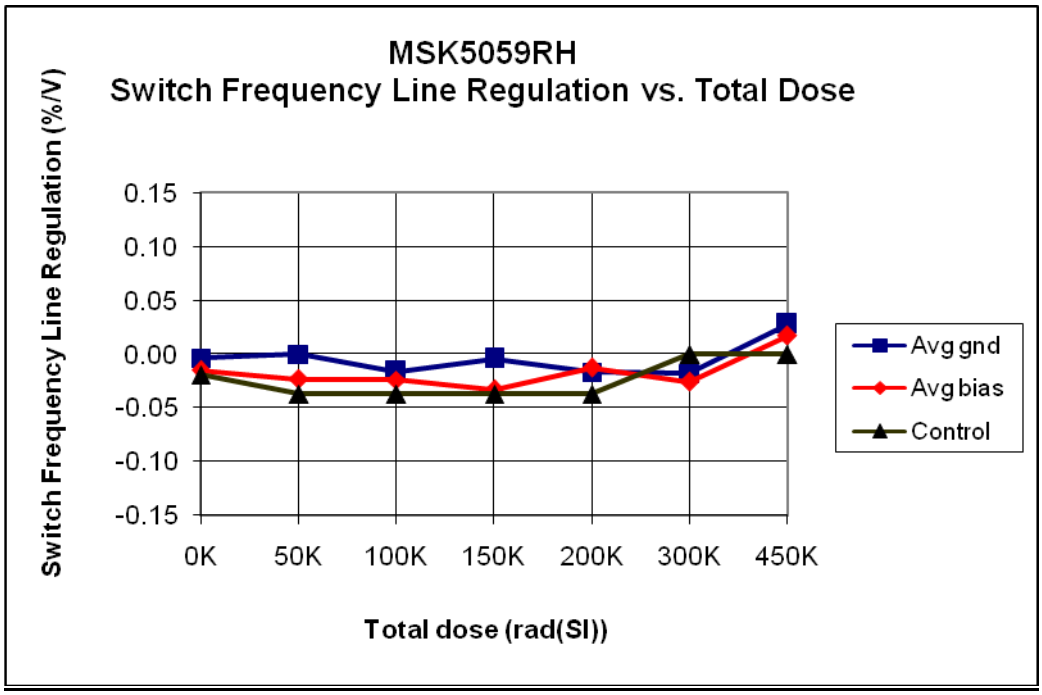

MSK5059RH
Lockout Threshold vs. Total Dose
Lockout Threshold (V)
2.46
2.44
2.42
2.40
2.38
2.36
2.34
2.32
2.30
0K
50K
100K
150K
200K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

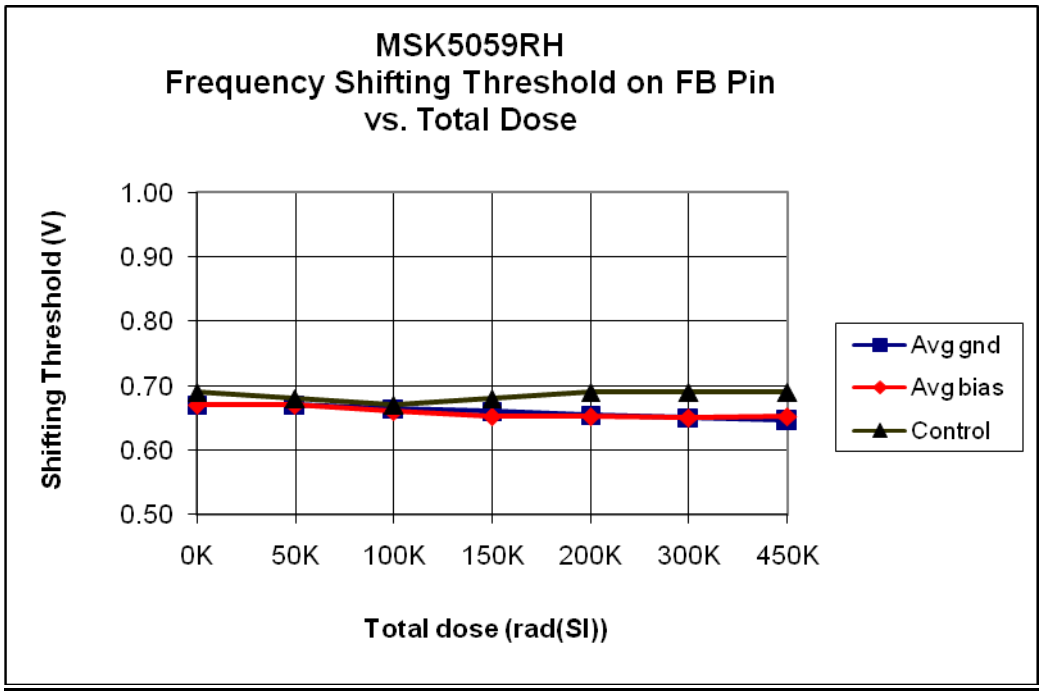

MSK5059RH
Feedback Voltage vs. Total Dose
Feedback Voltage (V)
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
0K
50K
100K
150K
200K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

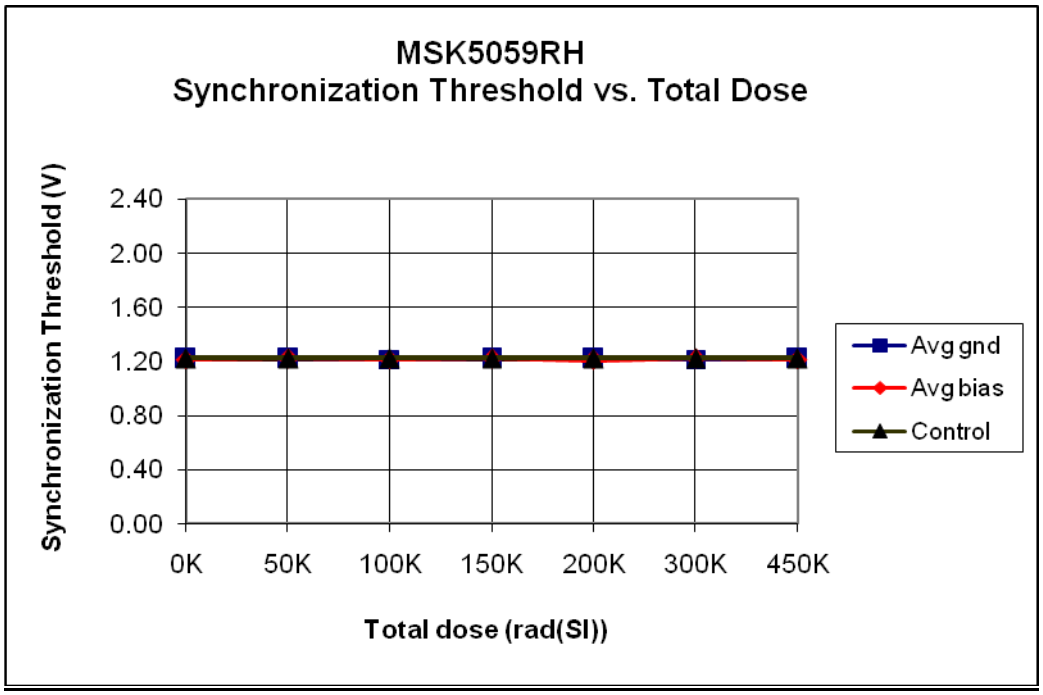

MSK5059RH
Feedback Line Regulation vs. Total Dose
Feedback Voltage Line Reg. (%/V)
0.05
0.03
0.01
-0.01
-0.03
-0.05
0K
50K
100K
150K
200K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

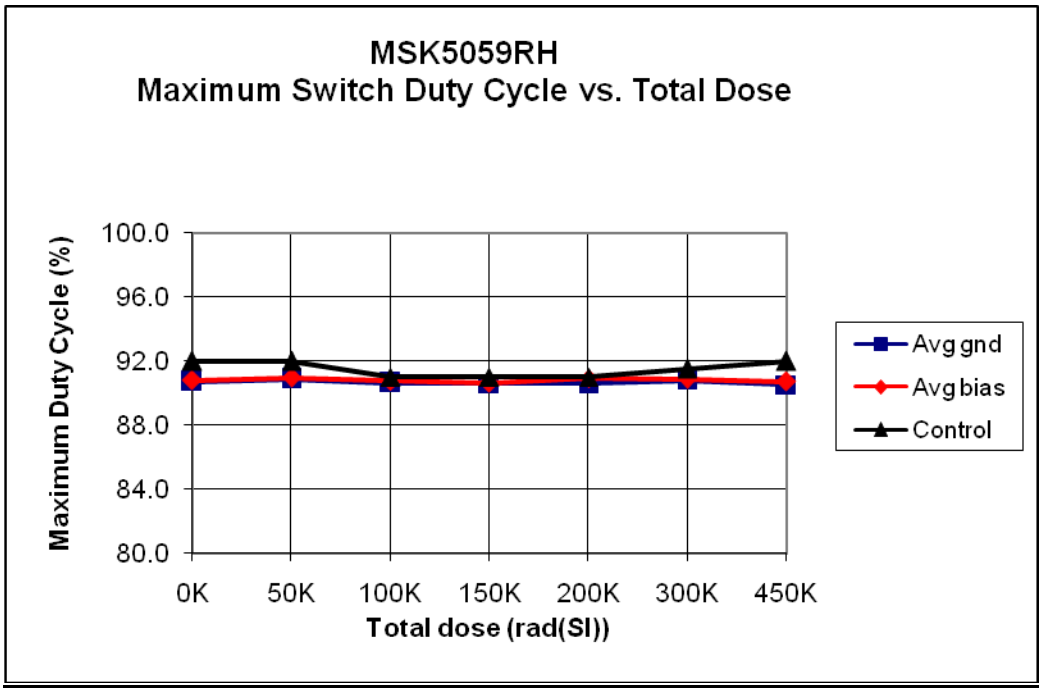

MSK5059RH
Feedback Input Bias Current vs. Total Dose
Feedback Input Bias Current (uA)
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
0K
50K
100K
150K
200K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

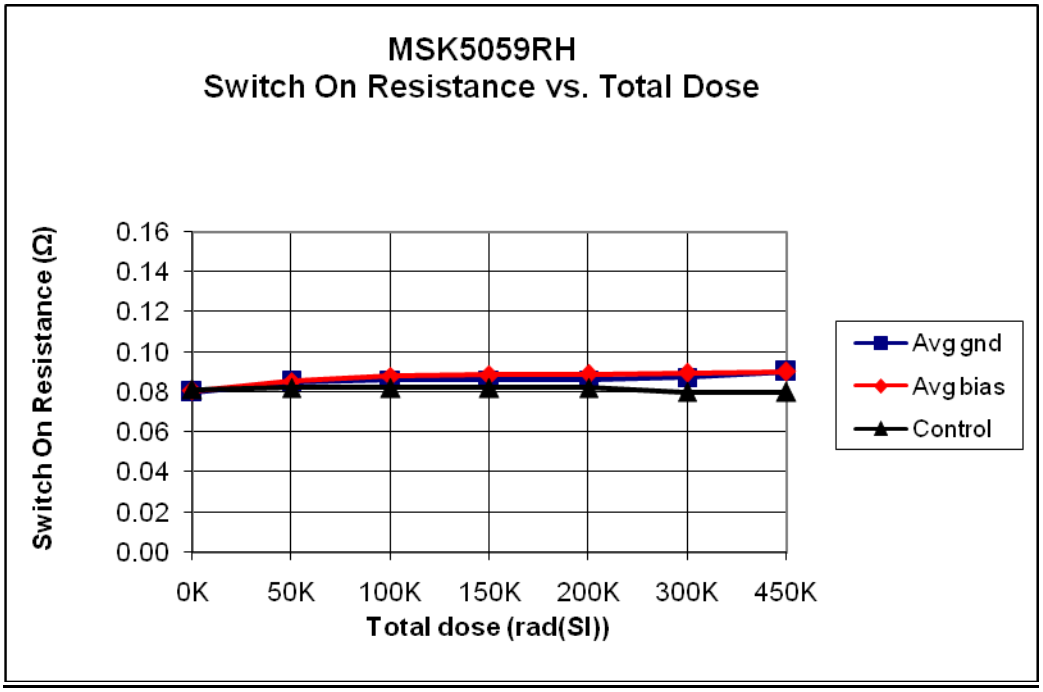

MSK5059RH
Switch Frequency vs. Total Dose
Switch Frequency (KHz)
540
520
500
480
460
440
420
400
380
0K
50K
100K
150K
200K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control

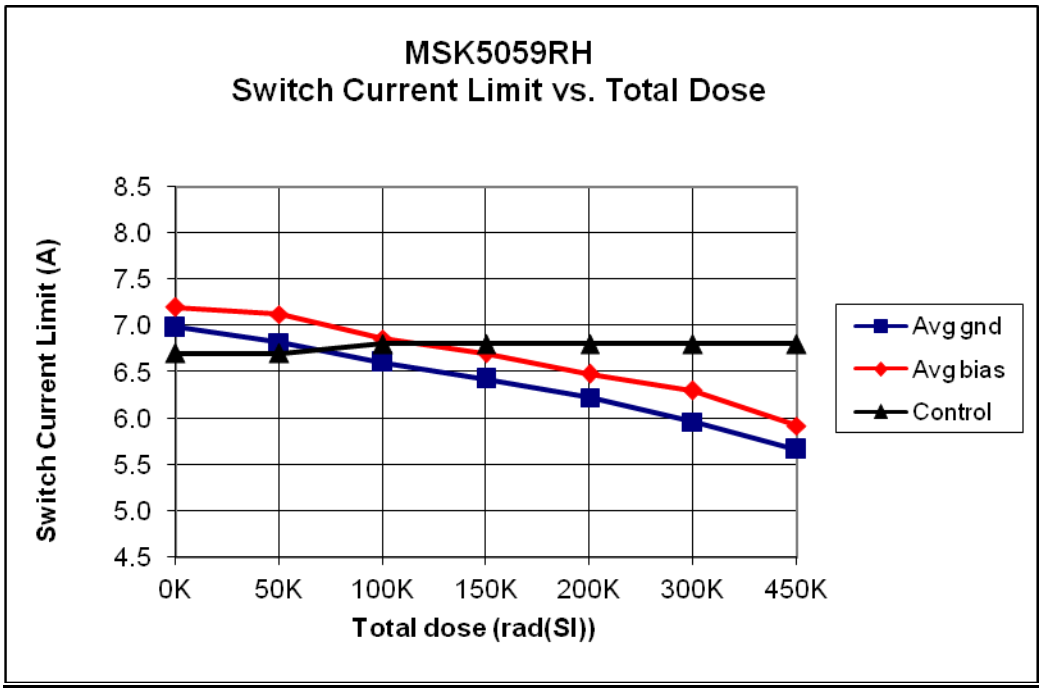

MSK5059RH
Switch Frequency Line Regulation vs. Total Dose
Switch Frequency Line Regulation (%/V)
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
0K
50K
100K
150K
200K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control


MSK5059RH
Frequency Shifting Threshold on FB Pin
vs. Total Dose
Shifting Threshold (V)
1.00
0.90
0.80
0.70
0.60
0.50
0K
50K
100K
150K
200K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control


MSK5059RH
Synchronization Threshold vs. Total Dose
Synchronization Threshold (V)
2.40
2.00
1.60
1.20
0.80
0.40
0.00
0K
50K
100K
150K
200K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control


MSK5059RH
Maximum Switch Duty Cycle vs. Total Dose
Maximum Duty Cycle (%)
100.0
96.0
92.0
88.0
84.0
80.0
0K
50K
100K
150K
200K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control


MSK5059RH
Switch On Resistance vs. Total Dose
Switch On Resistance (Ω)
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0K
50K
100K
150K
200K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control


MSK5059RH
Switch Current Limit vs. Total Dose
Switch Current Limit (A)
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
0K
50K
100K
150K
200K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control