Total Ionizing Dose Radiation Test Report

MSK5055RH,
RAD HARD High Voltage Synchronous Switching Regulator Controller

March 26, 2013 (First HDR TID, WAFER LOT: WD005797WF#9)
March 26, 2013 (Neutron Irradiation, WAFER LOT: WD005797WF#9)
March 20, 2018 (2nd HDR TID, WAFER LOT: W1621790.1WF#8)
March 21, 2018 (3rd HDR TID, WAFER LOT: W1535549.1WF#9)
May 24, 2018 (4th HDR TID, WAFER LOT: WP63227E.1WF#4)

N. Kresse
F. Freytag

Anaren, Inc – MSK Products

I. Introduction:

The Total Ionizing Dose radiation test plan for the MSK5055RH was developed to qualify the devices as RAD Hard to 300Krad(Si). 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. The MSK5055-1RH, and MSK5055-2RH both use the same active components. The data in this report is from direct measurement of the MSK5055-1RH response to irradiation but it is indicative of the response of both devices and is applicable to both.

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 MSK5055RH.

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 121.3 rad(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 of burn-in per MIL-STD-883 Method 1015 and were fully screened IAW MIL-PRF-38535 Class H. 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. 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 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 MSK5055RH qualifies as a 300Krad(Si) radiation hardened devices. Error Amp Reference Voltage, Vin UVLO Threshold (Rising), Operating Frequency, and Current Limit Sense Voltage exhibited the most significant shifts with irradiation. These parameters stayed well within specified post irradiation limits at 100Krad(Si) and 300krad(Si). All other parameters stayed within pre-irradiation specifications 300Krad(Si).

MSK5055-1RH Biased/Unbiased Dose Rate Schedule

Dosimetry Equipment
Bruker Biospin # 0162

Irradiation Date
5/24/18

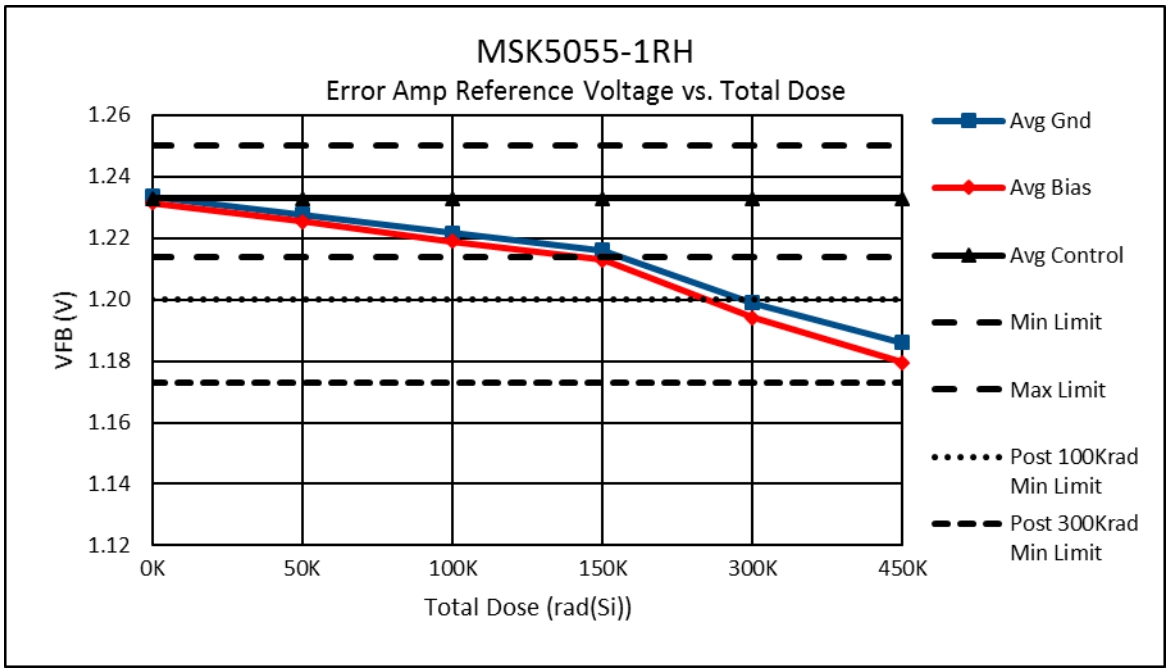
Exposure Length (min:sec)	Incremental Dose rad(Si)	Cumulative Dose rad(Si)
7:05	51,500	51,500
7:05	51,500	103,000
7:05	51,500	154,500
21:14	154.500	309,000
21:14	154,500	463,500

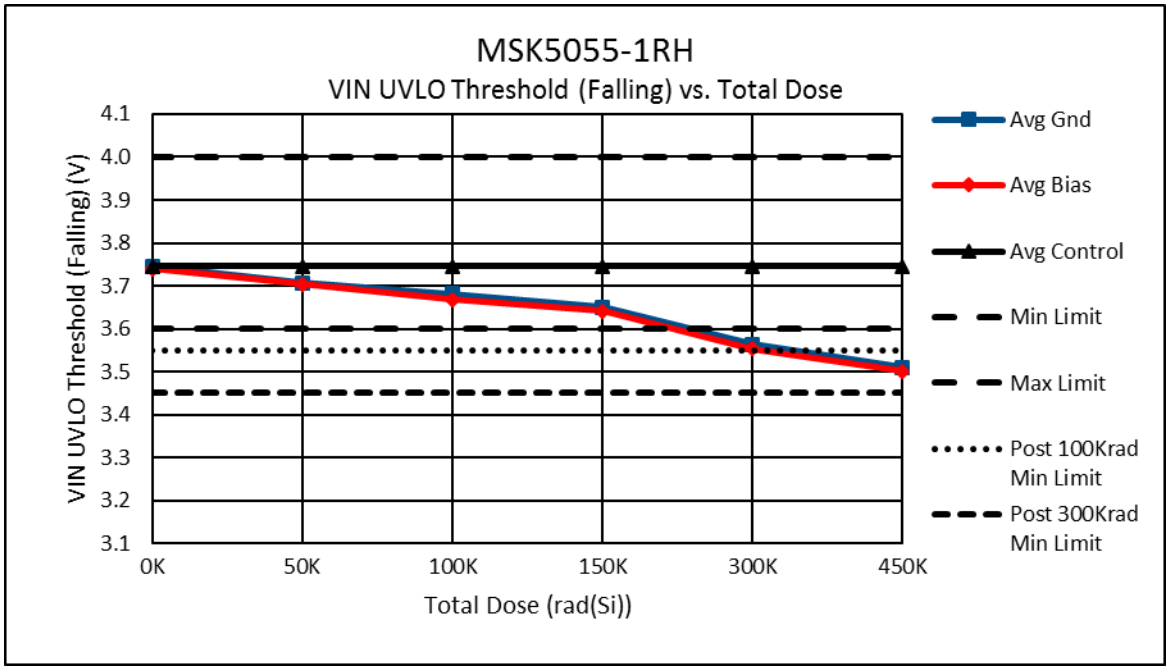
Biased S/N – 0013, 0014, 0015, 0017, 0018

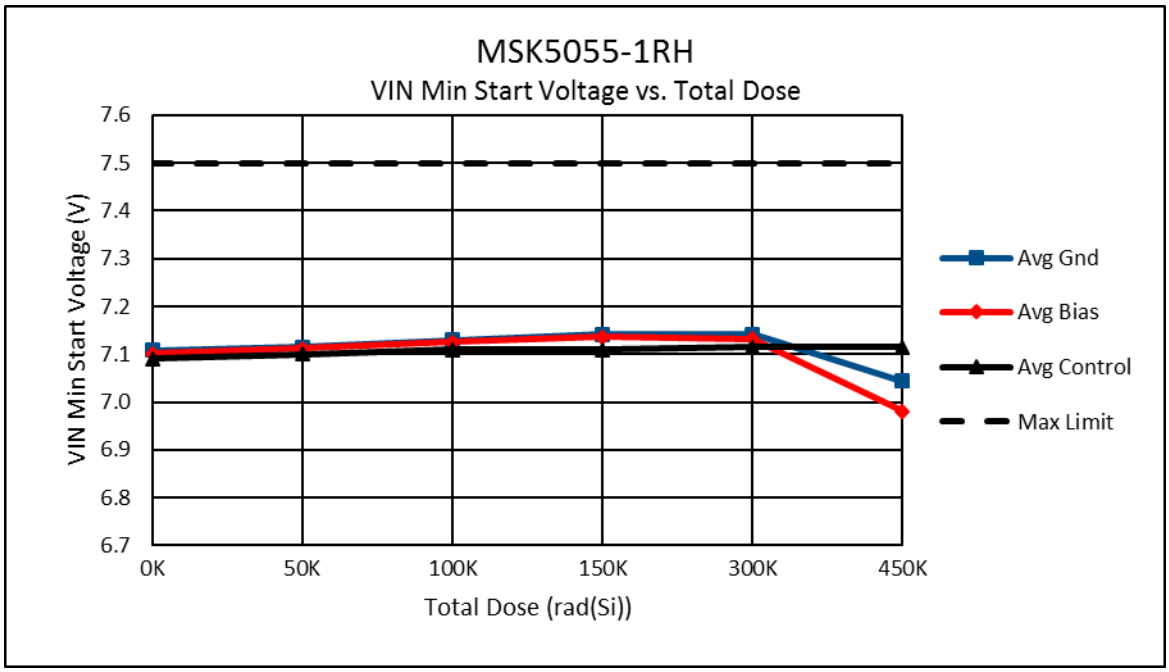
Unbiased S/N – 0020, 0021, 0022, 0023, 0024

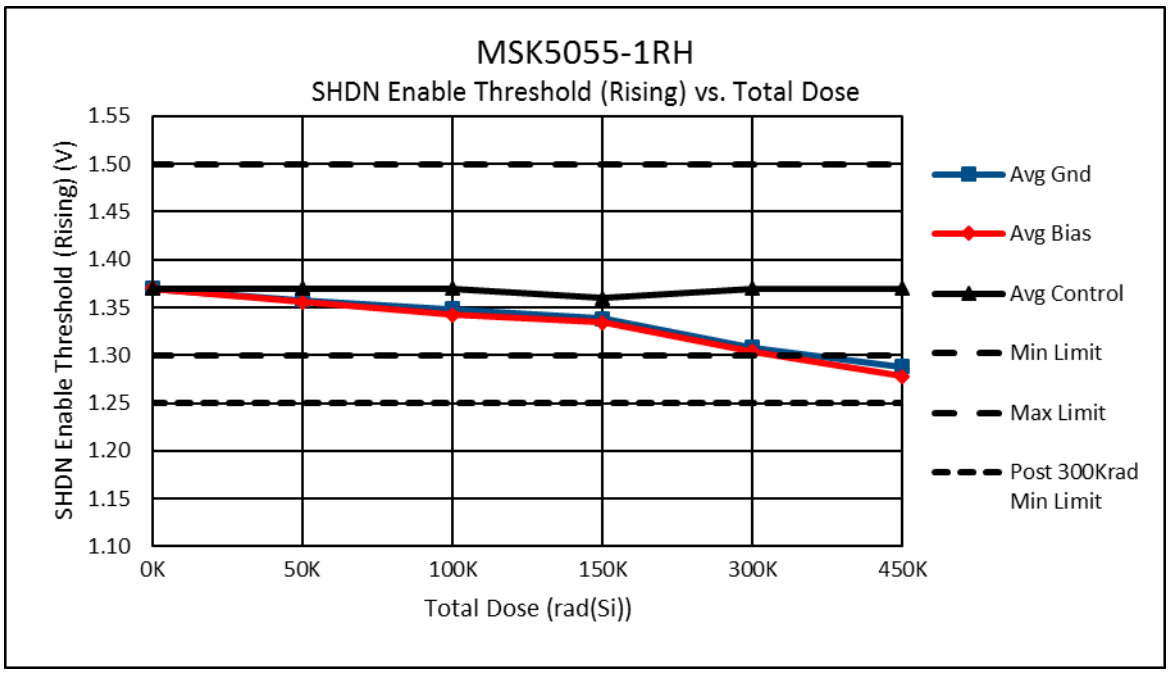
Table 1

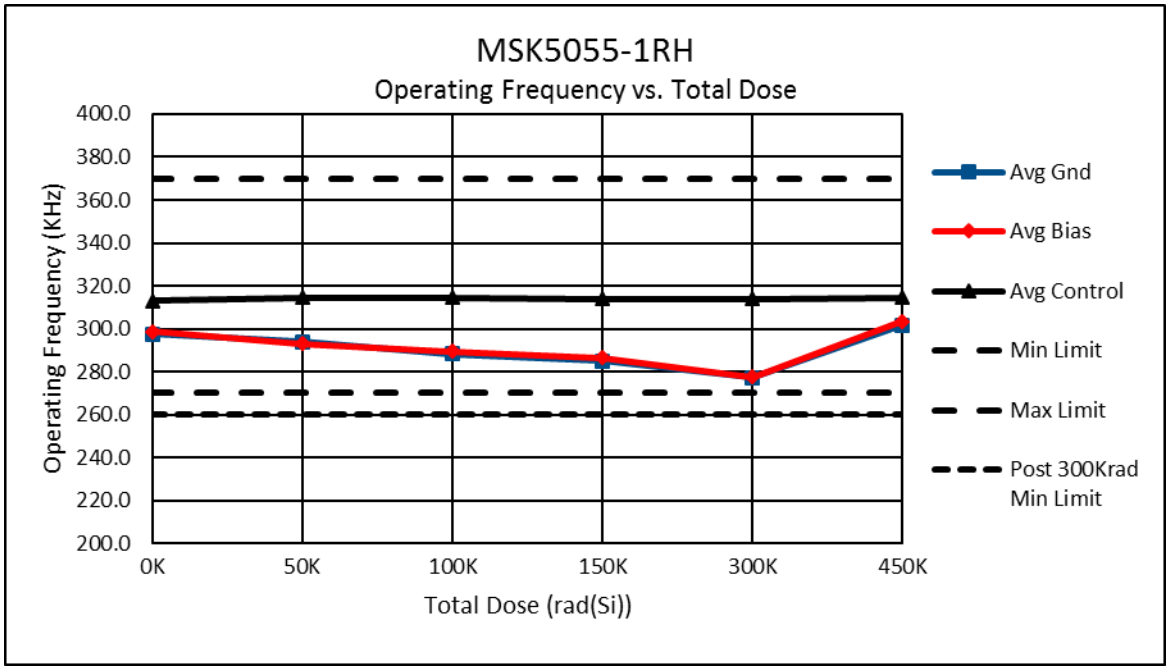
Dose Time, Incremental Dose and Total Cumulative Dose

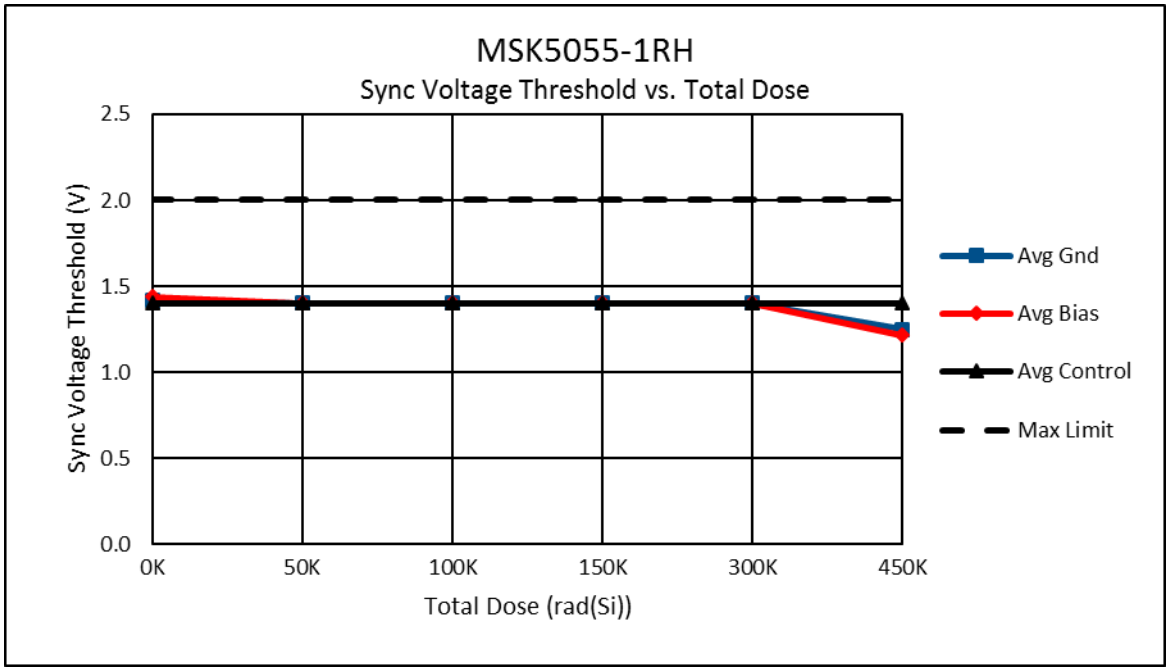

MSK5055-1RH
Error Amp Reference Voltage vs. Total Dose
VFB (V)
1.26
1.24
1.22
1.20
1.18
1.16
1.14
1.12
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Avg Control
Min Limit
Max Limit
Post 100Krad Min Limit
Post 300Krad Min Limit

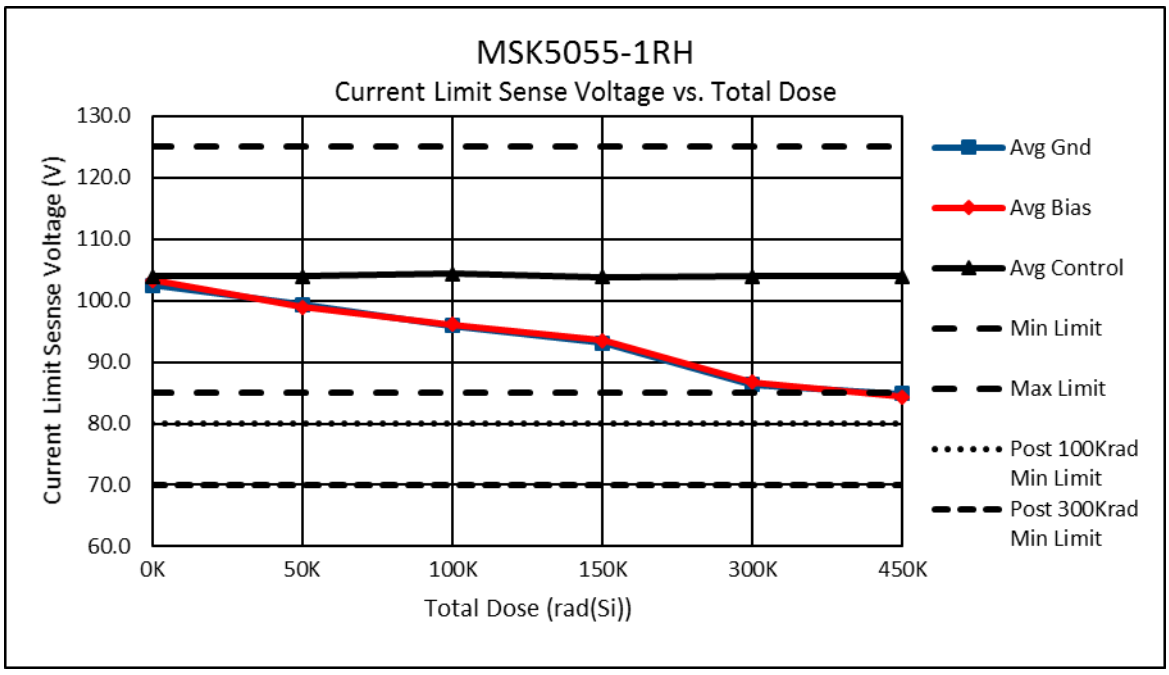

MSK5055-1RH
VIN UVLO Threshold (Falling) vs. Total Dose
VIN UVLO Threshold (Falling) (V)
4.1
4.0
3.9
3.8
3.7
3.6
3.5
3.4
3.3
3.2
3.1
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Avg Control
Min Limit
Max Limit
Post 100Krad Min Limit
Post 300Krad Min Limit

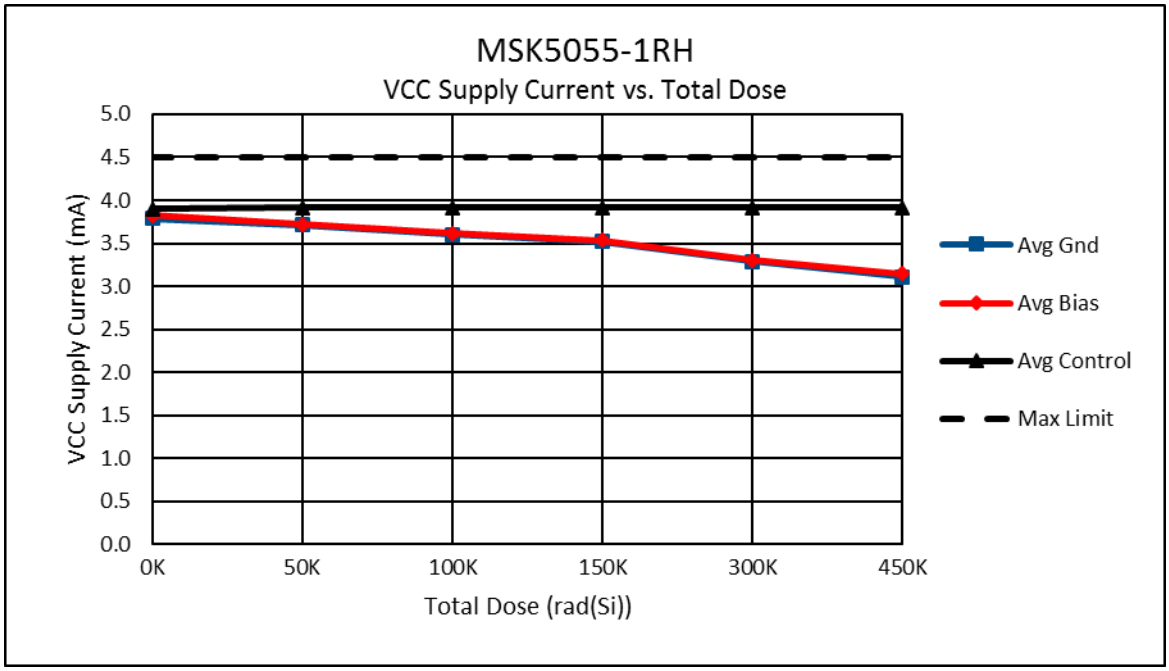

MSK5055-1RH
VIN Min Start Voltage vs. Total Dose
VIN Min Start Voltage (V)
7.6
7.5
7.4
7.3
7.2
7.1
7.0
6.9
6.8
6.7
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Avg Control
Max Limit

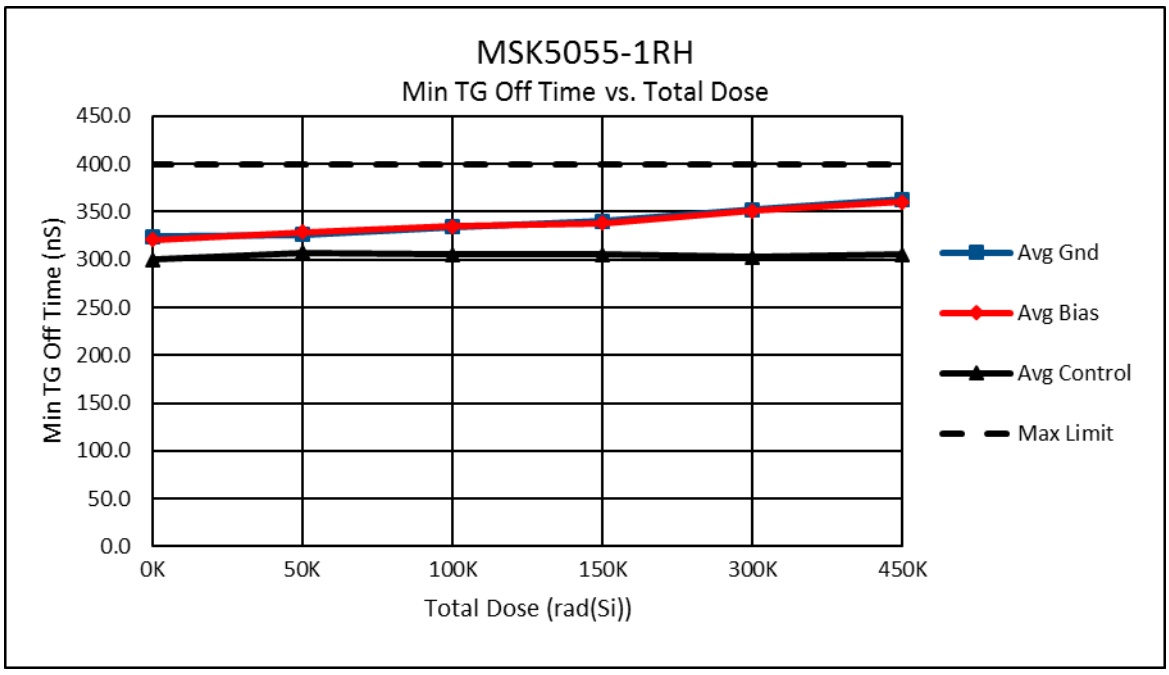

MSK5055-1RH
SHDN Enable Threshold (Rising) vs. Total Dose
SHDN Enable Threshold (Rising) (V)
1.55
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1.15
1.10
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Avg Control
Min Limit
Max Limit
Post 300Krad
Min Limit

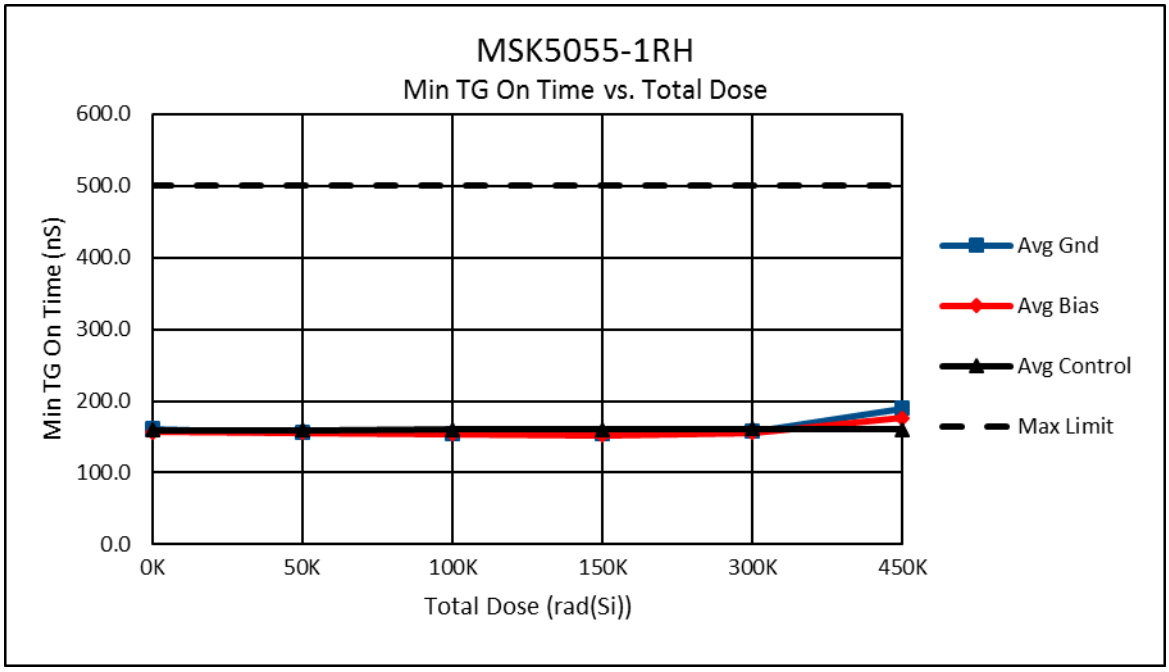

MSK5055-1RH
Operating Frequency vs. Total Dose
Operating Frequency (KHz)
400.0
380.0
360.0
340.0
320.0
300.0
280.0
260.0
240.0
220.0
200.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Avg Control
Min Limit
Max Limit
Post 300Krad Min Limit

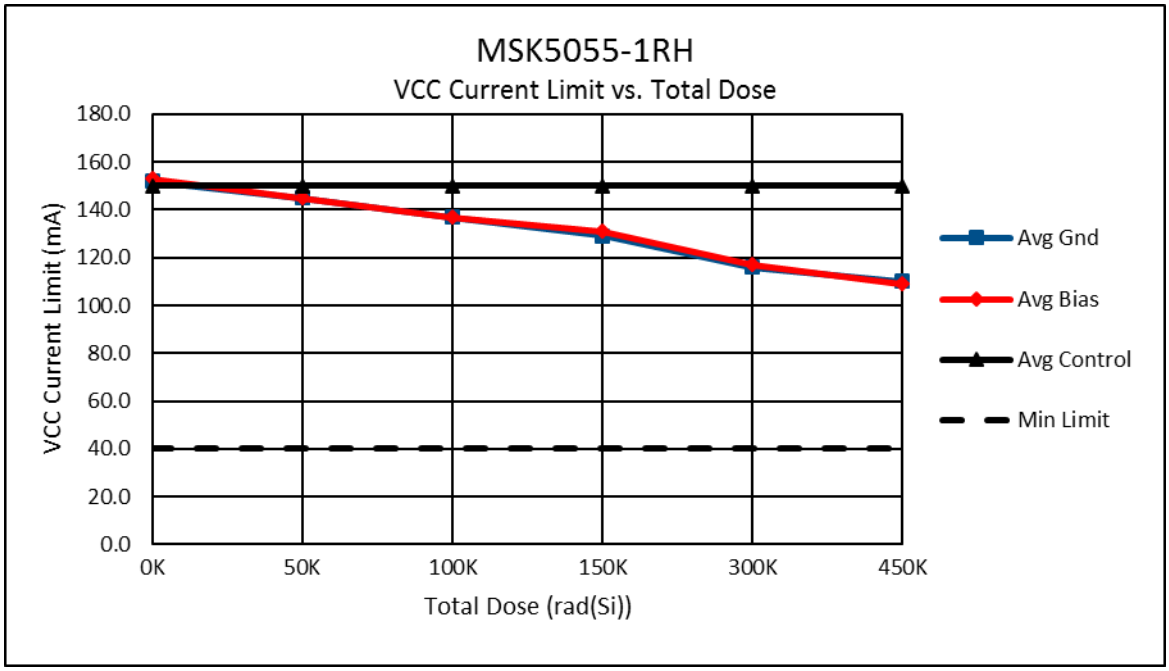

MSK5055-1RH
Sync Voltage Threshold vs. Total Dose
Sync Voltage Threshold (V)
2.5
2.0
1.5
1.0
0.5
0.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Avg Control
Max Limit


MSK5055-1RH
Current Limit Sense Voltage vs. Total Dose
Current Limit Sesnse Voltage (V)
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Avg Control
Min Limit
Max Limit
Post 100Krad Min Limit
Post 300Krad Min Limit


MSK5055-1RH
VCC Supply Current vs. Total Dose
VCC Supply Current (mA)
5.0
4.5
4.0
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
Avg Control
Max Limit


MSK5055-1RH
Min TG Off Time vs. Total Dose
Min TG Off Time (nS)
450.0
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Avg Control
Max Limit


MSK5055-1RH
Min TG On Time vs. Total Dose
Min TG On Time (nS)
600.0
500.0
400.0
300.0
200.0
100.0
0.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Avg Control
Max Limit


MSK5055-1RH
VCC Current Limit vs. Total Dose
VCC Current Limit (mA)
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0K
50K
100K
150K
300K
450K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Avg Control
Min Limit

Total Ionizing Dose Radiation Test Report

MSK5055RH,
RAD HARD High Voltage Synchronous Switching Regulator Controller

March 26, 2013 (First HDR TID, WAFER LOT: WD005797WF#9)
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March 21, 2018 (3rd HDR TID, WAFER LOT: W1535549.1WF#9)

B. Horton
J. Joy

Anaren, Inc – MSK Products

I. Introduction:

The Total Ionizing Dose radiation test plan for the MSK5055RH was developed to qualify the devices as RAD Hard to 300krad(Si). 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. The MSK5055-1RH, and MSK5055-2RH both use the same active components. The data in this report is from direct measurement of the MSK5055-1RH response to irradiation but it is indicative of the response of both devices and is applicable to both.

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 MSK5055RH.

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 124 rad(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 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. Nine 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. 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 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:

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 MSK5055RH qualifies as a 300krad(Si) radiation hardened devices. The parameter VIN MIN START VOLTAGE test was not properly executed and has been exclude from this report. Future test effort will include this parameter. Error Amp Reference Voltage, Vin UVLO Threshold (Rising), Operating Frequency, and Current Limit Sense Voltage exhibited the most significant shifts with irradiation. These parameters stayed well within specified post irradiation limits at 100krad(Si) and 300krad(Si). All other parameters stayed within pre-irradiation specifications 300krad(Si).

MSK5055-1RH Biased/Unbiased Dose Rate Schedule

Dosimetry Equipment
Bruker Biospin # 0162

Irradiation Date
3/21/18

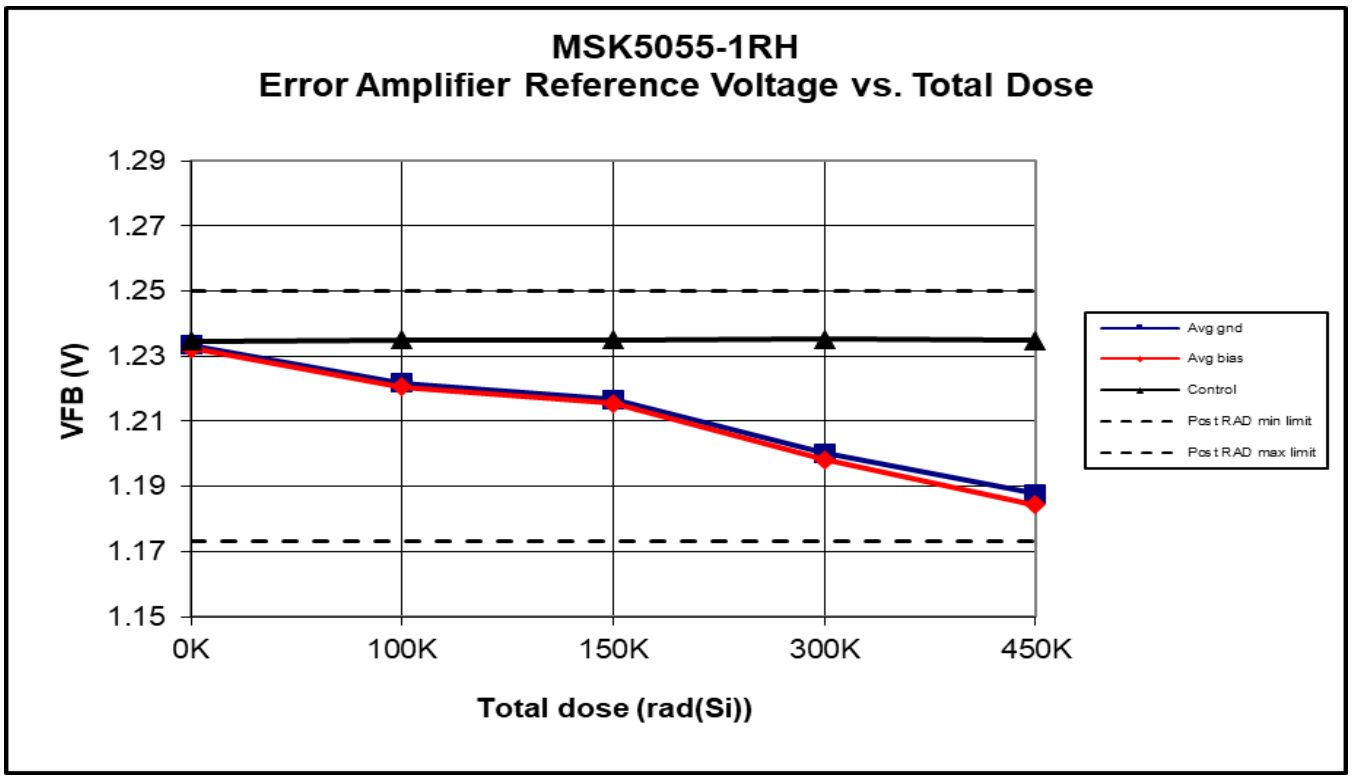
Exposure Length (min:sec)	Incremental Dose rad(Si)	Cumulative Dose rad(Si)
13:51	103,000	103,00
6:55	51,500	154,500
20:46	154,500	309,000
20:46	154,500	463,500

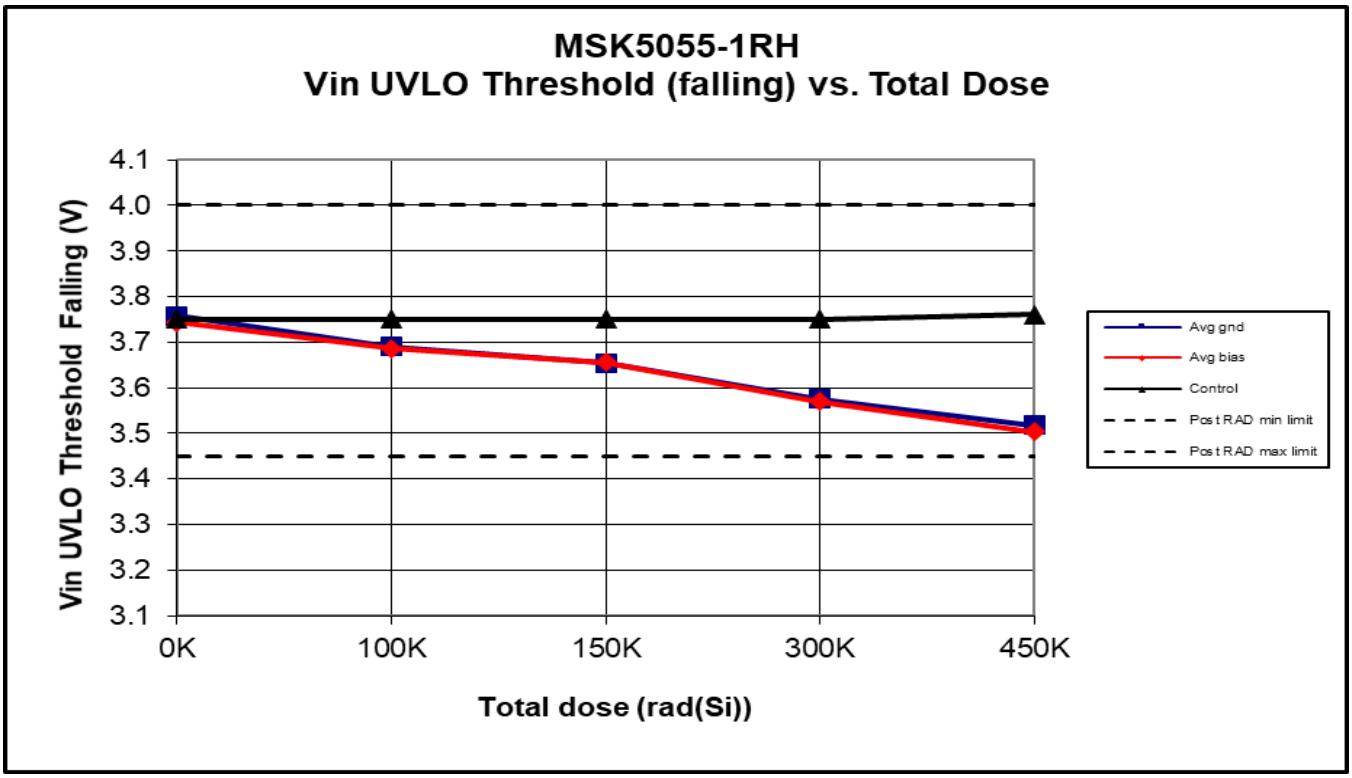
Biased S/N – 0001, 0002, 0003, 0004, 0005

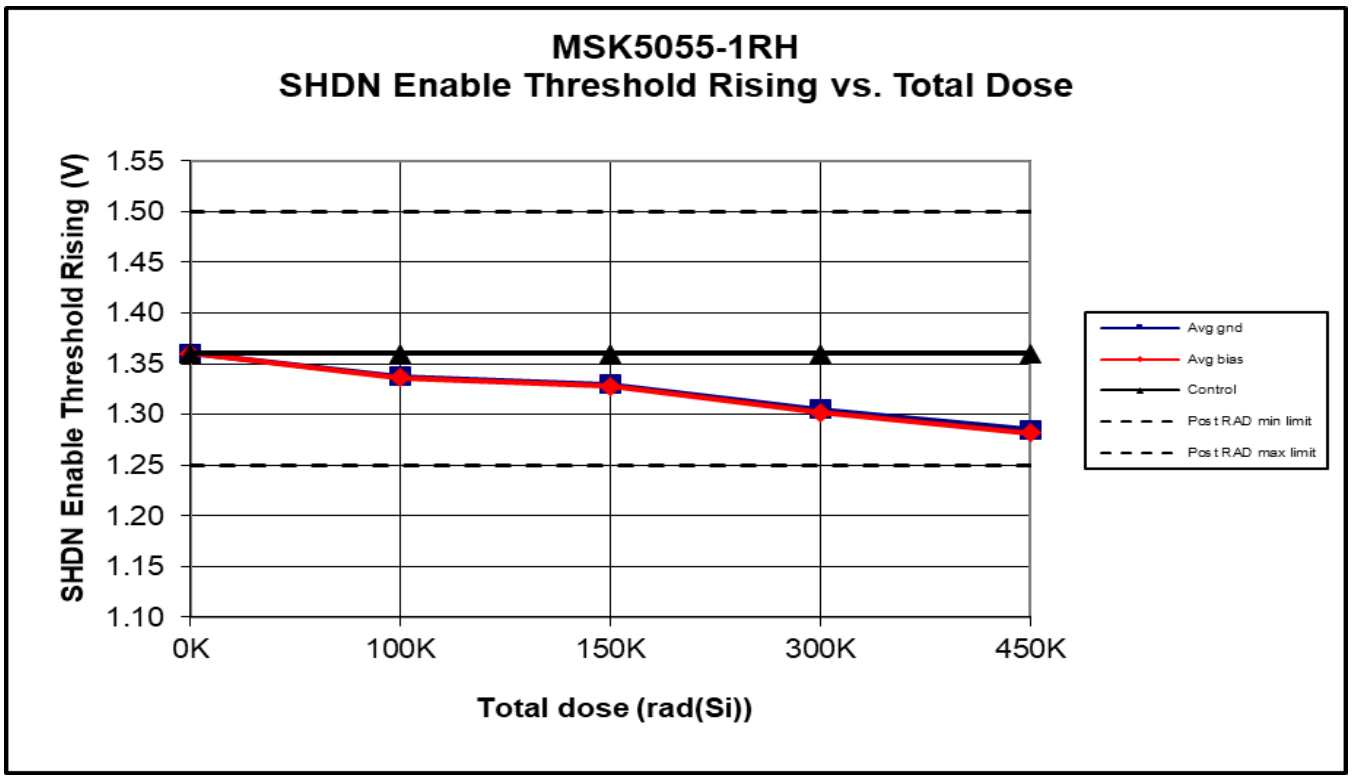
Unbiased S/N – 0006, 0007, 0008, 0011

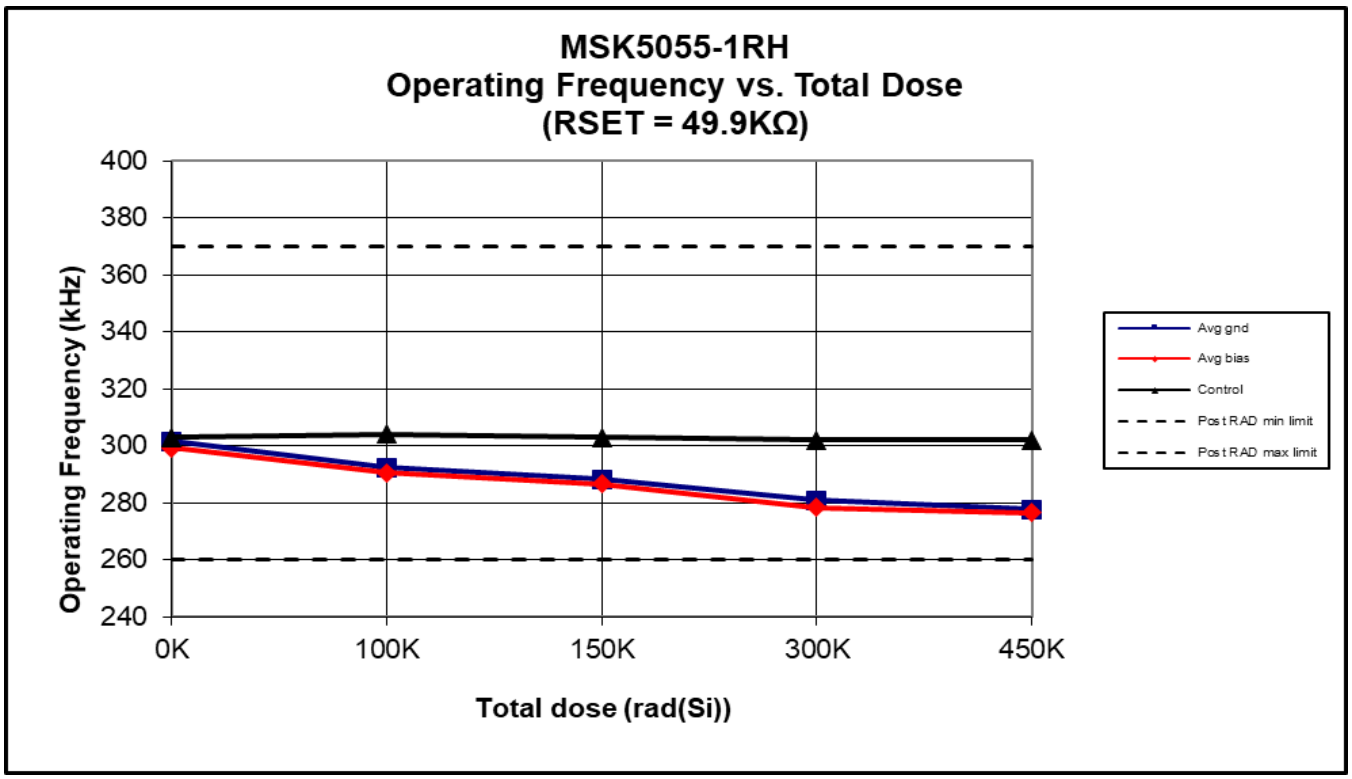
Table 1

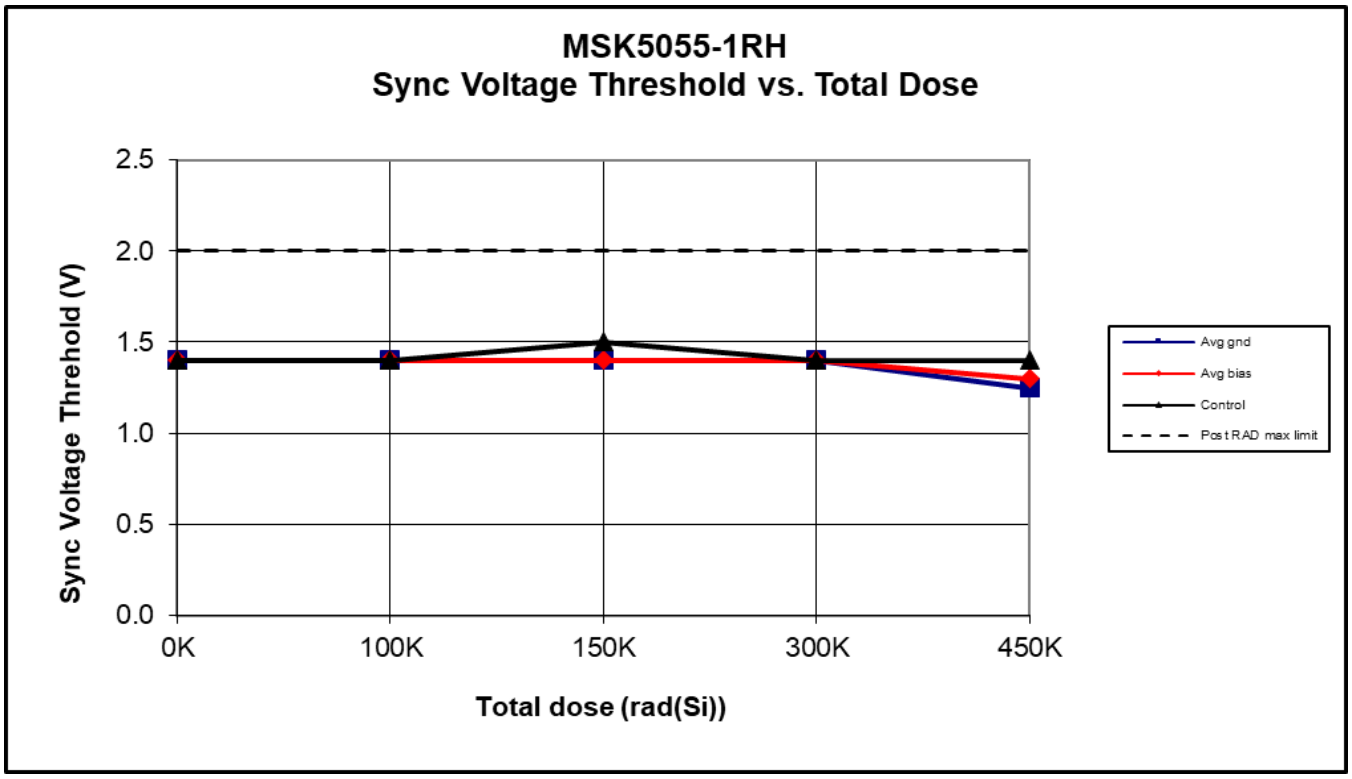
Dose Time, Incremental Dose and Total Cumulative Dose

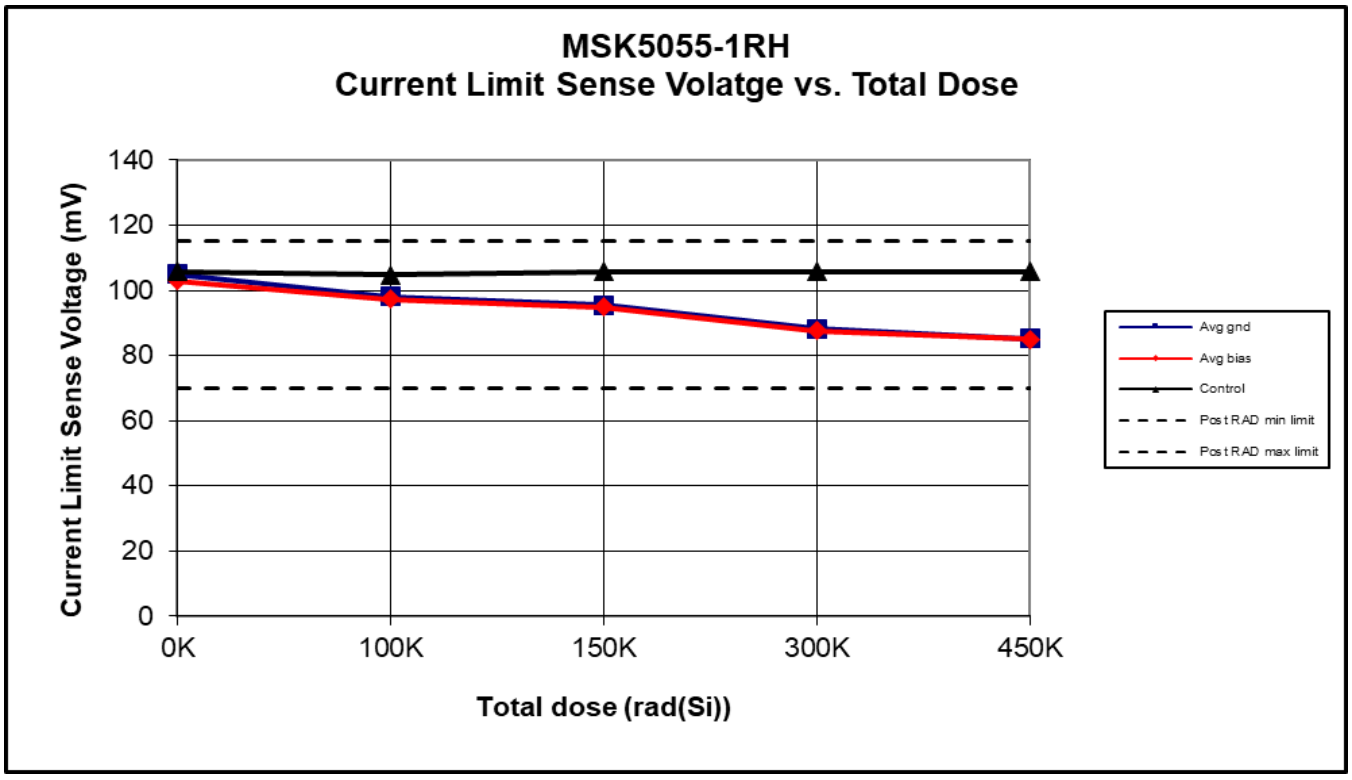

MSK5055-1RH
Error Amplifier Reference Voltage vs. Total Dose
VFB (V)
1.29
1.27
1.25
1.23
1.21
1.19
1.17
1.15
0K
100K
150K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control
Post RAD min limit
Post RAD max limit

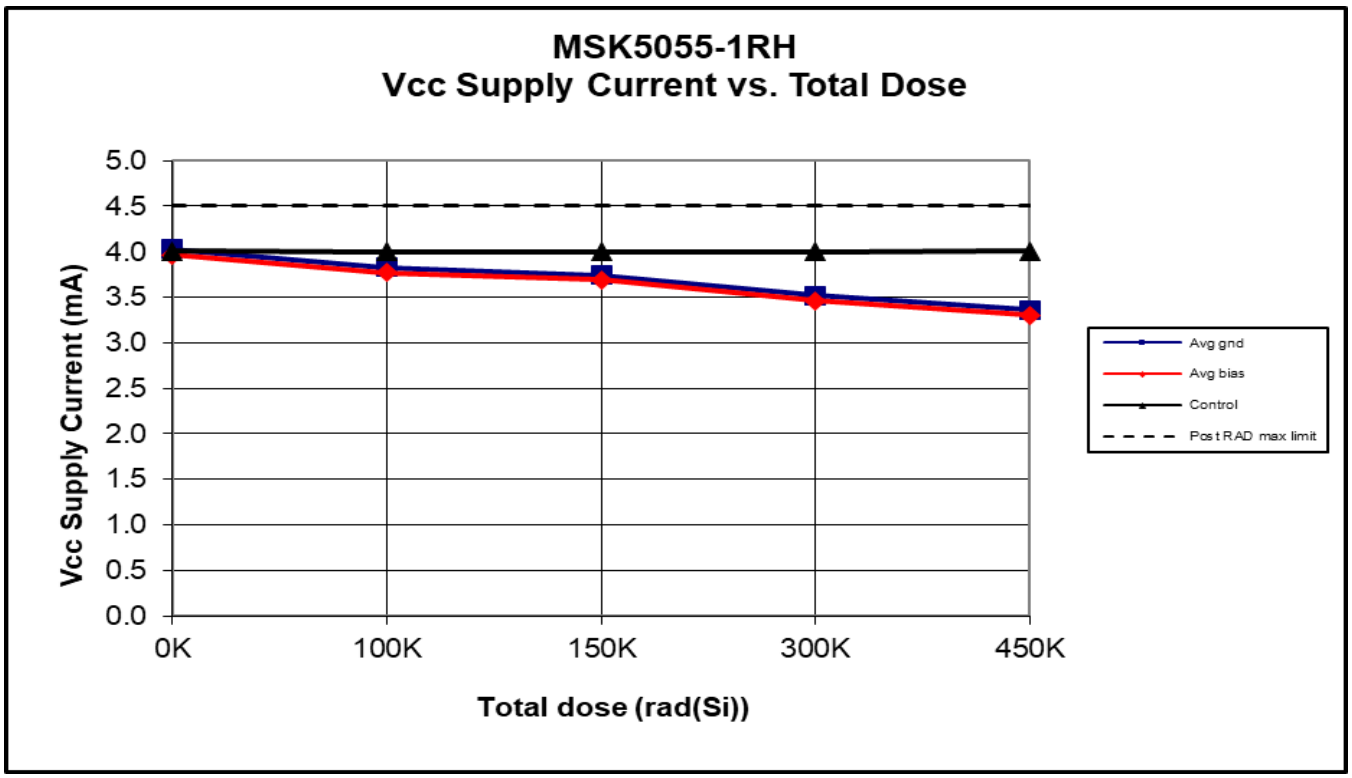

MSK5055-1RH
Vin UVLO Threshold (falling) vs. Total Dose
Vin UVLO Threshold Falling (V)
4.1
4.0
3.9
3.8
3.7
3.6
3.5
3.4
3.3
3.2
3.1
0K
100K
150K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control
Post RAD min limit
Post RAD max limit

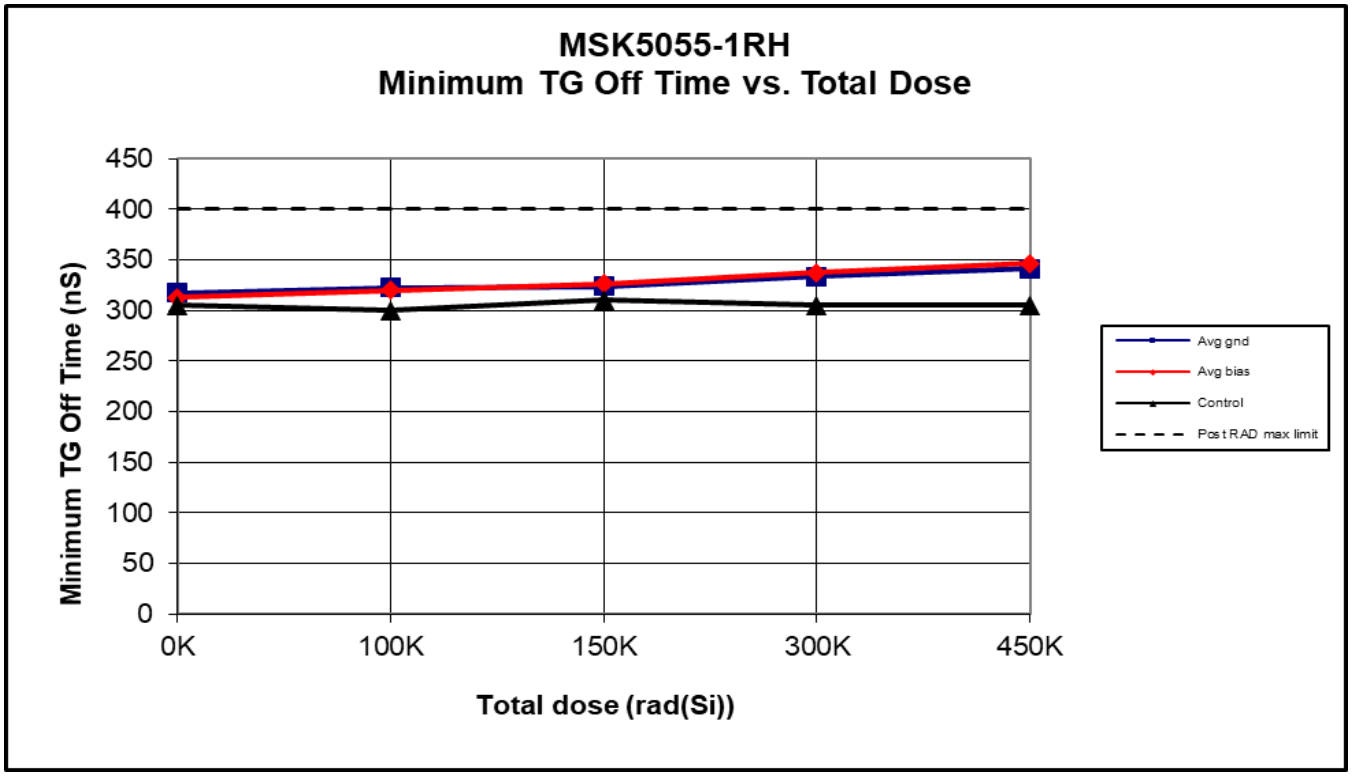

MSK5055-1RH
SHDN Enable Threshold Rising vs. Total Dose
SHDN Enable Threshold Rising (V)
1.55
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1.15
1.10
0K
100K
150K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control
Post RAD min limit
Post RAD max limit

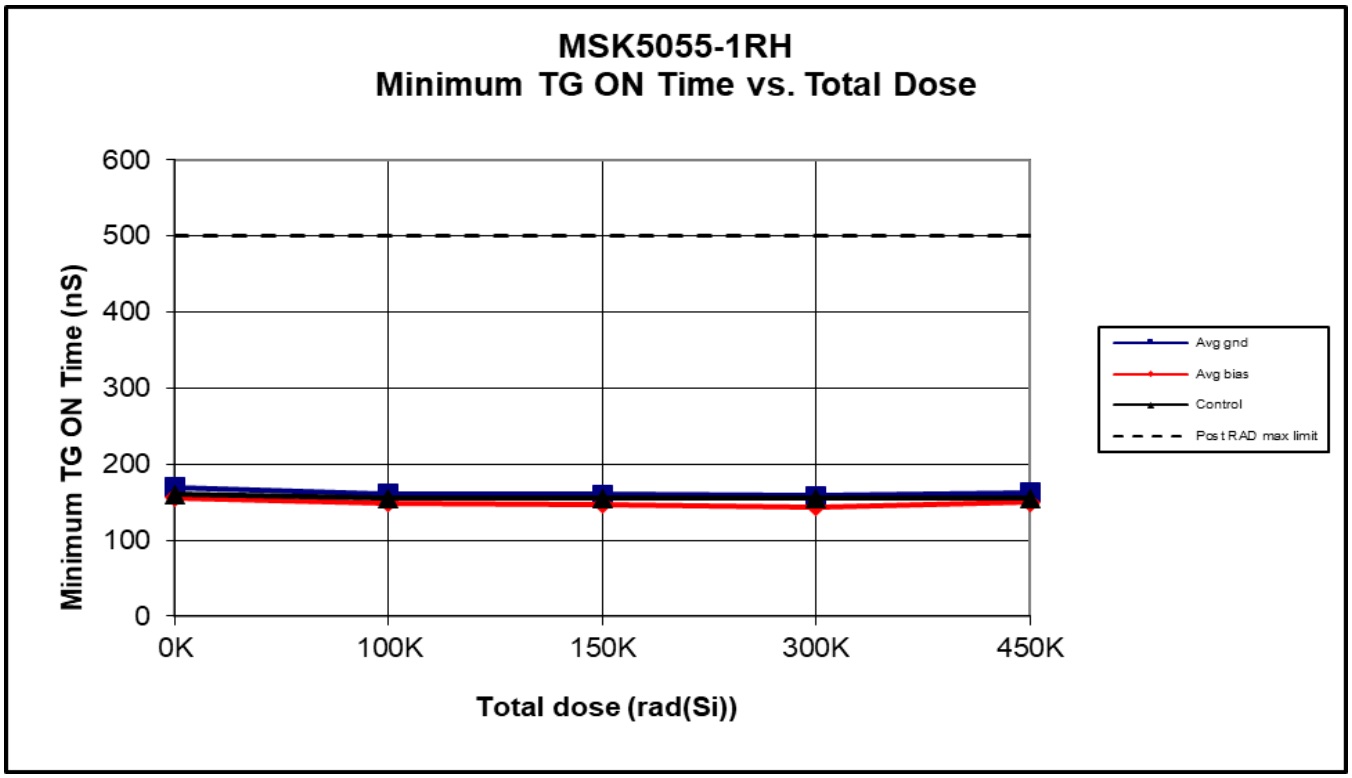

MSK5055-1RH
Operating Frequency vs. Total Dose
(RSET = 49.9KΩ)
Operating Frequency (kHz)
400
380
360
340
320
300
280
260
240
0K
100K
150K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control
Post RAD min limit
Post RAD max limit

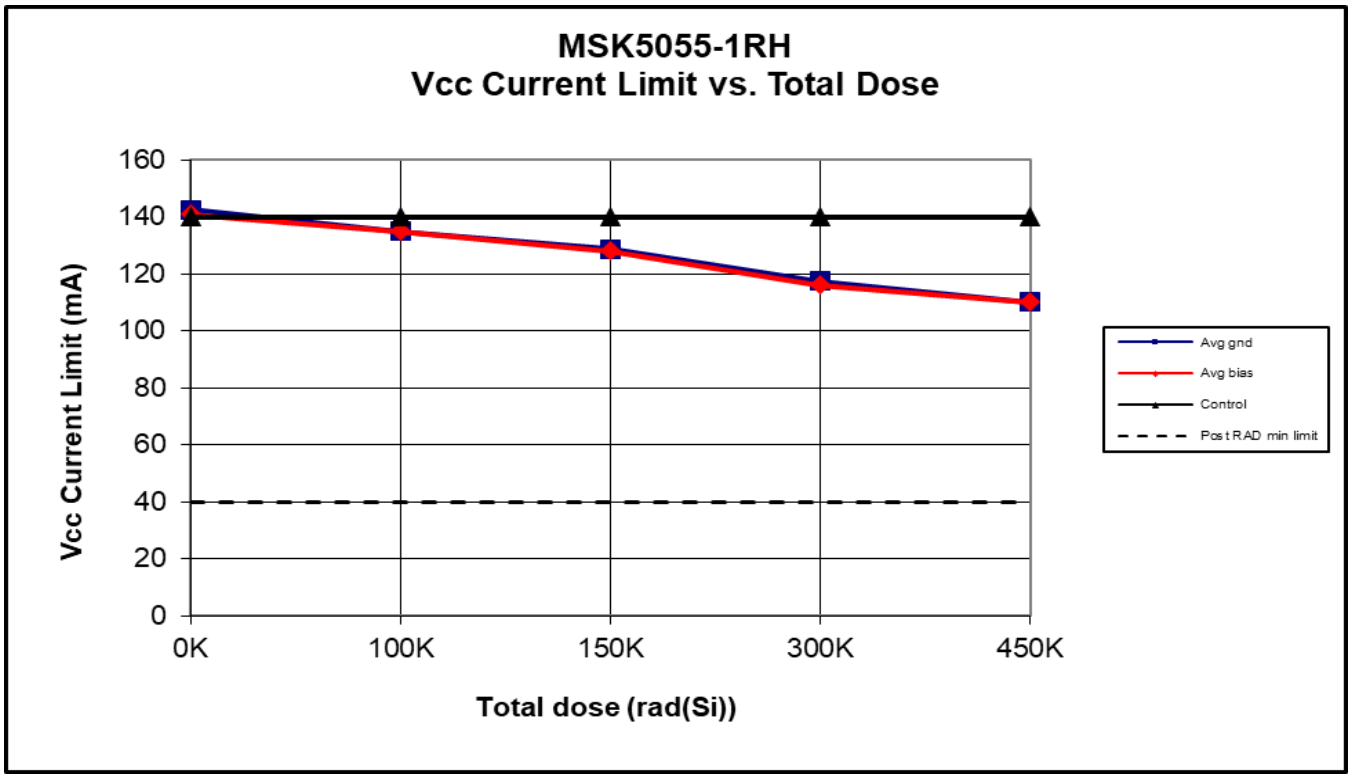

MSK5055-1RH
Sync Voltage Threshold vs. Total Dose
Sync Voltage Threhold (V)
2.5
2.0
1.5
1.0
0.5
0.0
0K
100K
150K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control
Post RAD max limit


MSK5055-1RH
Current Limit Sense Volatge vs. Total Dose
Current Limit Sense Voltage (mV)
140
120
100
80
60
40
20
0
0K
100K
150K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control
Post RAD min limit
Post RAD max limit


MSK5055-1RH
Vcc Supply Current vs. Total Dose
Vcc Supply Current (mA)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0K
100K
150K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control
Post RAD max limit


MSK5055-1RH
Minimum TG Off Time vs. Total Dose
Minimum TG Off Time (nS)
450
400
350
300
250
200
150
100
50
0
0K
100K
150K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control
Post RAD max limit


MSK5055-1RH
Minimum TG ON Time vs. Total Dose
Minimum TG ON Time (nS)
600
500
400
300
200
100
0
0K
100K
150K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control
Post RAD max limit


MSK5055-1RH
Vcc Current Limit vs. Total Dose
Vcc Current Limit (mA)
160
140
120
100
80
60
40
20
0
0K
100K
150K
300K
450K
Total dose (rad(Si))
Avg gnd
Avg bias
Control
Post RAD min limit

Total Ionizing Dose Radiation Test Report

MSK5055RH,
RAD HARD High Voltage Synchronous Switching Regulator Controller

March 26, 2013 (First HDR TID, WAFER LOT: WD005797WF#9)
March 26, 2013 (Neutron Irradiation, WAFER LOT: WD005797WF#9)
March 20, 2018 (2nd HDR TID, WAFER LOT: W1621790.1WF#8)

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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 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:

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 MSK5055RH qualifies as a 300krad(Si) radiation hardened devices. The parameter VIN MIN START VOLTAGE test was not properly executed and has been exclude from this report. Future test effort will include this parameter. Error Amp Reference Voltage, Vin UVLO Threshold (Rising), Operating Frequency, and Current Limit Sense Voltage exhibited the most significant shifts with irradiation. These parameters stayed well within specified post irradiation limits at 100krad(Si) and 300krad(Si). All other parameters stayed within pre-irradiation specifications 300krad(Si).

MSK5055-1RH Biased/Unbiased Dose Rate Schedule

Dosimetry Equipment
Bruker Biospin # 0162

Irradiation Date
3/20/18

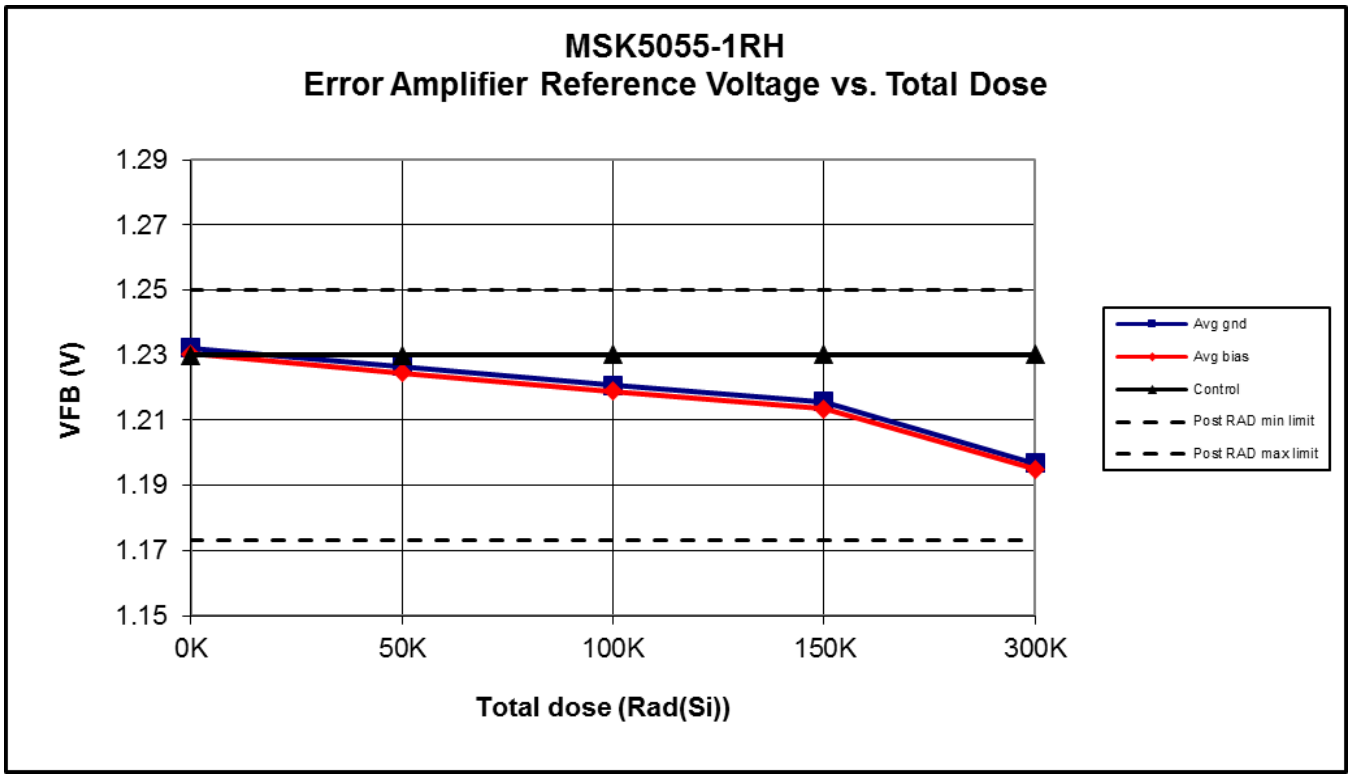
Exposure Length (min:sec)	Incremental Dose rad(Si)	Cumulative Dose rad(Si)
06:55	51,500	51,500
06:55	51,500	103,000
06:55	51,500	154,500
20:46	154,500	309,000

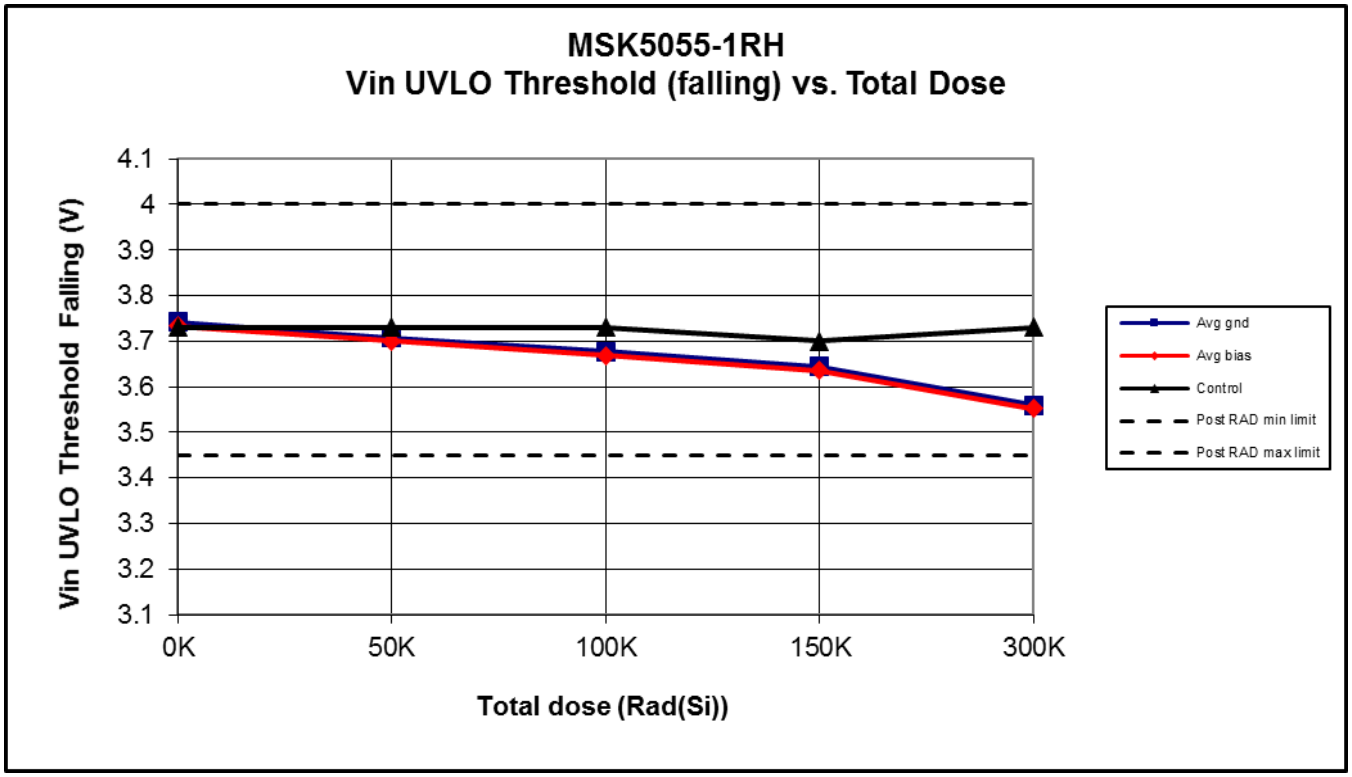
Biased S/N – 0674, 0675, 0676, 0677, 0678

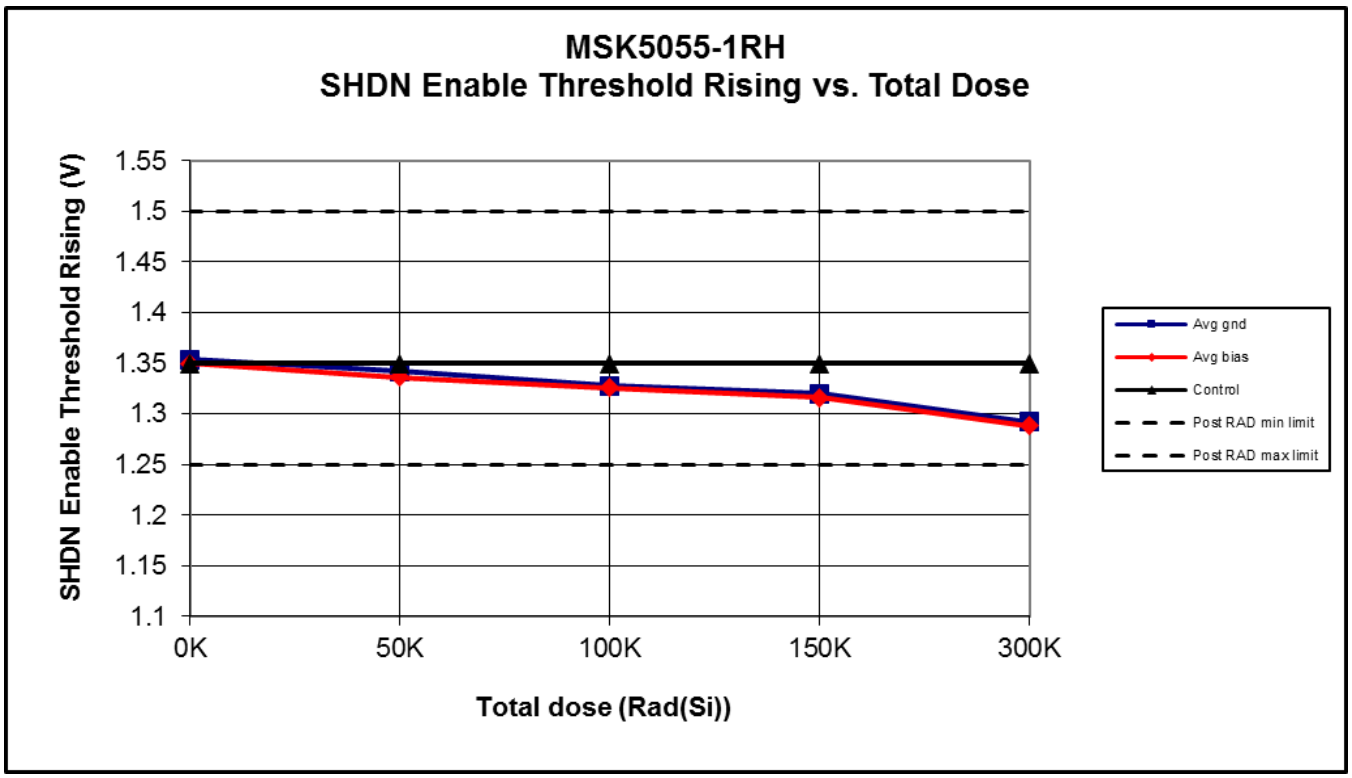
Unbiased S/N – 0679, 0680, 0681, 0682, 0683

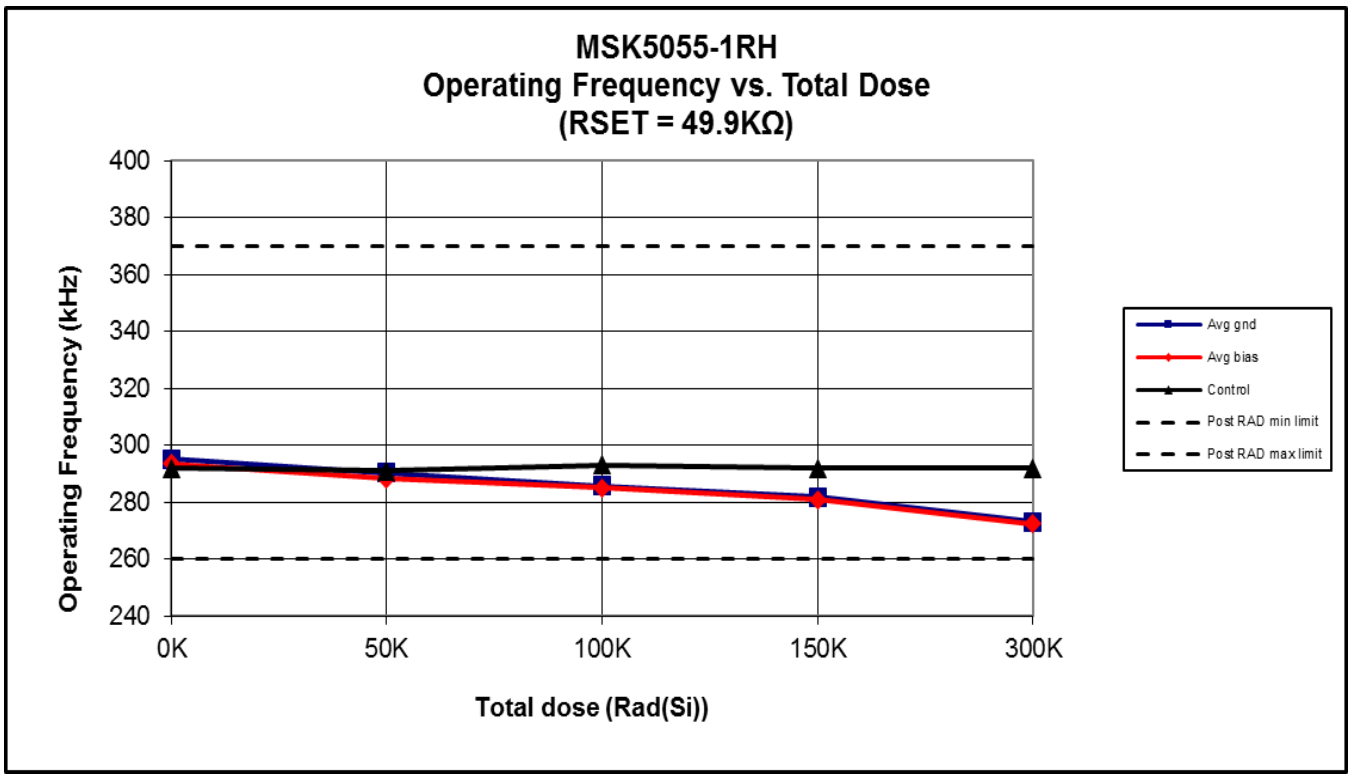
Table 1

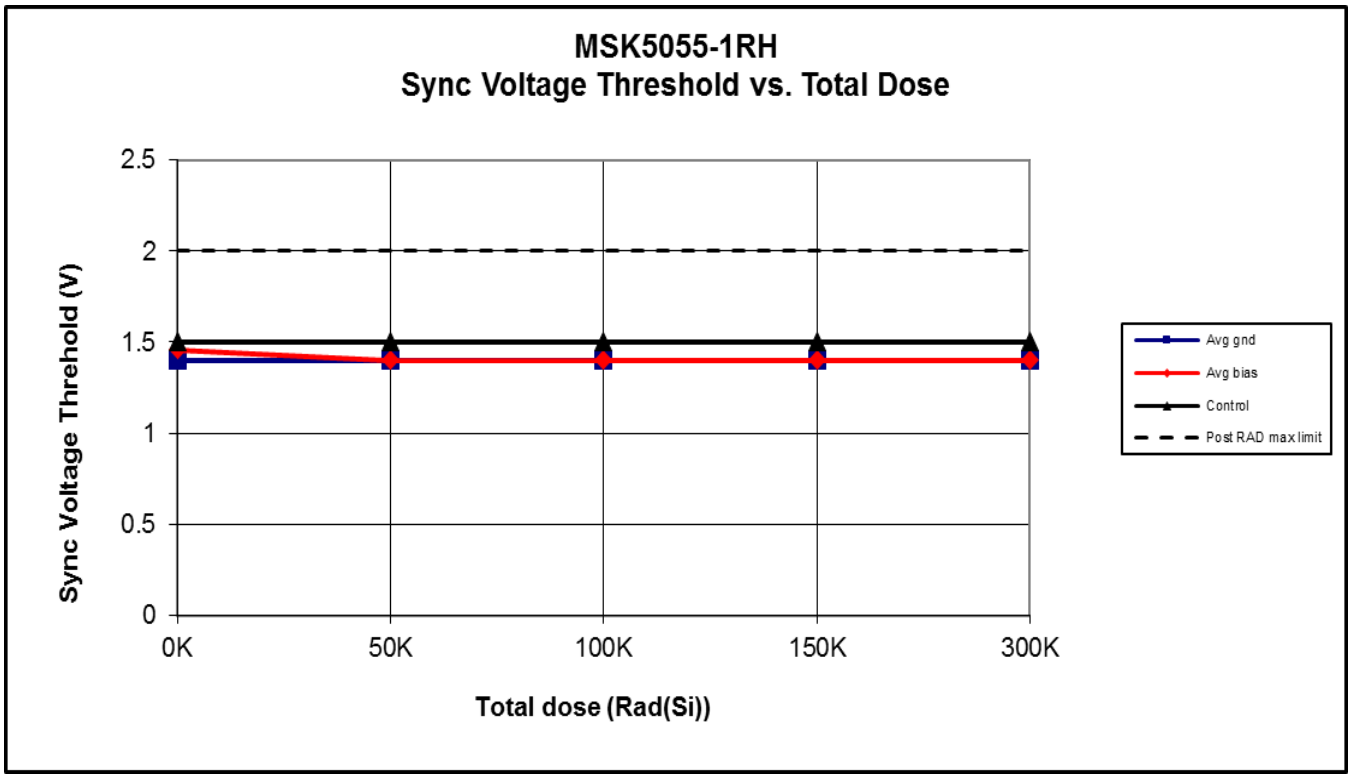
Dose Time, Incremental Dose and Total Cumulative Dose

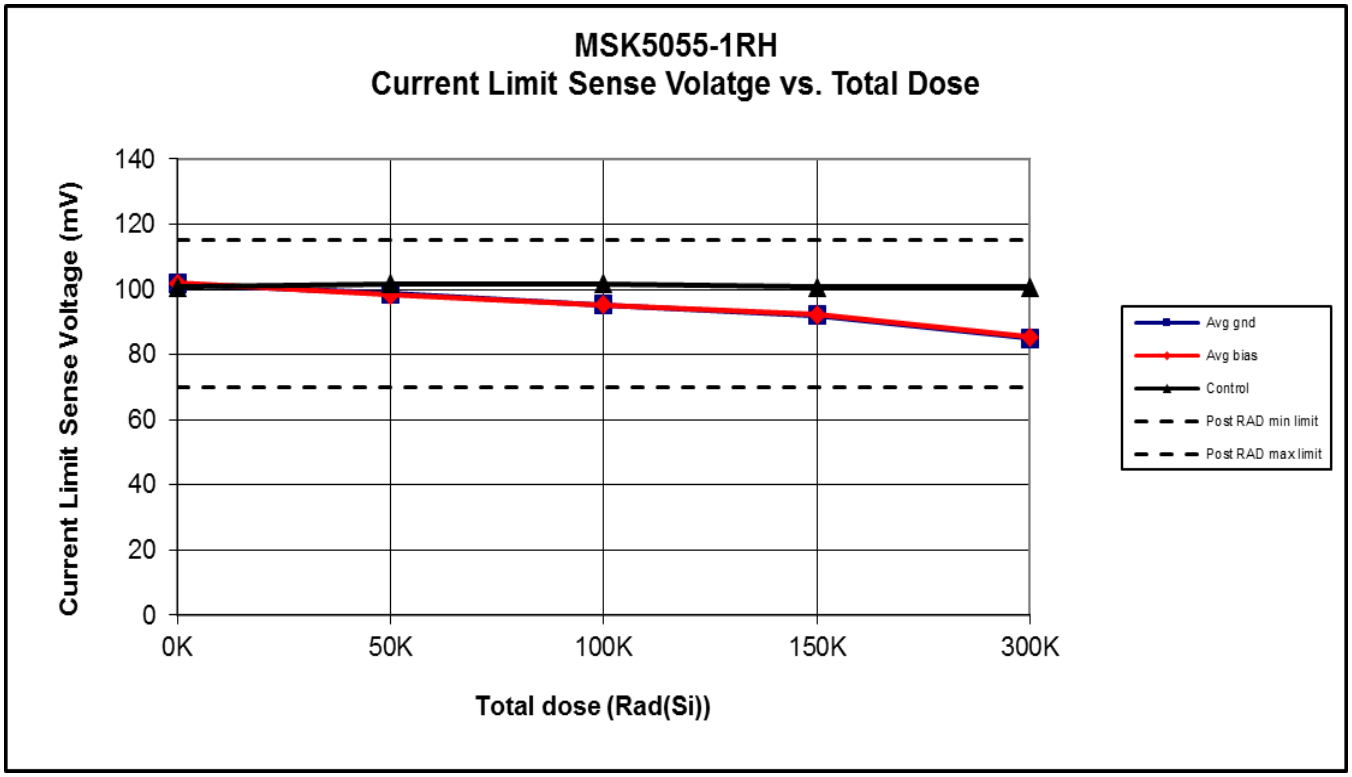

MSK5055-1RH
Error Amplifier Reference Voltage vs. Total Dose
VFB (V)
1.29
1.27
1.25
1.23
1.21
1.19
1.17
1.15
0K
50K
100K
150K
300K
Total dose (Rad(Si))
Avg gnd
Avg bias
Control
Post RAD min limit
Post RAD max limit

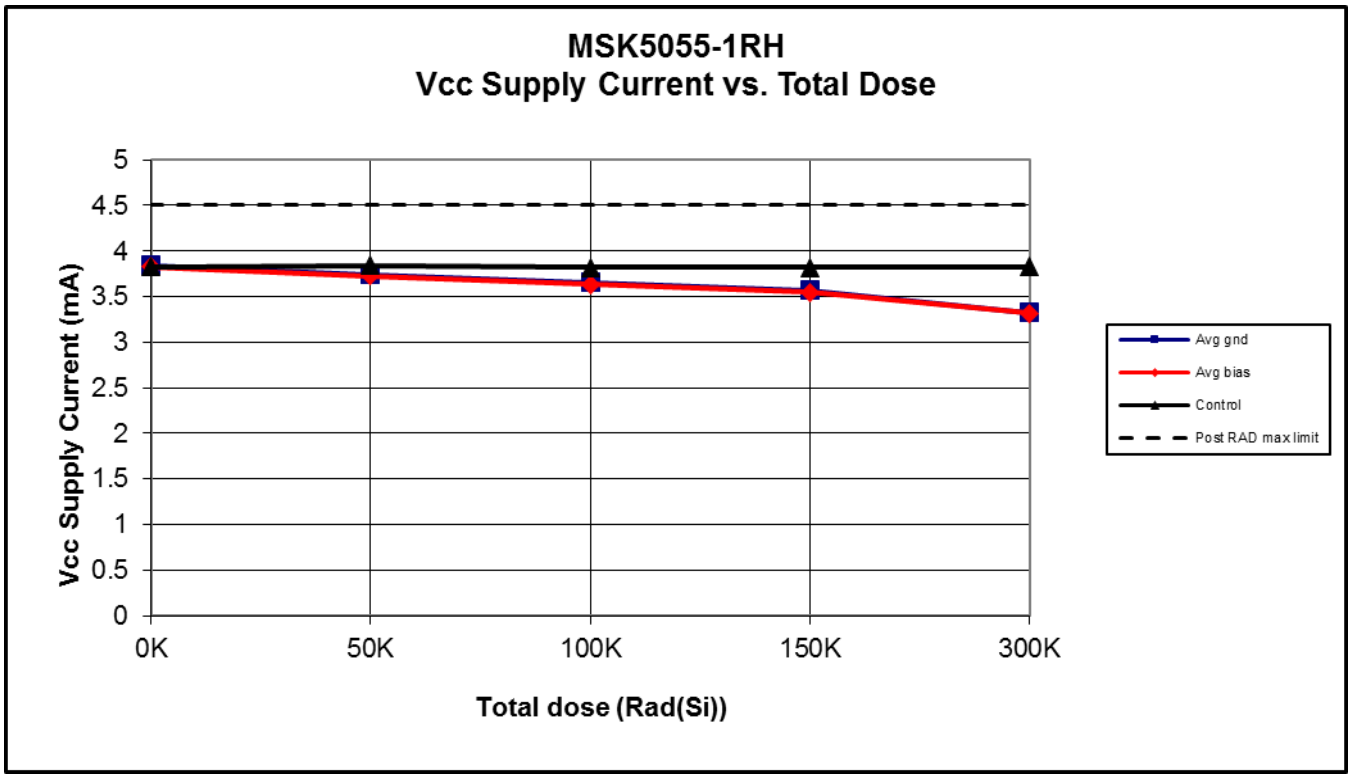

MSK5055-1RH
Vin UVLO Threshold (falling) vs. Total Dose
Vin UVLO Threshold Falling (V)
4.1
4
3.9
3.8
3.7
3.6
3.5
3.4
3.3
3.2
3.1
0K
50K
100K
150K
300K
Total dose (Rad(Si))
Avg gnd
Avg bias
Control
Post RAD min limit
Post RAD max limit

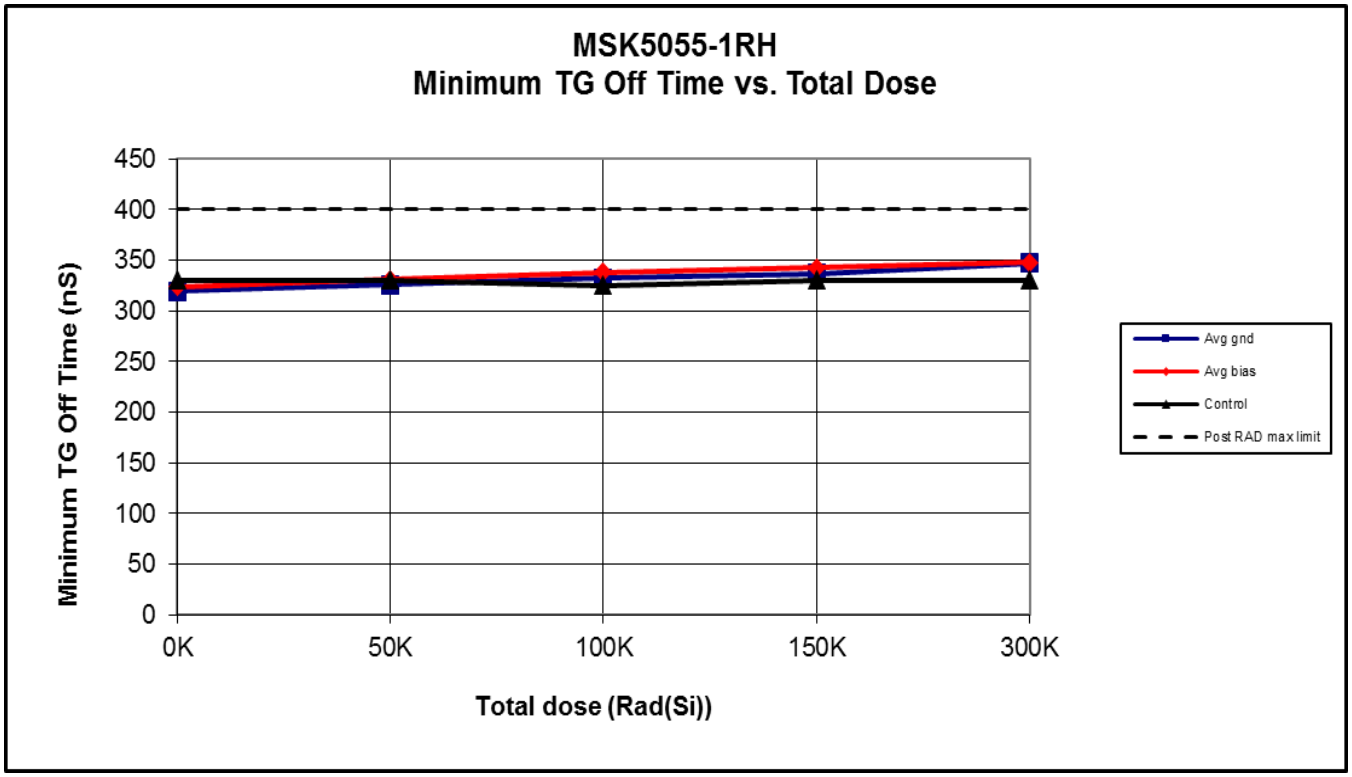

MSK5055-1RH
SHDN Enable Threshold Rising vs. Total Dose
SHDN Enable Threshold Rising (V)
1.55
1.5
1.45
1.4
1.35
1.3
1.25
1.2
1.15
1.1
0K
50K
100K
150K
300K
Total dose (Rad(Si))
Avg gnd
Avg bias
Control
Post RAD min limit
Post RAD max limit

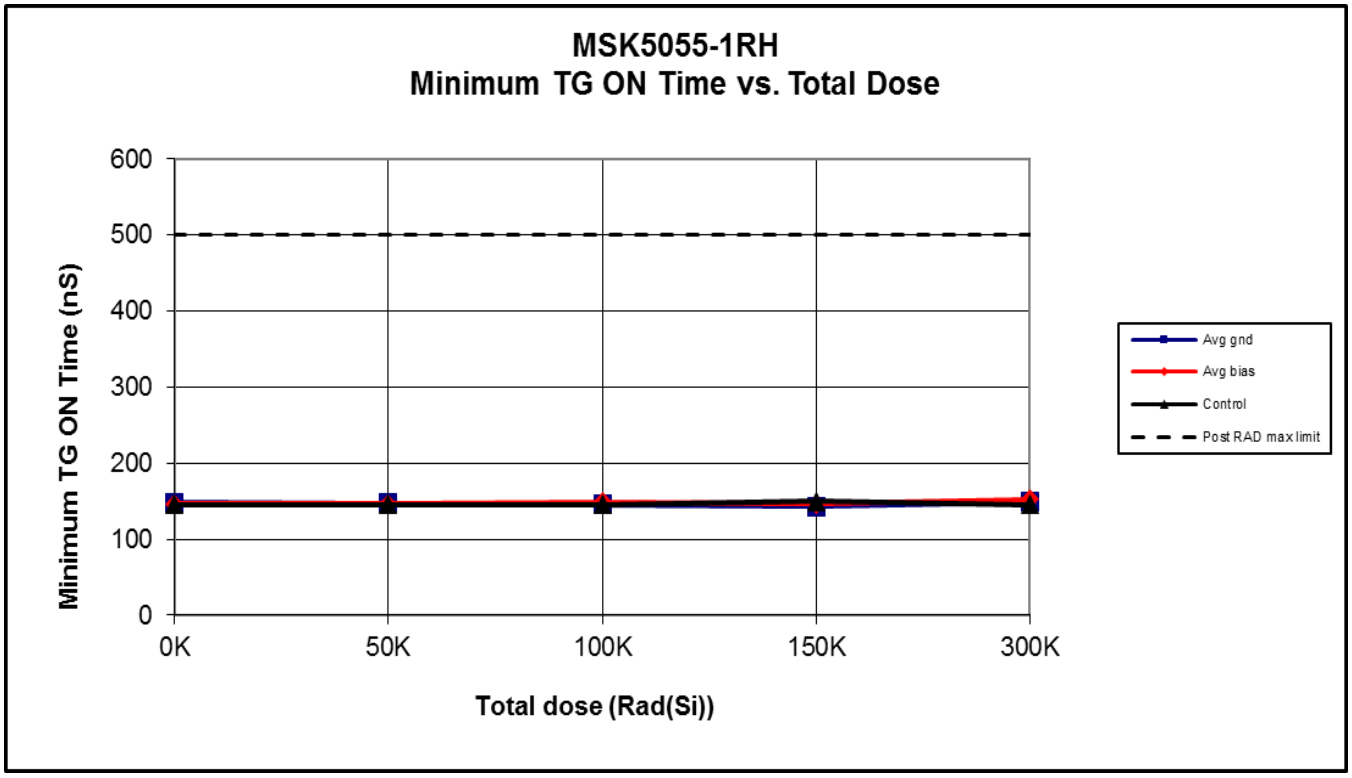

MSK5055-1RH
Operating Frequency vs. Total Dose
(RSET = 49.9KΩ)
Operating Frequency (kHz)
400
380
360
340
320
300
280
260
240
0K
50K
100K
150K
300K
Total dose (Rad(Si))
Avg gnd
Avg bias
Control
Post RAD min limit
Post RAD max limit

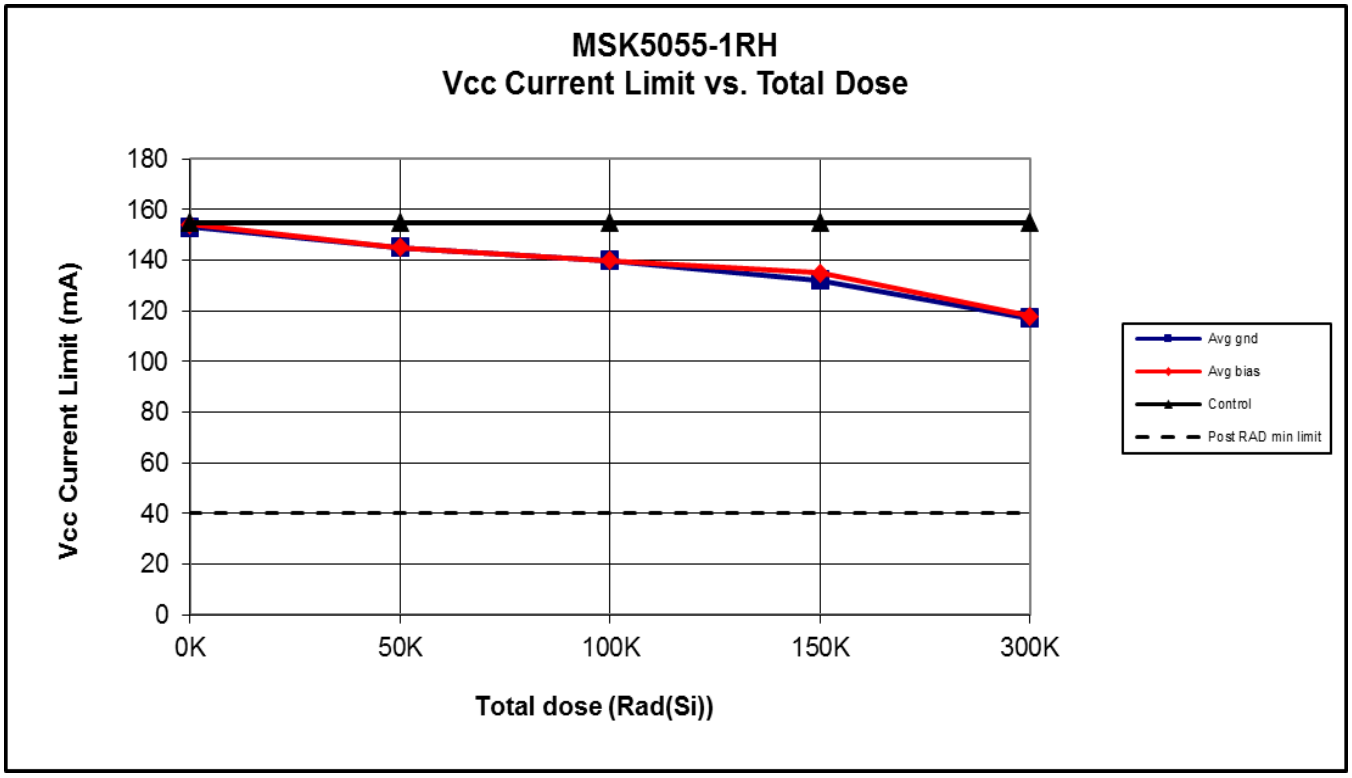

MSK5055-1RH
Sync Voltage Threshold vs. Total Dose
Sync Voltage Threhold (V)
2.5
2
1.5
1
0.5
0
0K
50K
100K
150K
300K
Total dose (Rad(Si))
Avg gnd
Avg bias
Control
Post RAD max limit


MSK5055-1RH
Current Limit Sense Volatge vs. Total Dose
Current Limit Sense Voltage (mV)
140
120
100
80
60
40
20
0
0K
50K
100K
150K
300K
Total dose (Rad(Si))
Avg gnd
Avg bias
Control
Post RAD min limit
Post RAD max limit


MSK5055-1RH
Vcc Supply Current vs. Total Dose
Vcc Supply Current (mA)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0K
50K
100K
150K
300K
Total dose (Rad(Si))
Avg gnd
Avg bias
Control
Post RAD max limit


MSK5055-1RH
Minimum TG Off Time vs. Total Dose
Minimum TG Off Time (nS)
450
400
350
300
250
200
150
100
50
0
0K
50K
100K
150K
300K
Total dose (Rad(Si))
Avg gnd
Avg bias
Control
Post RAD max limit


MSK5055-1RH
Minimum TG ON Time vs. Total Dose
Minimum TG ON Time (nS)
600
500
400
300
200
100
0
0K
50K
100K
150K
300K
Total dose (Rad(Si))
Avg gnd
Avg bias
Control
Post RAD max limit


MSK5055-1RH
Vcc Current Limit vs. Total Dose
Vcc Current Limit (mA)
180
160
140
120
100
80
60
40
20
0
0K
50K
100K
150K
300K
Total dose (Rad(Si))
Avg gnd
Avg bias
Control
Post RAD min limit

Neutron and Total Ionizing Dose Radiation Test Report

MSK5055RH,
RAD HARD High Voltage Synchronous Switching Regulator Controller

March 26, 2013 (TID, WAFER LOT: WD005797WF#9)
March 26, 2013 (Neutron Irradiation, WAFER LOT: WD005797WF#9)

B. Horton
R. Wakeman

M.S. Kennedy Corporation
Liverpool, NY

I. Introduction:

The Neutron Irradiation test for the MSK5055RH was performed to determine the change in device performance as a function of neutron fluence. The testing was performed to 5.38 x 10^{11} n/cm^2 total integral fluence. The test does not classify maximum radiation tolerance of the device, but simply offers designers insight to the critical parameter-shifts up to the indicated fluence levels. The MSK5055RH-1 and MSK5055RH-2 use the same active component. The data herein is from direct measurement of the MSK5055RH-1 response to neutron irradiation, but is indicative of the response of both device types.

MIL-STD-883 Method 1017.9 was used as the basis in the development and implementation of the Neutron Irradiation test plan for the MSK5055RH series.

II. Radiation Source:

Neutron Irradiation was performed at the University of Massachusetts, Lowell, using the Reactor Facility-FNI. The neutron flux was determined by dosimetry system S/P-32, method ASTM E-265, to be 4.05 x 10^8 n/cm^2-S (1 MeV equivalent) for each irradiation step.

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 fully screened I.A.W. MIL-PRF-38534 Class K. For test platform verification, one control device was tested at 25°C. Five devices were then tested at 25°C, prior to irradiation, and were found to be within acceptable test limits.

During irradiation, devices leads were shorted together using antistatic foam and then devices were placed into an anti-static bag. Devices were then vertically aligned with the radiation source.

After each irradiation step, the devices were transported to the MSK electrical test platform. Testing was performed in accordance with the MSK5055RH data sheet. Electrical testing was performed on the irradiated devices, as well as the control device, at each fluence level. Electrical tests were completed within twenty four hours of irradiation.

IV. Data:

All performance curves are averaged from the test results of the irradiated devices. Post 300KRAD(Si) limits have also been plotted for reference only. If required, full test data can be obtained by contacting M.S. Kennedy Corporation.

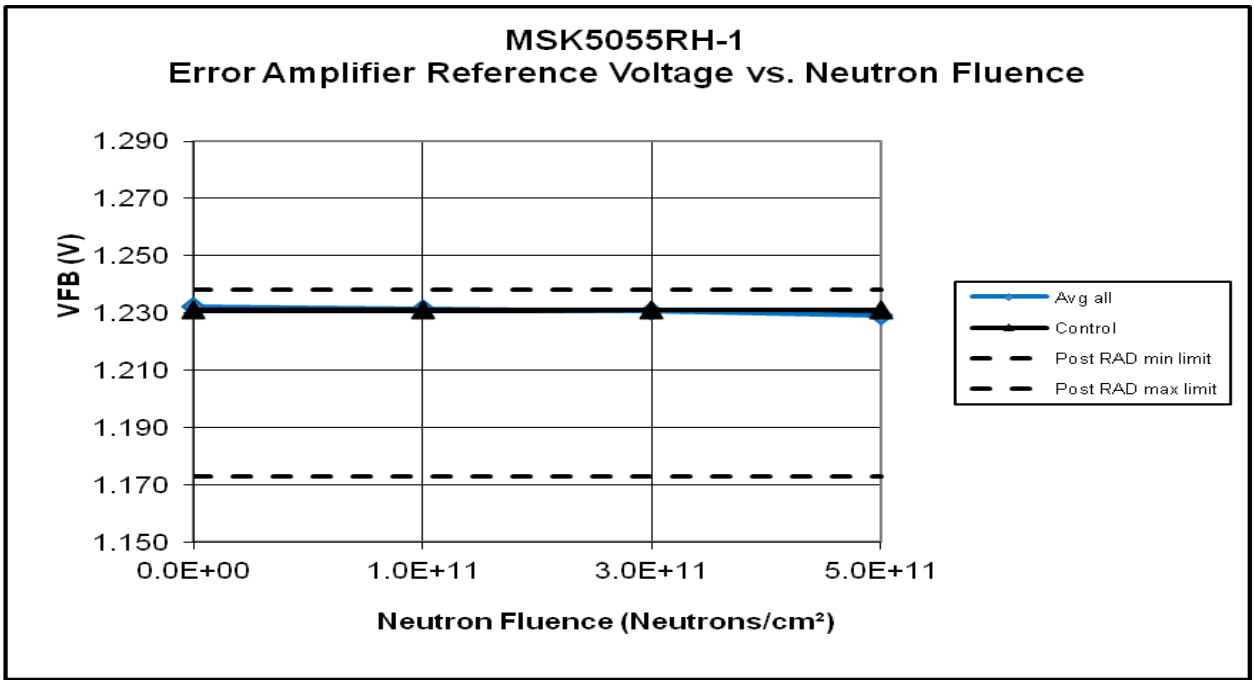
V. Summary:

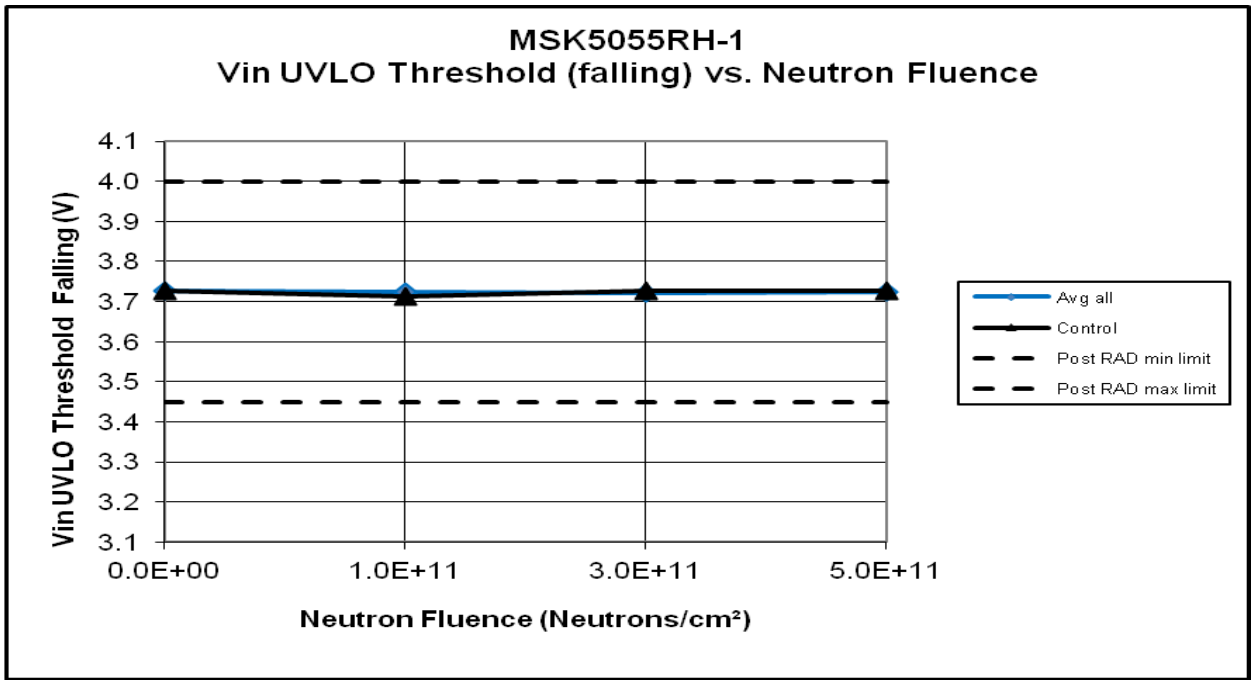
Based on data recorded during neutron irradiation testing and statistical analysis, the MSK5055RH series exhibits low susceptibility to neutron displacement damage. All devices performed well within data sheet specifications throughout all test intervals.

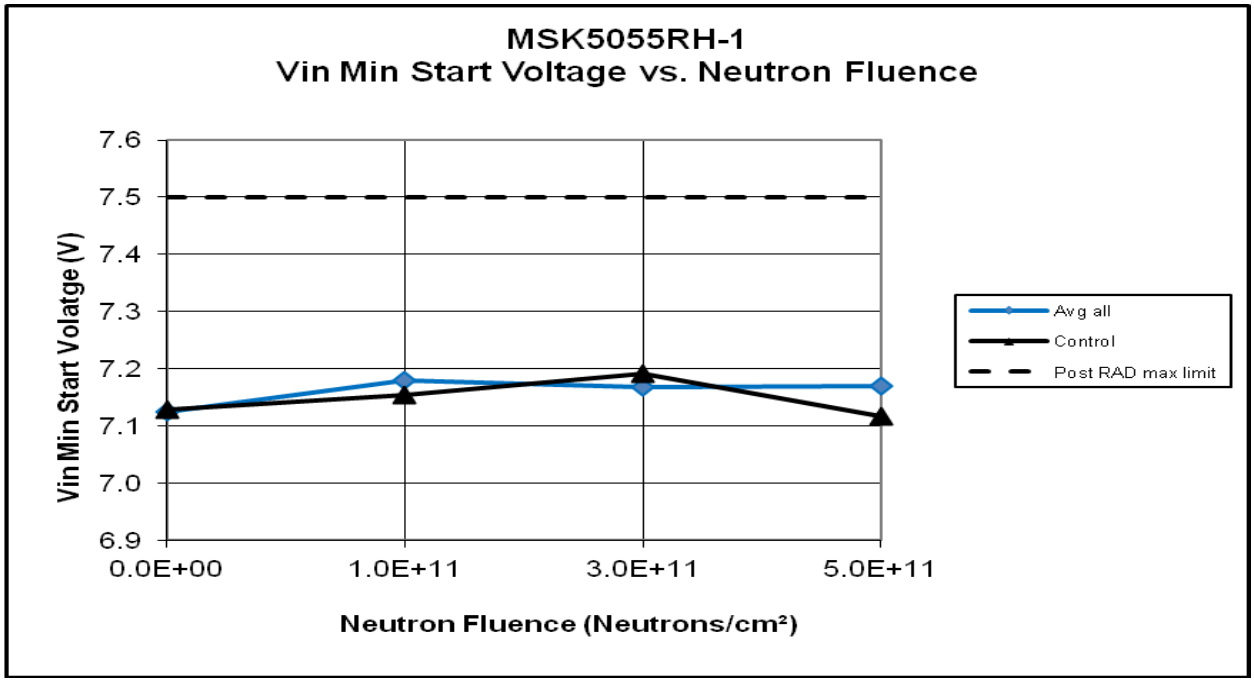
Table 1.

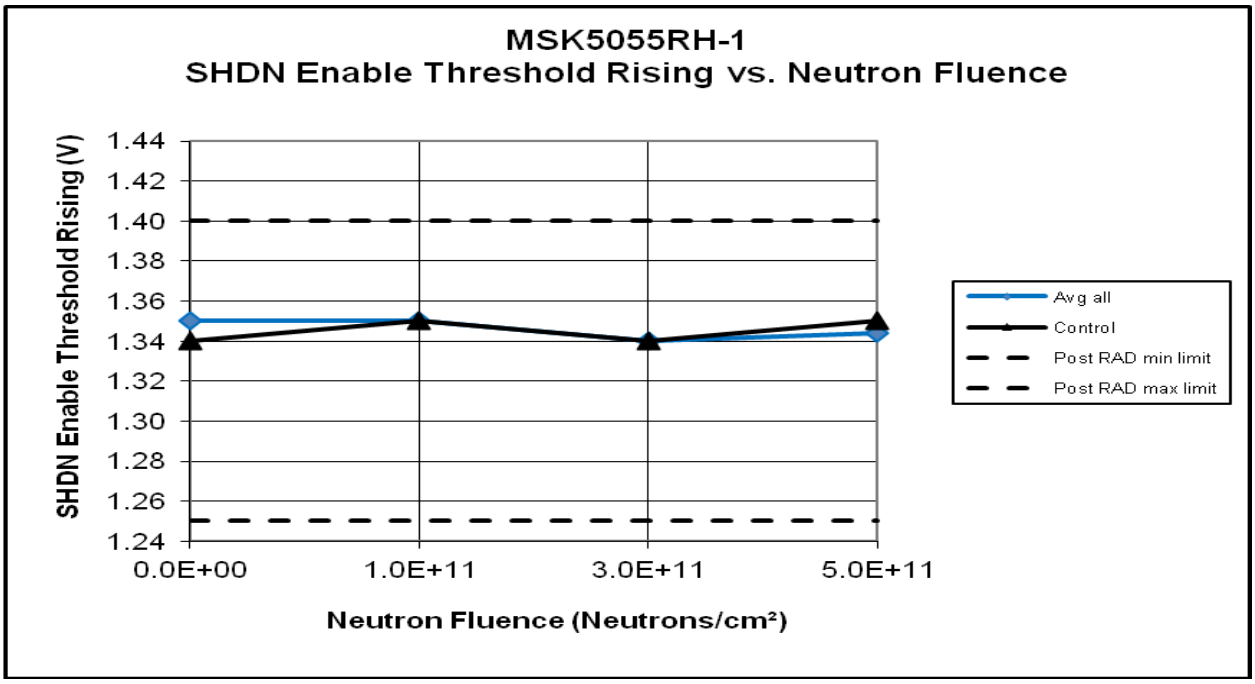
MSK5055RH Neutron Irradiation						
Reactor Facility – Fast Neutron Irradiation (FNI) Dosimetry System: S/P-32 (ASTM E-265)						
Exposure Date: 3/26/13						
Irradiation	Reactor Power (kW)	Gamma Dose Rad (Si)	Flux (n/cm^2-S)	Time(s)	Fluence (n/cm^2)	Total Fluence (n/cm^2)
Step 1	5	14	4.05E8	247	1.14E11	1.14E11
Step 2	5	28	4.05E8	494	2.14E11	3.28E11
Step 3	5	28	4.05E8	494	2.10E11	5.38E11

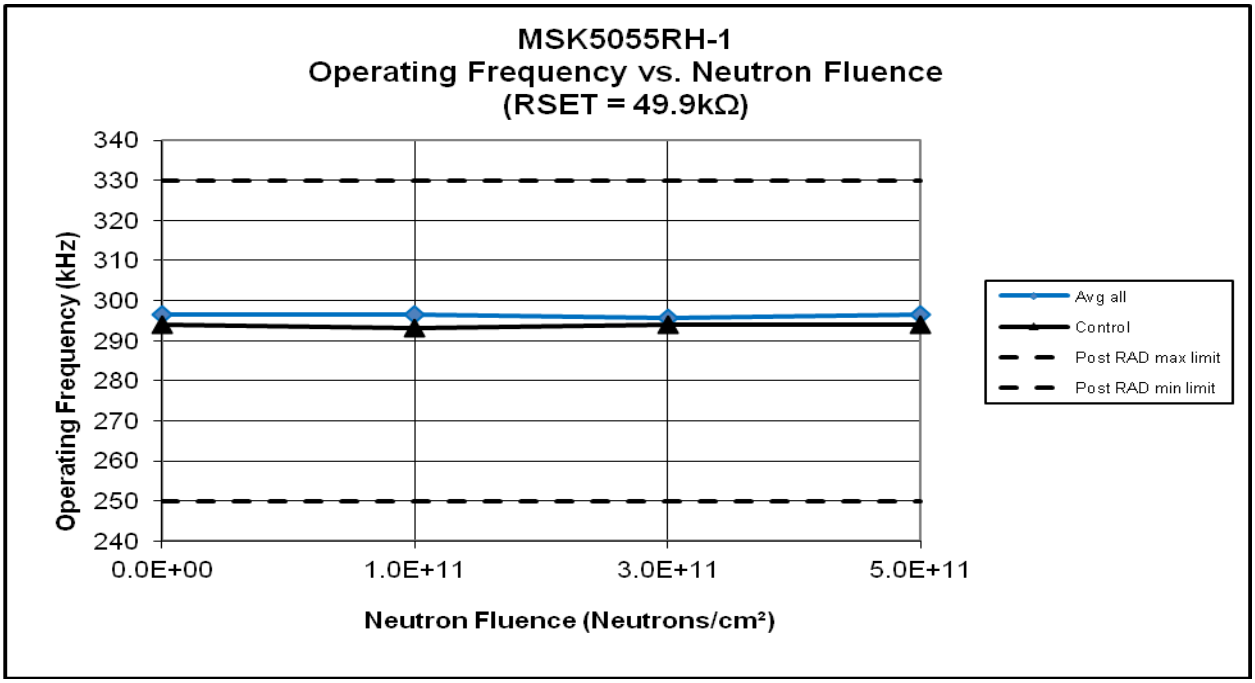
Gamma Dose, Neutron Flux and Total Fluence

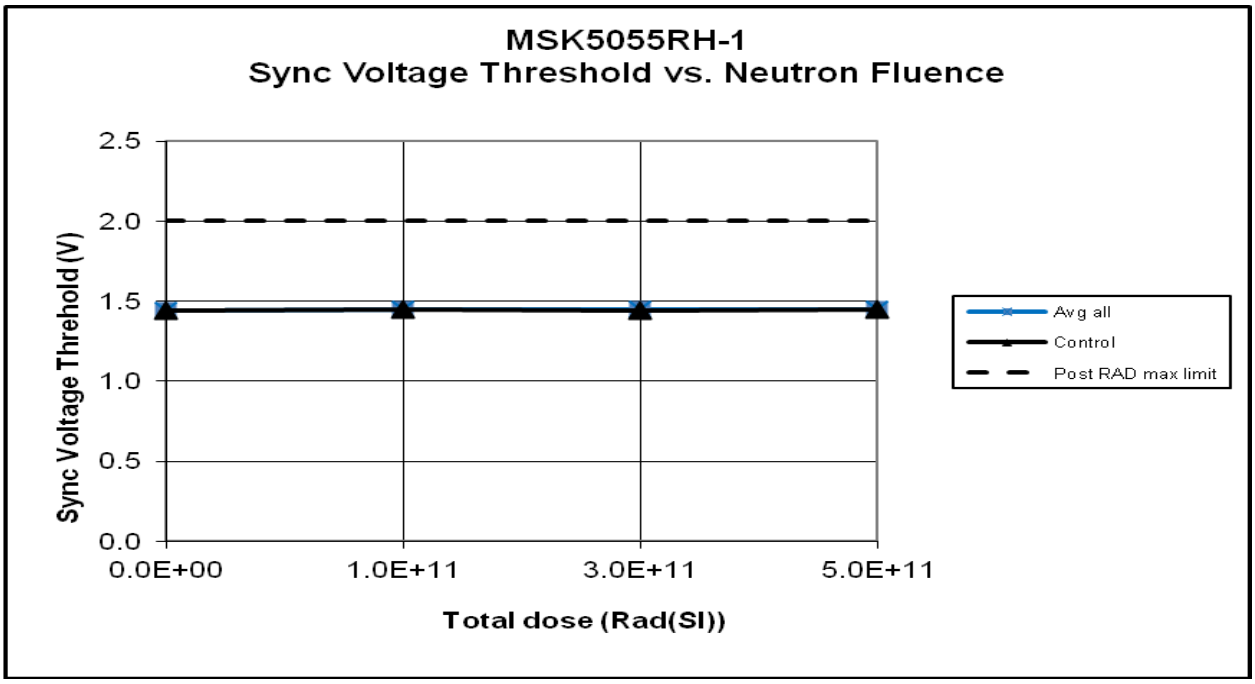

MSK5055RH-1
Error Amplifier Reference Voltage vs. Neutron Fluence
VFB (V)
1.290
1.270
1.250
1.230
1.210
1.190
1.170
1.150
0.0E+00
1.0E+11
3.0E+11
5.0E+11
Neutron Fluence (Neutrons/cm²)
Avg all
Control
Post RAD min limit
Post RAD max limit

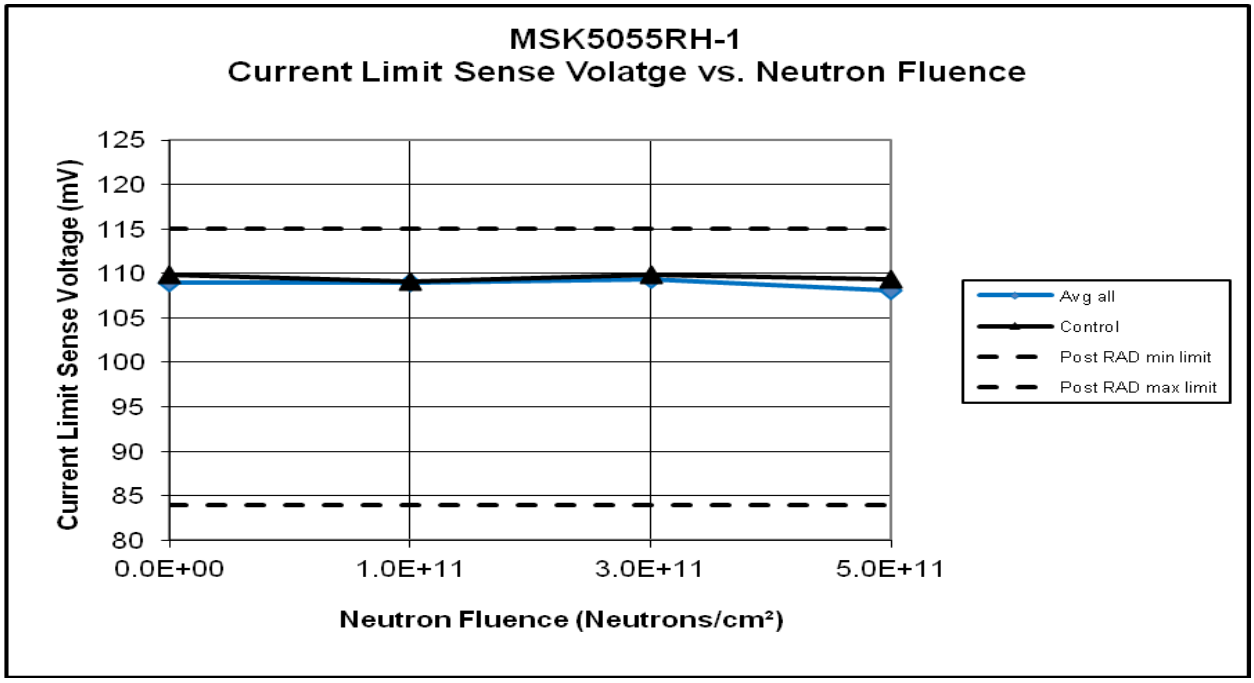

MSK5055RH-1
Vin UVLO Threshold (falling) vs. Neutron Fluence
Vin UVLO Threshold Falling (V)
4.1
4.0
3.9
3.8
3.7
3.6
3.5
3.4
3.3
3.2
3.1
0.0E+00
1.0E+11
3.0E+11
5.0E+11
Neutron Fluence (Neutrons/cm²)
Avg all
Control
Post RAD min limit
Post RAD max limit

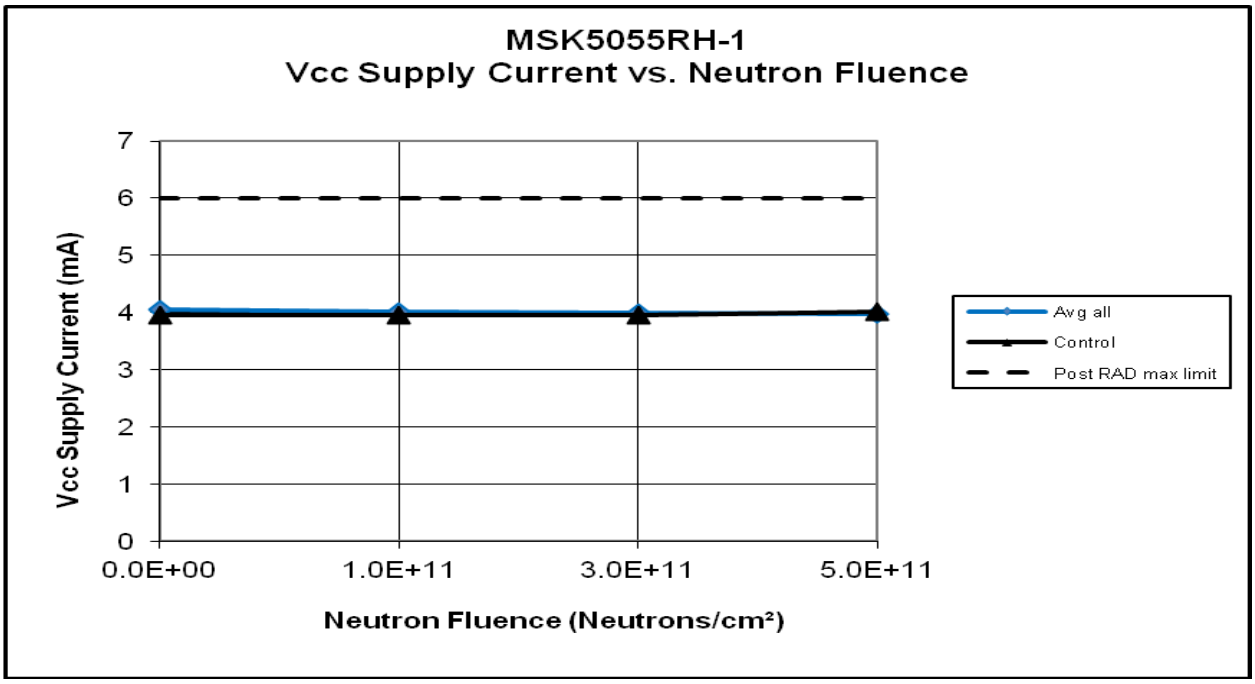

MSK5055RH-1
Vin Min Start Voltage vs. Neutron Fluence
Vin Min Start Volatge (V)
7.6
7.5
7.4
7.3
7.2
7.1
7.0
6.9
0.0E+00
1.0E+11
3.0E+11
5.0E+11
Neutron Fluence (Neutrons/cm²)
Avg all
Control
Post RAD max limit

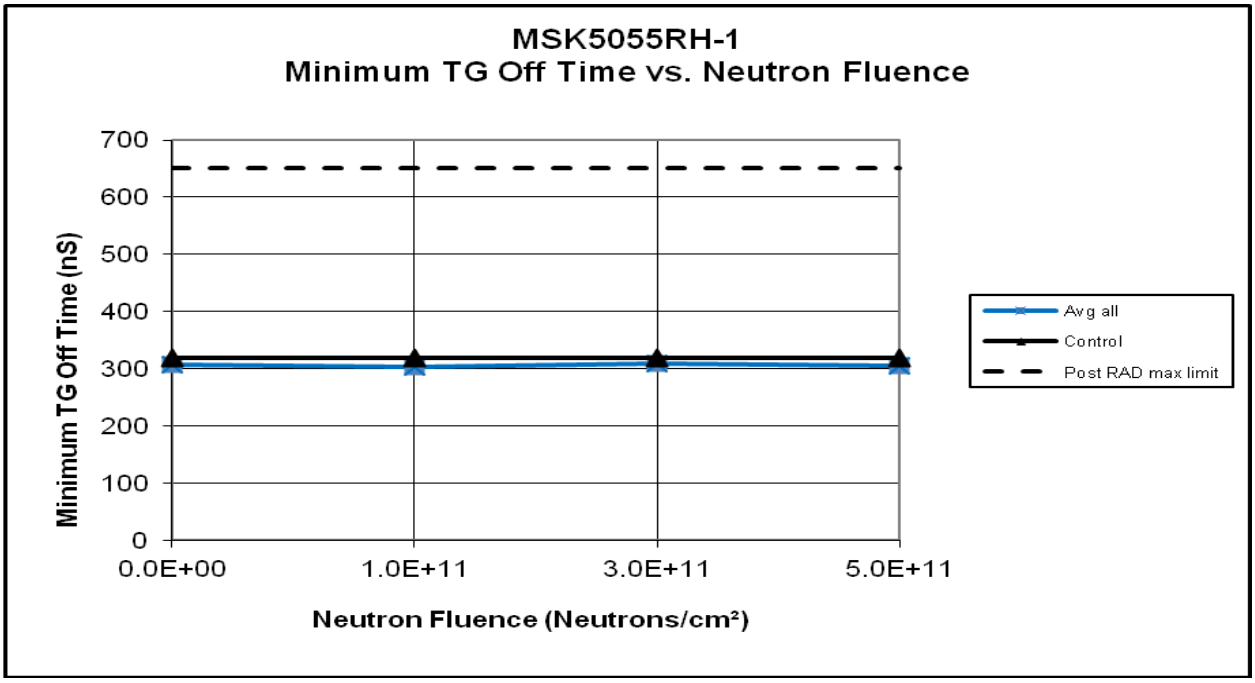

MSK5055RH-1
SHDN Enable Threshold Rising vs. Neutron Fluence
SHDN Enable Threshold Rising (V)
1.44
1.42
1.40
1.38
1.36
1.34
1.32
1.30
1.28
1.26
1.24
0.0E+00
1.0E+11
3.0E+11
5.0E+11
Neutron Fluence (Neutrons/cm²)
Avg all
Control
Post RAD min limit
Post RAD max limit

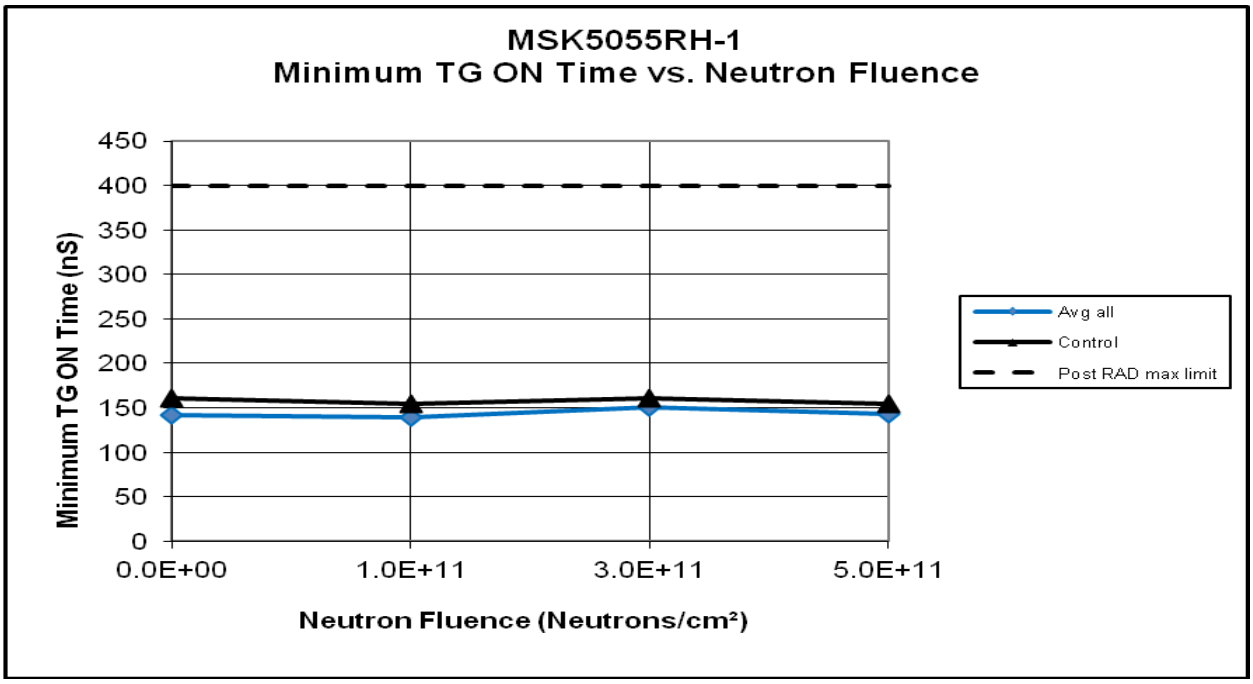

MSK5055RH-1
Operating Frequency vs. Neutron Fluence
(RSET = 49.9kΩ)
Operating Frequency (kHz)
340
330
320
310
300
290
280
270
260
250
240
0.0E+00
1.0E+11
3.0E+11
5.0E+11
Neutron Fluence (Neutrons/cm²)
Avg all
Control
Post RAD max limit
Post RAD min limit

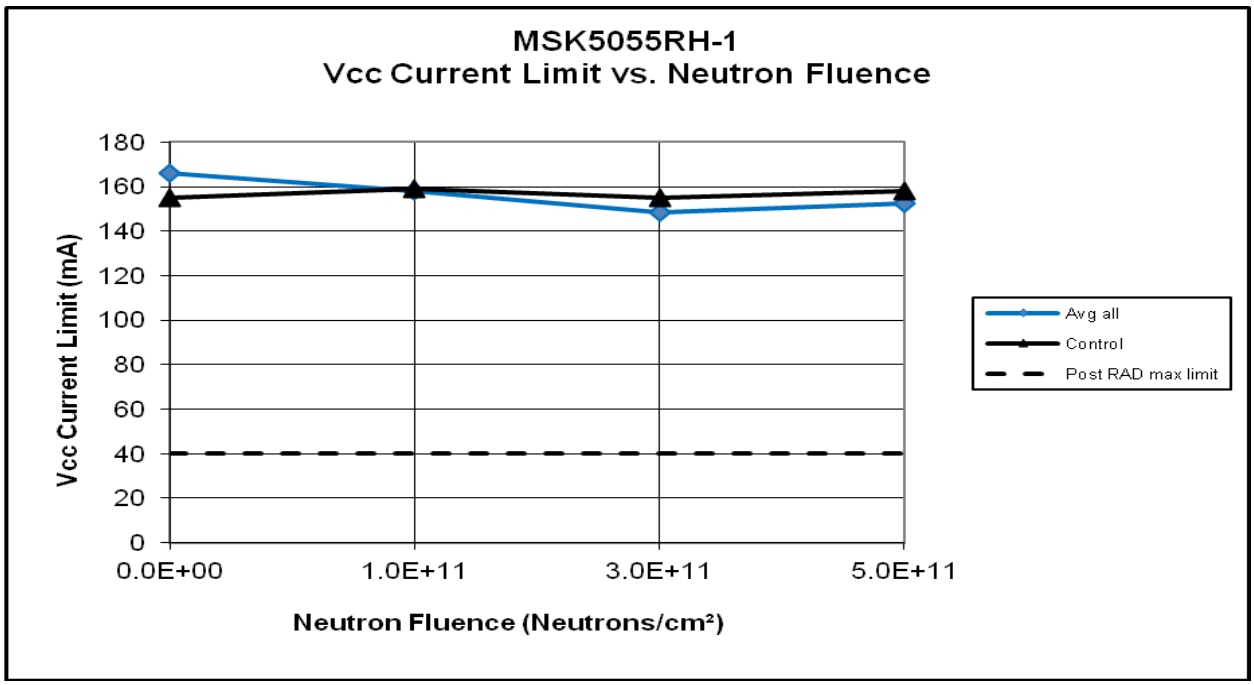

MSK5055RH-1
Sync Voltage Threshold vs. Neutron Fluence
Sync Voltage Threhold (V)
2.5
2.0
1.5
1.0
0.5
0.0
0.0E+00
1.0E+11
3.0E+11
5.0E+11
Total dose (Rad(Si))
Avg all
Control
Post RAD max limit


MSK5055RH-1
Current Limit Sense Volatge vs. Neutron Fluence
Current Limit Sense Voltage (mV)
125
120
115
110
105
100
95
90
85
80
0.0E+00
1.0E+11
3.0E+11
5.0E+11
Neutron Fluence (Neutrons/cm²)
Avg all
Control
Post RAD min limit
Post RAD max limit


MSK5055RH-1
Vcc Supply Current vs. Neutron Fluence
Vcc Supply Current (mA)
7
6
5
4
3
2
1
0
0.0E+00
1.0E+11
3.0E+11
5.0E+11
Neutron Fluence (Neutrons/cm²)
Avg all
Control
Post RAD max limit


MSK5055RH-1
Minimum TG Off Time vs. Neutron Fluence
Minimum TG Off Time (nS)
700
600
500
400
300
200
100
0
0.0E+00
1.0E+11
3.0E+11
5.0E+11
Neutron Fluence (Neutrons/cm²)
Avg all
Control
Post RAD max limit


MSK5055RH-1
Minimum TG ON Time vs. Neutron Fluence
Minimum TG ON Time (nS)
450
400
350
300
250
200
150
100
50
0
0.0E+00
1.0E+11
3.0E+11
5.0E+11
Neutron Fluence (Neutrons/cm²)
Avg all
Control
Post RAD max limit


MSK5055RH-1
Vcc Current Limit vs. Neutron Fluence
Vcc Current Limit (mA)
180
160
140
120
100
80
60
40
20
0
0.0E+00
1.0E+11
3.0E+11
5.0E+11
Neutron Fluence (Neutrons/cm²)
Avg all
Control
Post RAD max limit

Total Ionizing Dose Radiation Test Report

MSK5055RH,
RAD HARD High Voltage Synchronous Switching Regulator Controller

March 26, 2013 (TID, WAFER LOT: WD005797WF#9)

B. Horton
R. Wakeman

M.S. Kennedy Corporation
Liverpool, NY

I. Introduction:

The Total Ionizing Dose radiation test plan for the MSK 5055RH was developed to qualify the devices as RAD Hard to 300KRADS(Si). Testing was performed beyond 300 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. The MSK5055RH-1, and MSK5055RH-2 both use the same active components. The data in this report is from direct measurement of the MSK5055RH-1 response to irradiation but it is indicative of the response of both devices and is applicable to both.

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 MSK5055RH.

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 97 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 240 hours of burn-in per MIL-STD-883 Method 1015 and were fully screened IAW MIL-PRF-38535 Class K. For test platform verification, one control device was 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. 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 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 M.S. Kennedy Corporation.

V. Summary:

Based on the test data recorded during radiation testing and statistical analysis, the MSK5055RH qualifies as 300 KRad(Si) radiation hardened devices. Error Amplifier Reference Voltage, Vin UVLO Threshold (falling), Operating Frequency, and Current Limit Sense Voltage exhibited the most significant shifts with irradiation. These parameters stayed within specified post irradiation limits at 100KRad(Si) and 300KRad(si). All other parameters stayed within pre-irradiation specifications up to or beyond 300KRad(Si).

MSK5055RH Biased/Unbiased Dose Rate Schedule

Dosimetry Equipment
Bruker Biospin # 0162

Irradiation Date
3/27/13

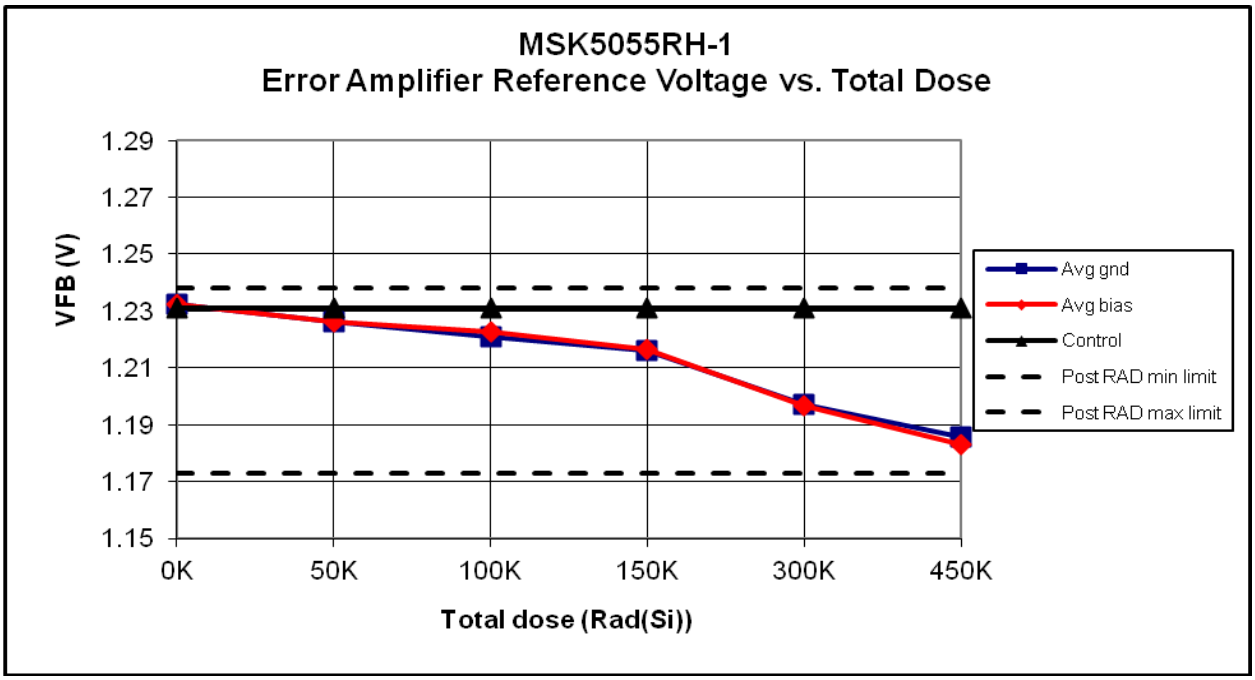
Exposure Length (min:sec)	Incremental Dose rads(Si)	Cumulative Dose rads(Si)
08:51	51,507	51,507
08:51	51,507	103,014
08:51	51,507	154,521
26:33	154,521	309,042
26:33	154,521	463,563

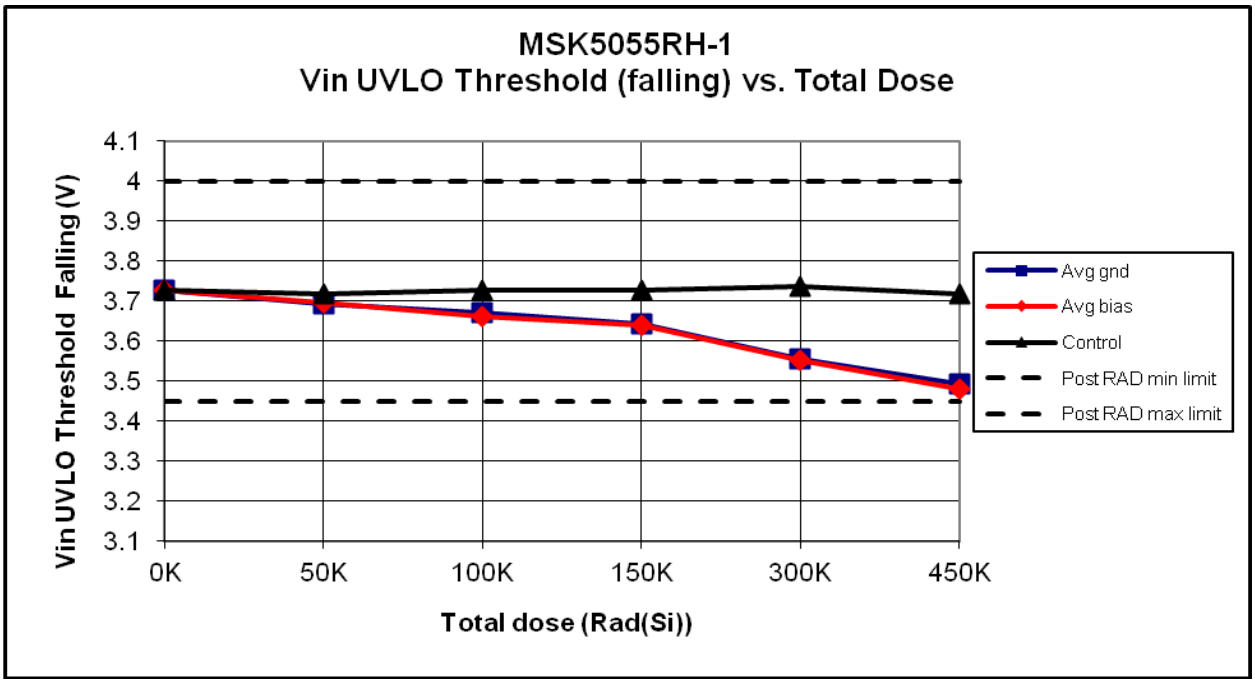
Biased S/N – 0012, 0013, 0014, 0015, 0016

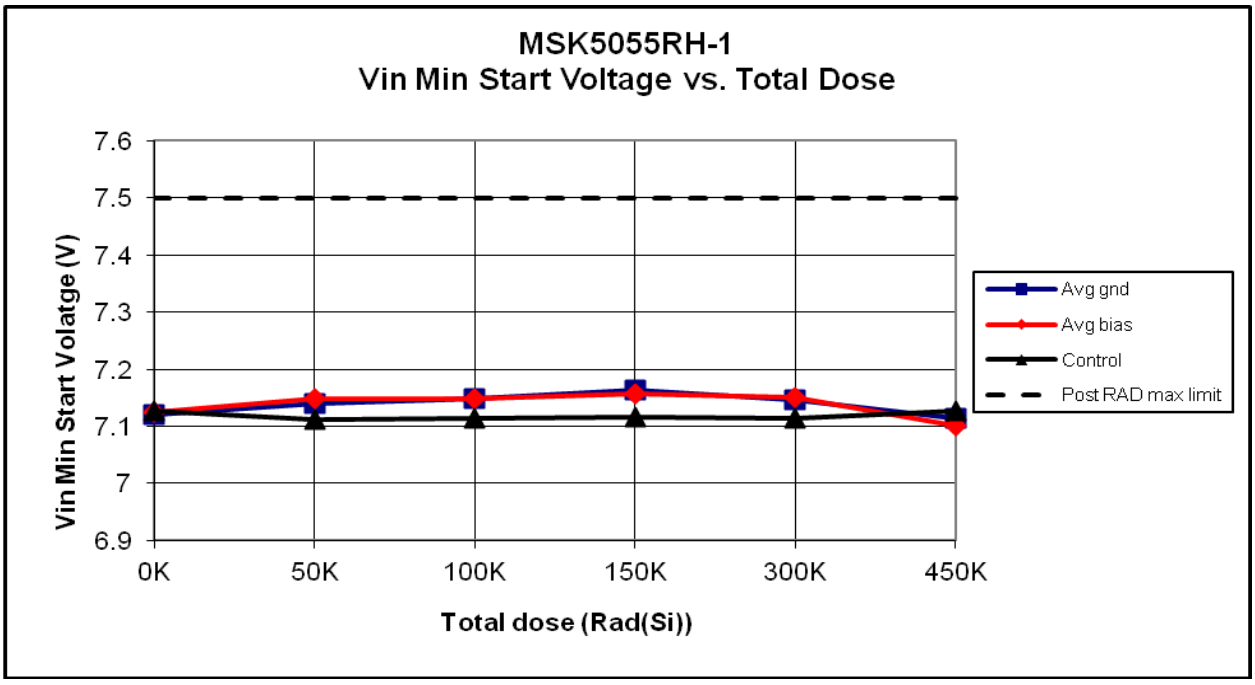
Unbiased S/N – 0017, 0018, 0020, 0022, 0023

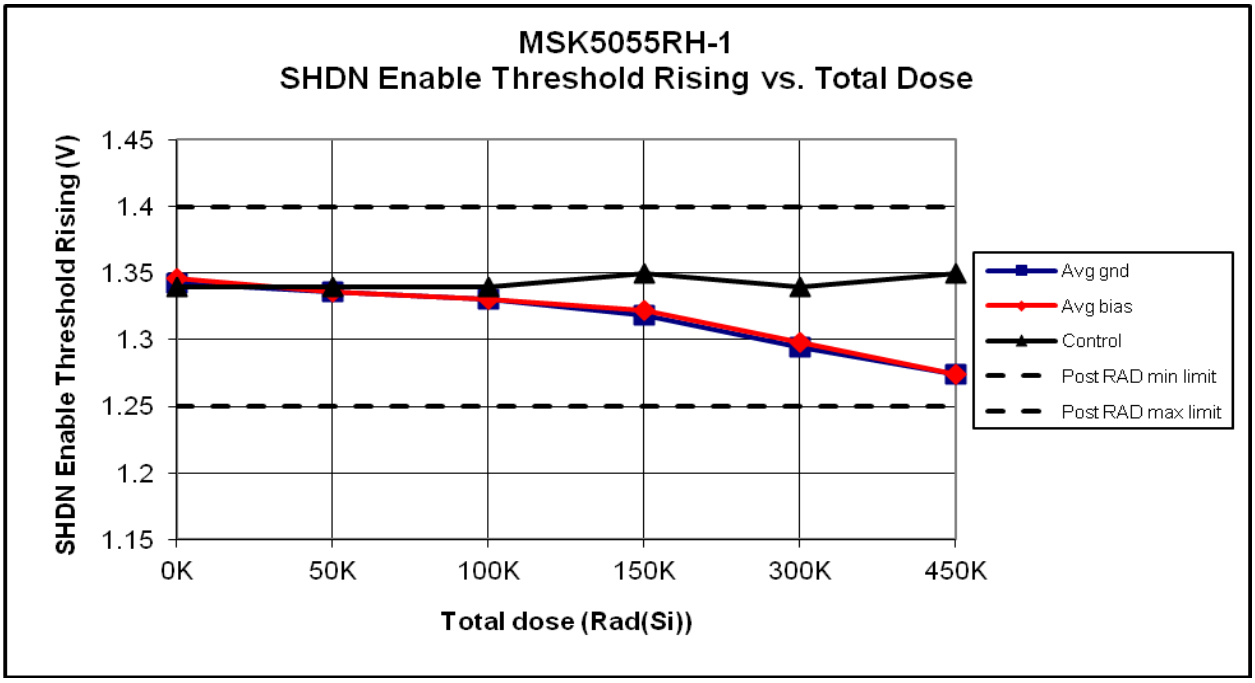
Table 1

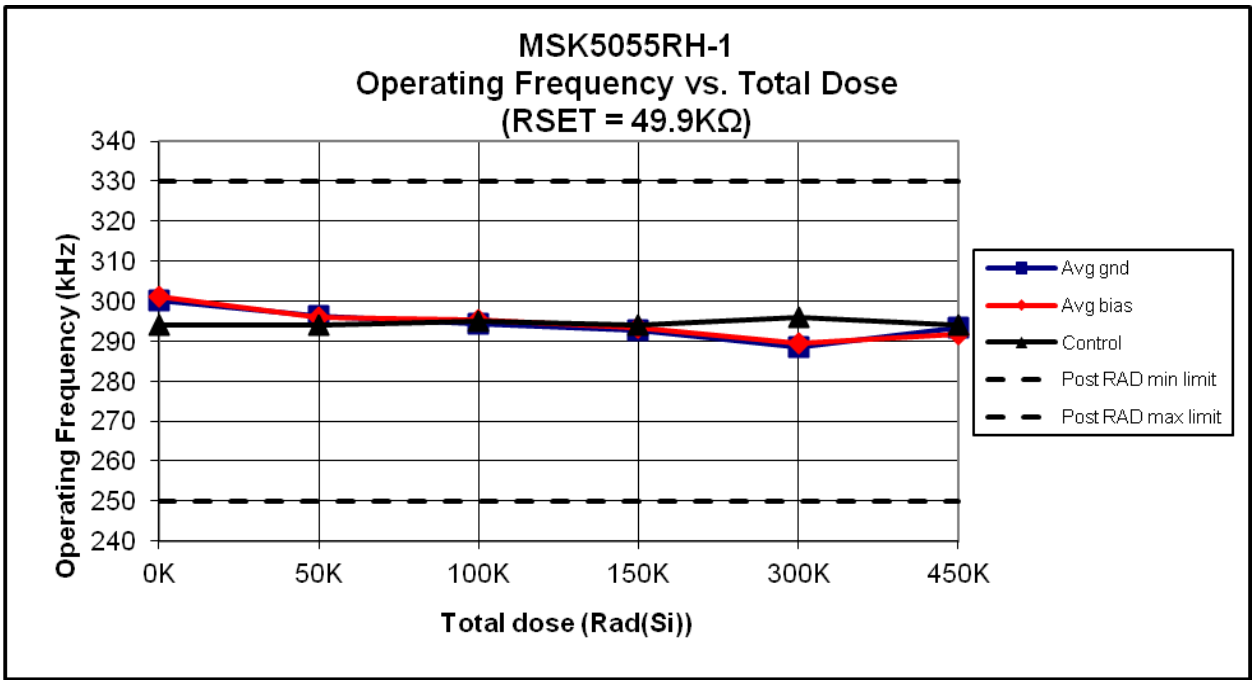
Dose Time, Incremental Dose and Total Cumulative Dose

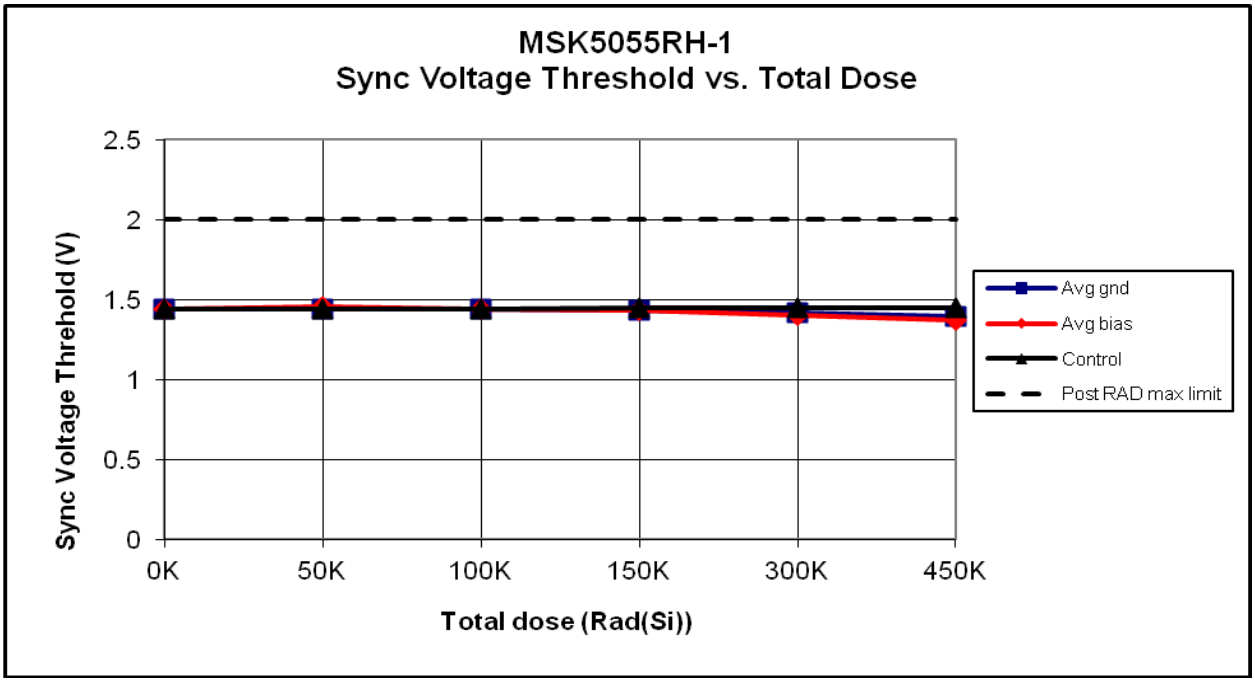

MSK5055RH-1
Error Amplifier Reference Voltage vs. Total Dose
VFB (V)
1.29
1.27
1.25
1.23
1.21
1.19
1.17
1.15
0K
50K
100K
150K
300K
450K
Total dose (Rad(Si))
Avg gnd
Avg bias
Control
Post RAD min limit
Post RAD max limit

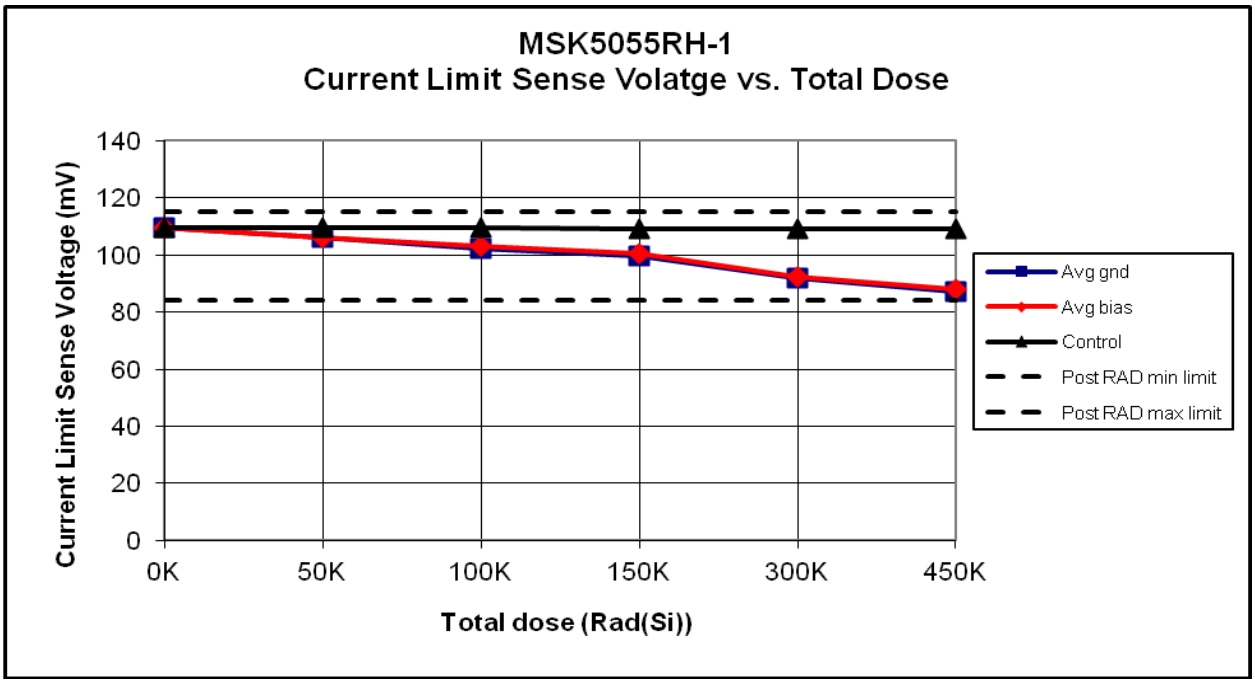

MSK5055RH-1
Vin UVLO Threshold (falling) vs. Total Dose
Vin UVLO Threshold Falling (V)
4.1
4
3.9
3.8
3.7
3.6
3.5
3.4
3.3
3.2
3.1
0K
50K
100K
150K
300K
450K
Total dose (Rad(Si))
Avg gnd
Avg bias
Control
Post RAD min limit
Post RAD max limit

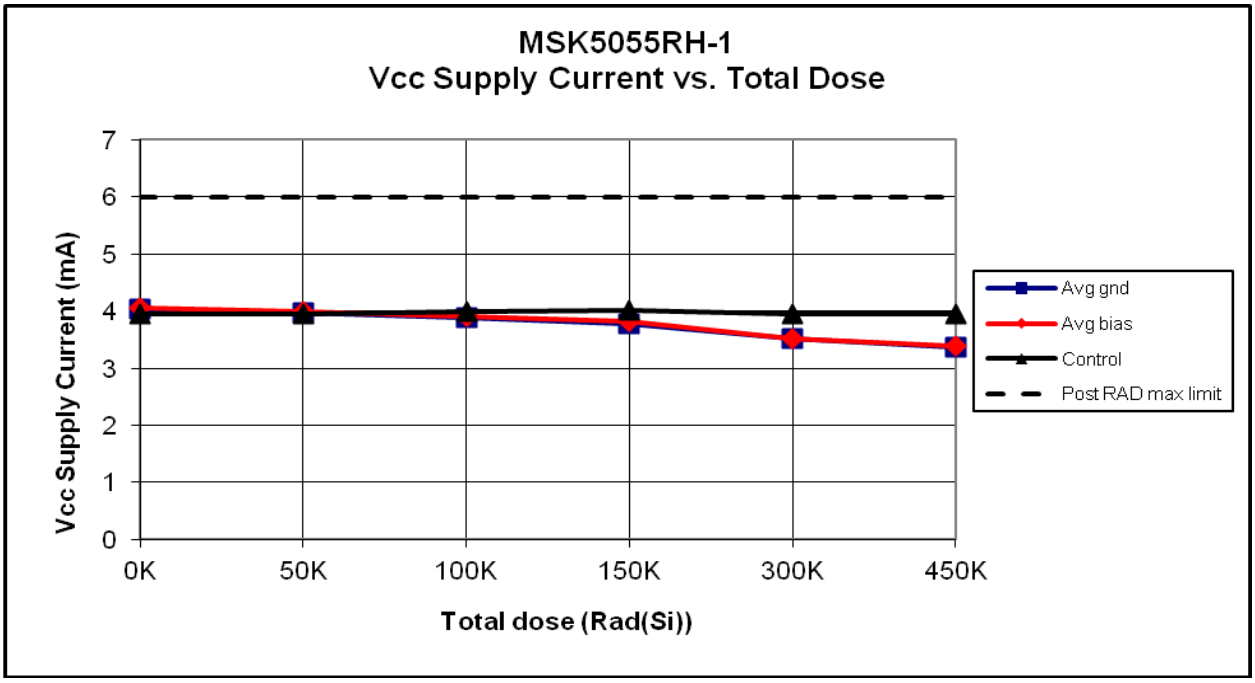

MSK5055RH-1
Vin Min Start Voltage vs. Total Dose
Vin Min Start Volatge (V)
7.6
7.5
7.4
7.3
7.2
7.1
7
6.9
0K
50K
100K
150K
300K
450K
Total dose (Rad(Si))
Avg gnd
Avg bias
Control
Post RAD max limit

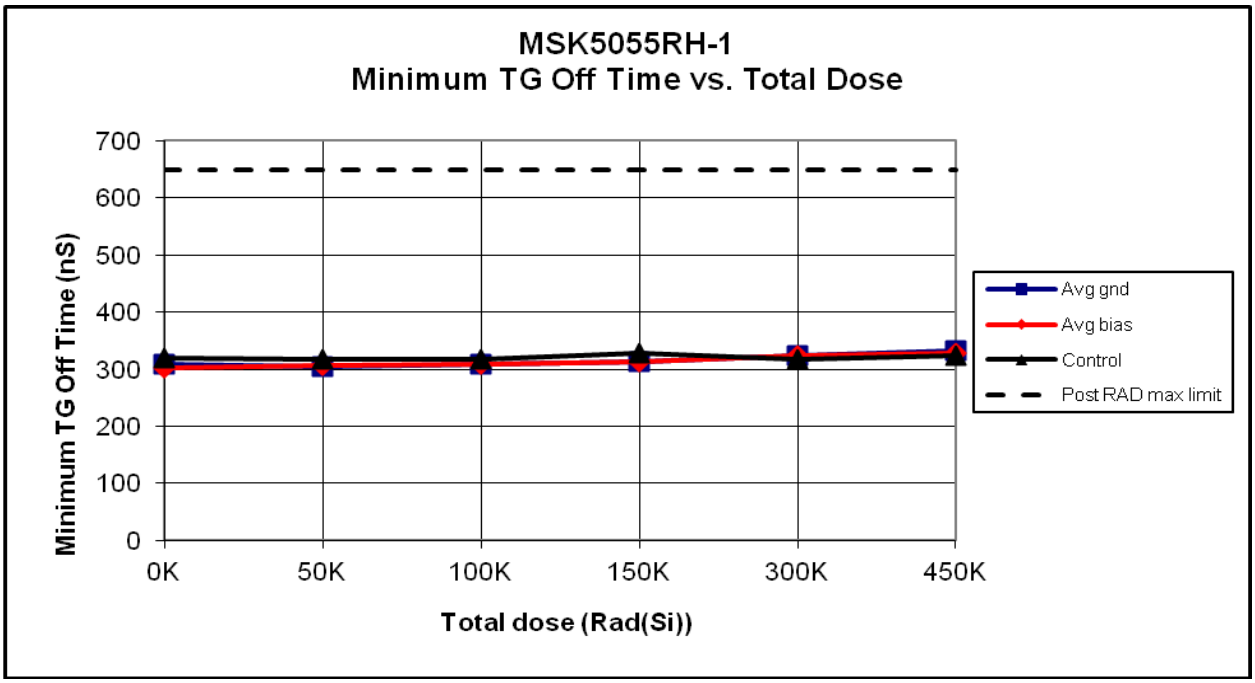

MSK5055RH-1
SHDN Enable Threshold Rising vs. Total Dose
SHDN Enable Threshold Rising (V)
1.45
1.4
1.35
1.3
1.25
1.2
1.15
0K
50K
100K
150K
300K
450K
Total dose (Rad(Si))
Avg gnd
Avg bias
Control
Post RAD min limit
Post RAD max limit

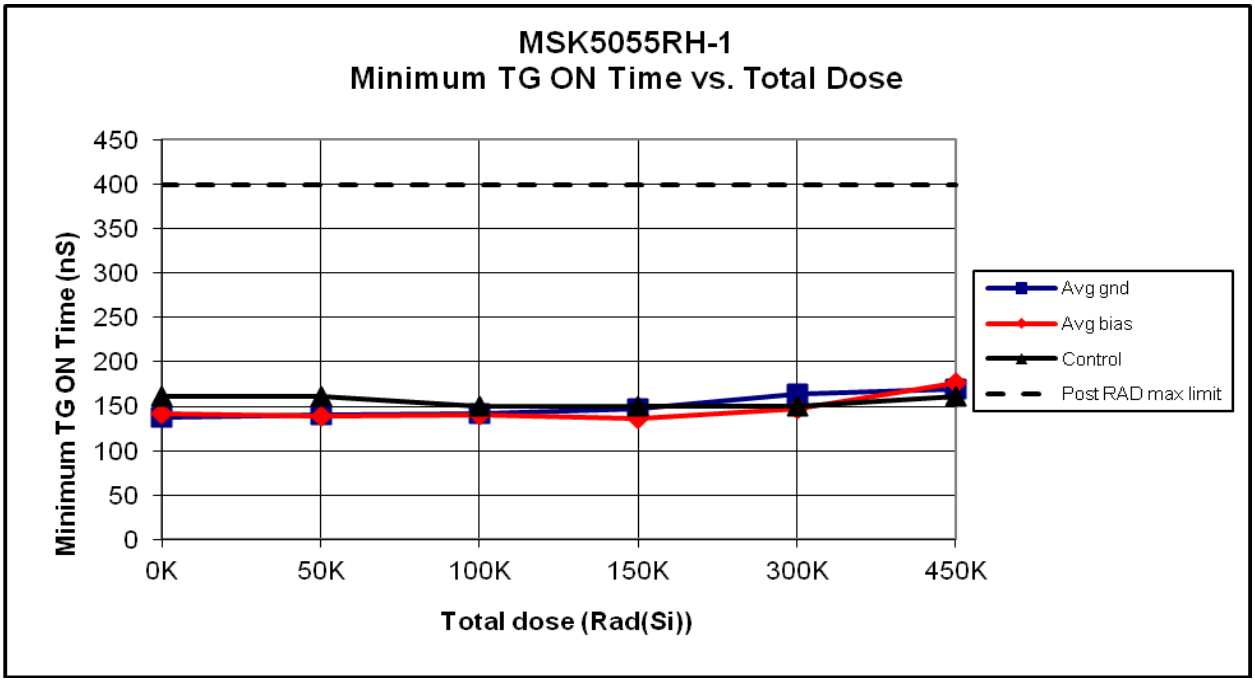

MSK5055RH-1
Operating Frequency vs. Total Dose
(RSET = 49.9KΩ)
Operating Frequency (kHz)
340
330
320
310
300
290
280
270
260
250
240
0K
50K
100K
150K
300K
450K
Total dose (Rad(Si))
Avg gnd
Avg bias
Control
Post RAD min limit
Post RAD max limit

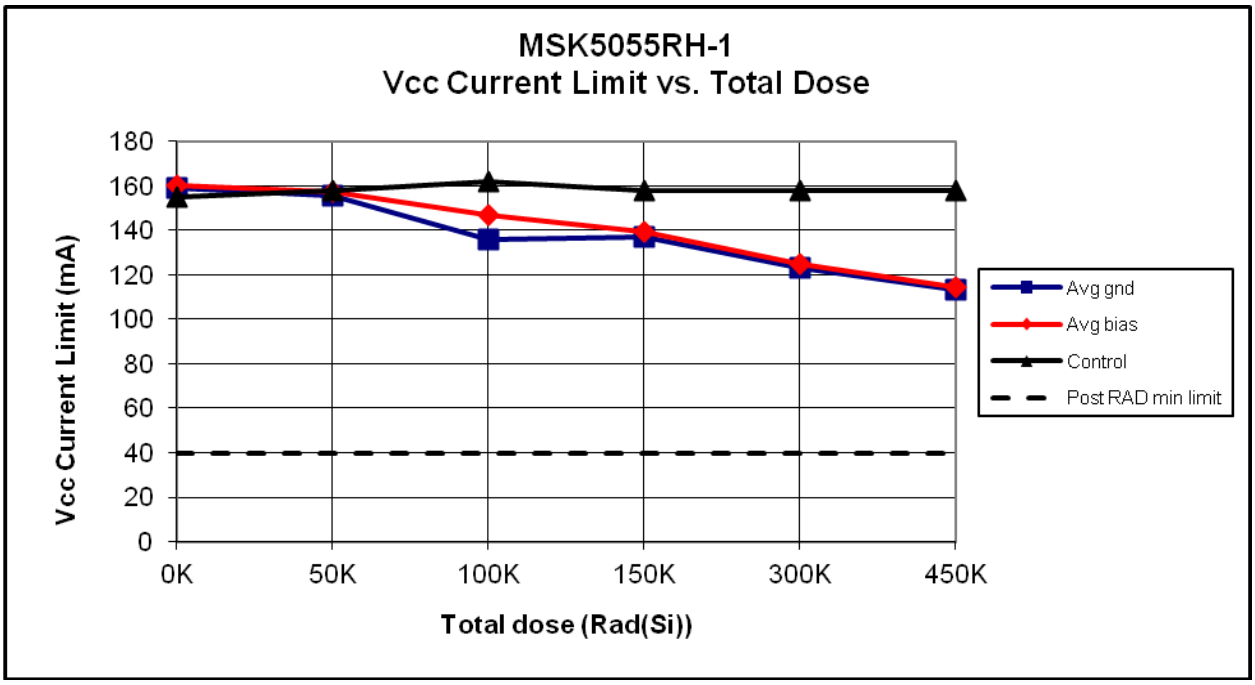

MSK5055RH-1
Sync Voltage Threshold vs. Total Dose
Sync Voltage Threhold (V)
2.5
2
1.5
1
0.5
0
0K
50K
100K
150K
300K
450K
Total dose (Rad(Si))
Avg gnd
Avg bias
Control
Post RAD max limit


MSK5055RH-1
Current Limit Sense Volatge vs. Total Dose
Current Limit Sense Voltage (mV)
140
120
100
80
60
40
20
0
0K
50K
100K
150K
300K
450K
Total dose (Rad(Si))
Avg gnd
Avg bias
Control
Post RAD min limit
Post RAD max limit


MSK5055RH-1
Vcc Supply Current vs. Total Dose
Vcc Supply Current (mA)
7
6
5
4
3
2
1
0
0K
50K
100K
150K
300K
450K
Total dose (Rad(Si))
Avg gnd
Avg bias
Control
Post RAD max limit


MSK5055RH-1
Minimum TG Off Time vs. Total Dose
Minimum TG Off Time (nS)
700
600
500
400
300
200
100
0
0K
50K
100K
150K
300K
450K
Total dose (Rad(Si))
Avg gnd
Avg bias
Control
Post RAD max limit


MSK5055RH-1
Minimum TG ON Time vs. Total Dose
Minimum TG ON Time (nS)
450
400
350
300
250
200
150
100
50
0
0K
50K
100K
150K
300K
450K
Total dose (Rad(Si))
Avg gnd
Avg bias
Control
Post RAD max limit


MSK5055RH-1
Vcc Current Limit vs. Total Dose
Vcc Current Limit (mA)
180
160
140
120
100
80
60
40
20
0
0K
50K
100K
150K
300K
450K
Total dose (Rad(Si))
Avg gnd
Avg bias
Control
Post RAD min limit