Neutron and Total Ionizing Dose Radiation Test Report

MSK196RH,
MSK197RH,
(MSK496RH)
RAD Hard (QUAD) Precision Rail To Rail Current Sense Amplifier

May 11, 2012 (TID, First Test, WAFER LOT: WD005335.3 WF#5); Updated February 12, 2013
March 26, 2013 (Neutron Irradiation, WAFER LOT: WD005335.3 WF#5)
Revised May 23, 2017
May 25, 2018 (TID, 2nd Test, Wafer Lot: WD34907E.1 Wf#2)
January 19, 2021 (TID, 3rd Test, WAFER LOT: WD34907E.1 WF3);
March 23, 2021 (TID, 4th Test, WAFER LOT: WD005624.3 WF8);
October 12, 2021 (TID 5th Test, Wafer Lot: WP01665E.1 WF2);

J. Saucier
E. Davis
J. Dubose

TTM Technologies – MSK Products

I. Introduction:

The total dose radiation test plan for the MSK197RH was developed to qualify the devices as RAD Hard to 100Krads(Si). The testing was performed beyond 100Krads(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 MSK196RH, MSK197RH and MSK496RH use the same active components. The data in this report is from direct measurement of the MSK197RH response to irradiation but it is indicative of the response of all devices and is applicable to all.

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 196RH, MSK197RH and MSK 496RH.

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 82.54 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 burn-in per MIL-STD-883 Method 1015 and were fully screened IAW MIL-PRF-38534 Class K or MIL-PRF-38535 Class V. 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. An operating voltage of +30 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 automatic 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. If required, full test data can be obtained by contacting TTM Technologies – MSK Products.

V. Summary:

Based on the test data recorded during radiation testing and statistical analysis, the MSK196RH, MSK197RH and MSK496RH qualify as a 100KRad(Si) radiation hardened devices. Voltage Gain Error 2 (Vs+=0V), Input Offset voltage, PSRR and CMRR exhibited the most significant shift due to irradiation. All other parameters stayed within pre-irradiation specification up to 150KRad(Si).

MSK197RH Biased/Unbiased Dose Rate Schedule

Dosimetry Equipment
Bruker Biospin # 0162

Irradiation Date
10/12/21

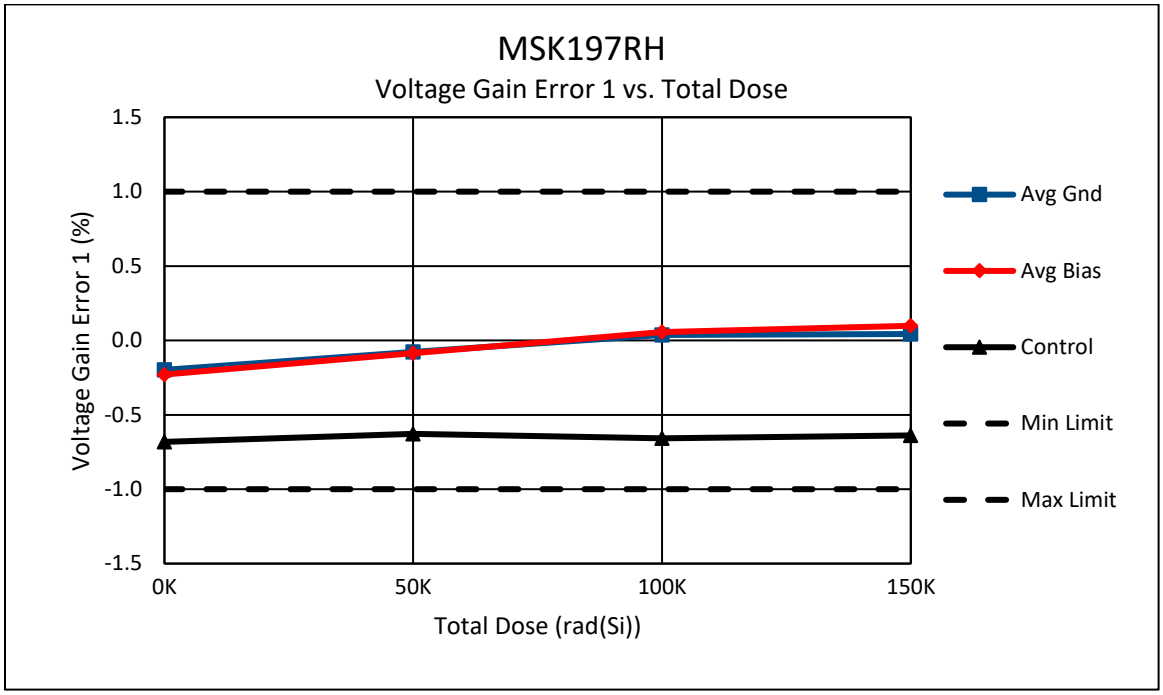
Exposure Length (min:sec)	Incremental Dose rads(Si)	Cumulative Dose rads(Si)
10:24	51,500	51,500
10:24	51,500	103,000
10:24	51,500	154,500

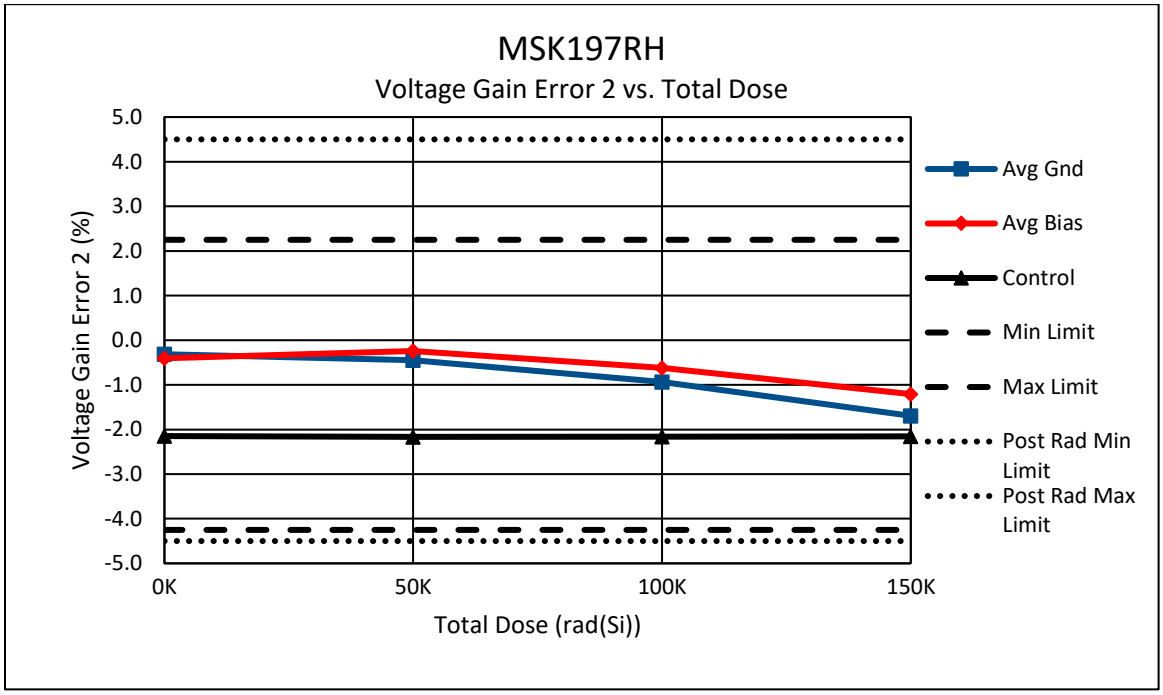
Biased S/N – 0075, 0076, 0077, 0078, 0079

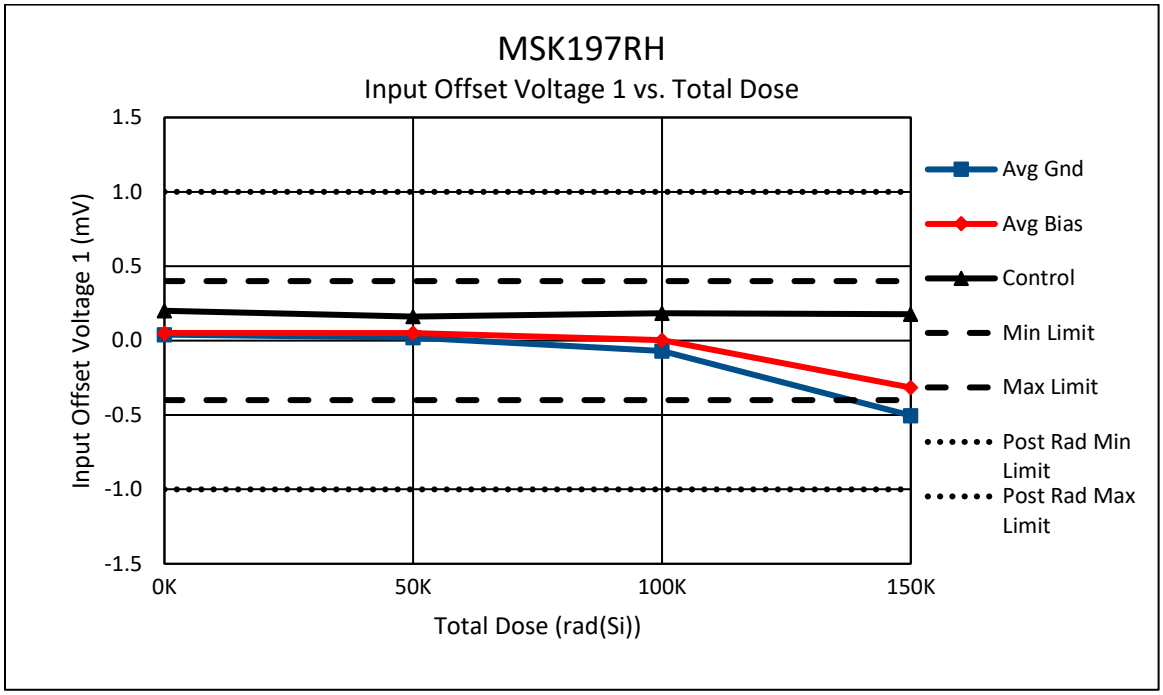
Unbiased S/N – 0080, 0082, 0083, 0084, 0085

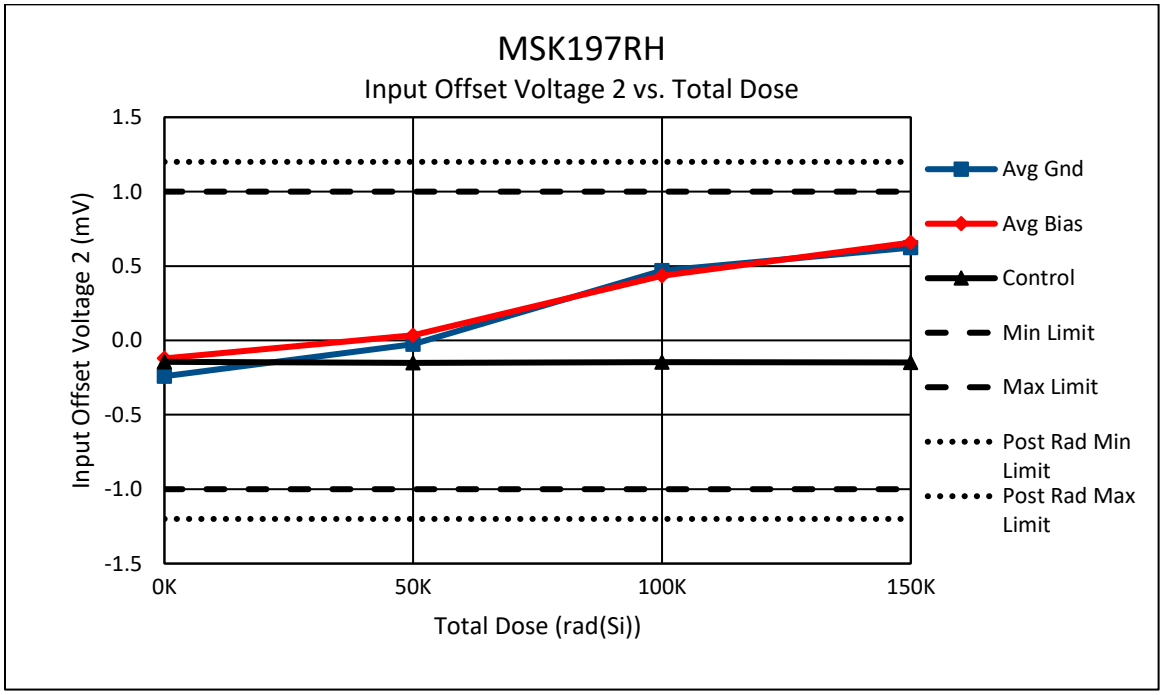
Table 1

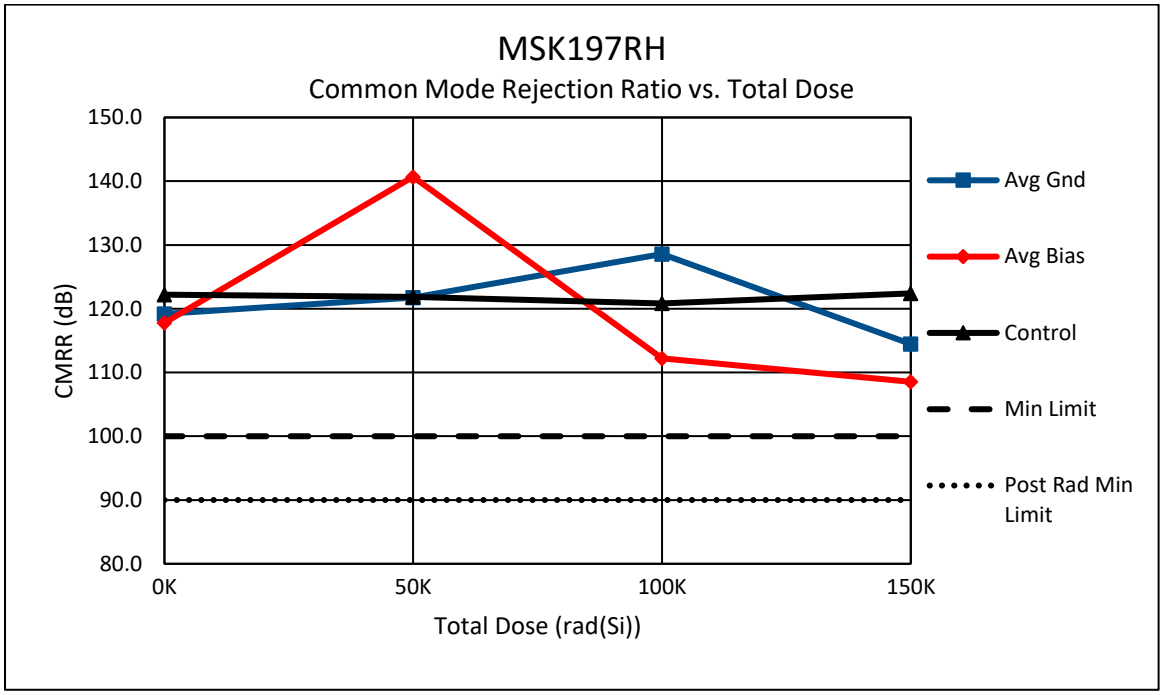
Dose Time, Incremental Dose and Total Cumulative Dose

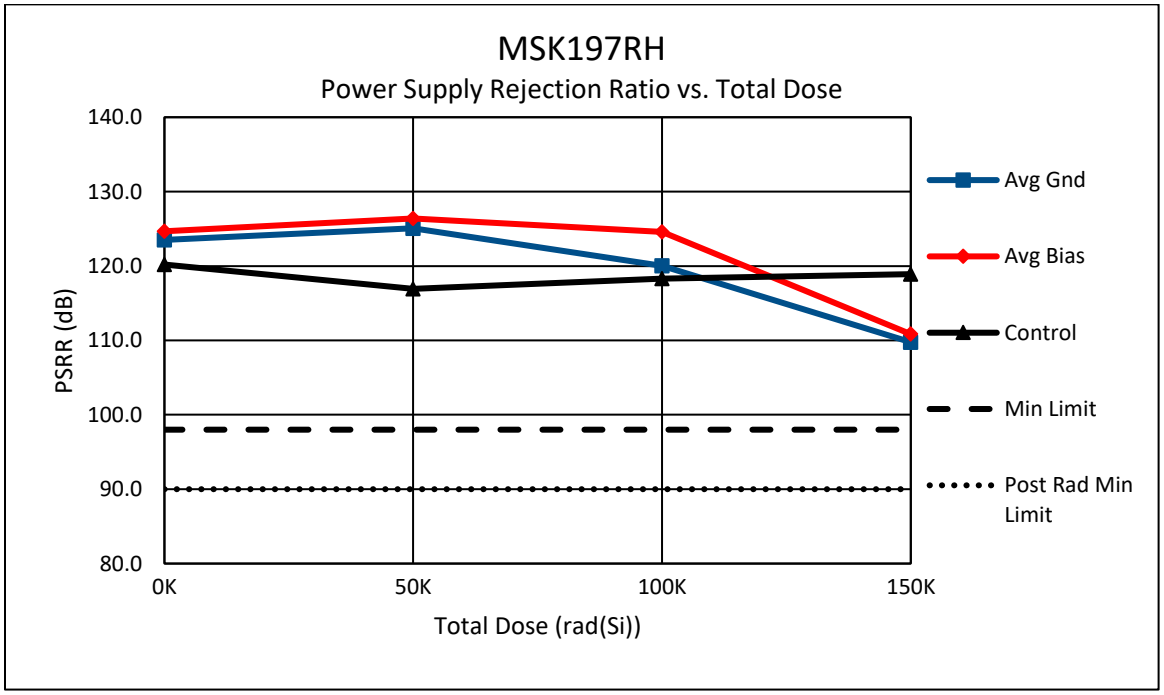

MSK197RH
Voltage Gain Error 1 vs. Total Dose
Voltage Gain Error 1 (%)
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Min Limit
Max Limit

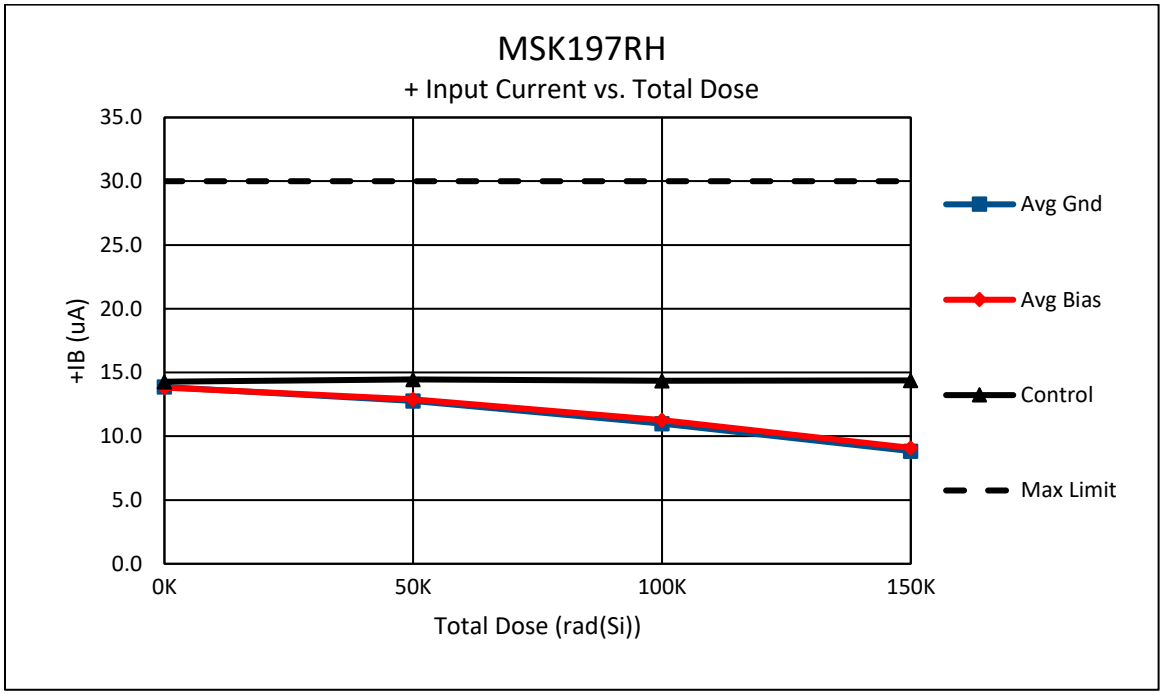

MSK197RH
Voltage Gain Error 2 vs. Total Dose
Voltage Gain Error 2 (%)
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Min Limit
Max Limit
Post Rad Min Limit
Post Rad Max Limit

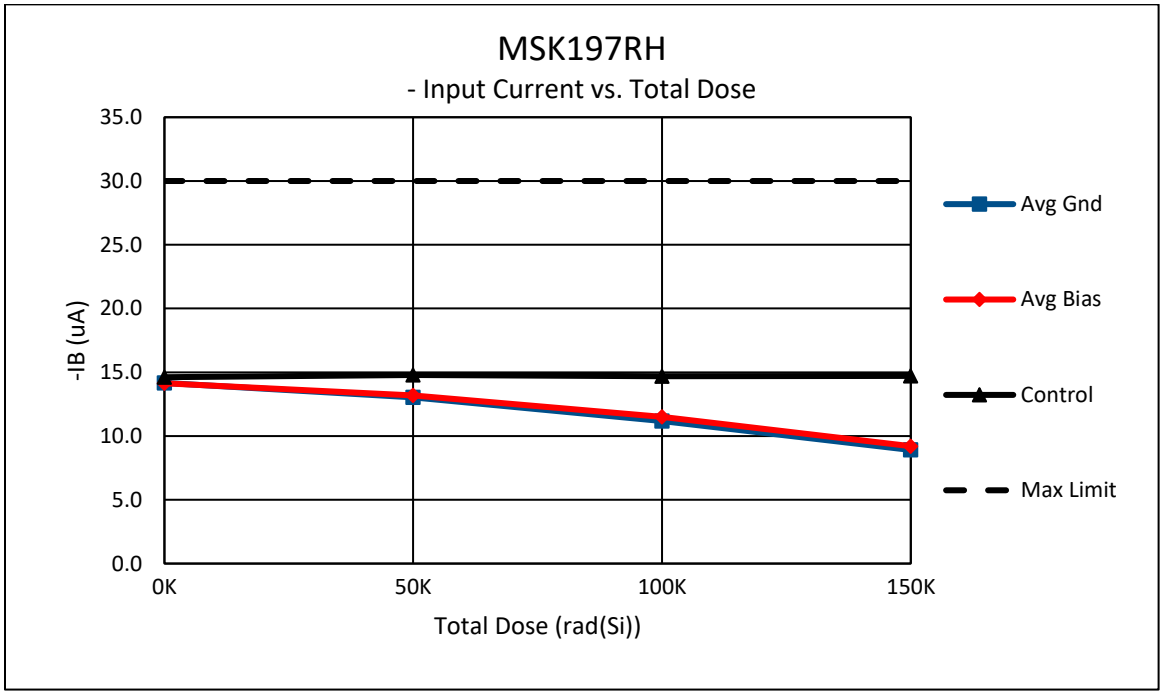

MSK197RH
Input Offset Voltage 1 vs. Total Dose
Input Offset Voltage 1 (mV)
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Min Limit
Max Limit
Post Rad Min Limit
Post Rad Max Limit

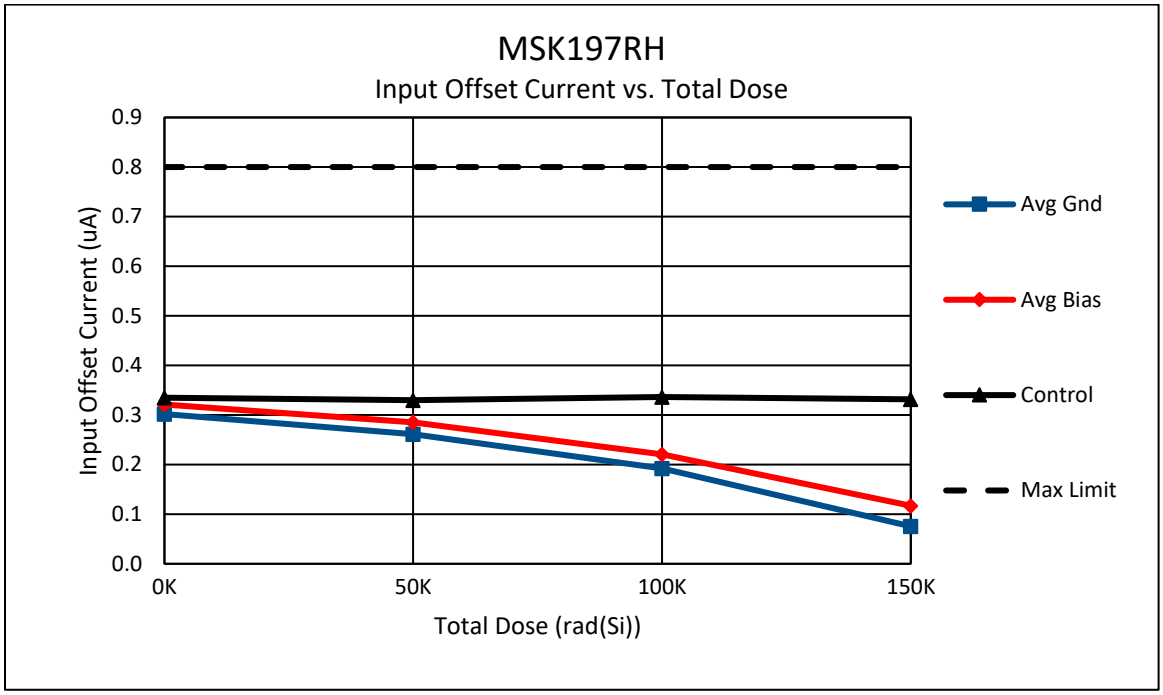

MSK197RH
Input Offset Voltage 2 vs. Total Dose
Input Offset Voltage 2 (mV)
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Min Limit
Max Limit
Post Rad Min Limit
Post Rad Max Limit

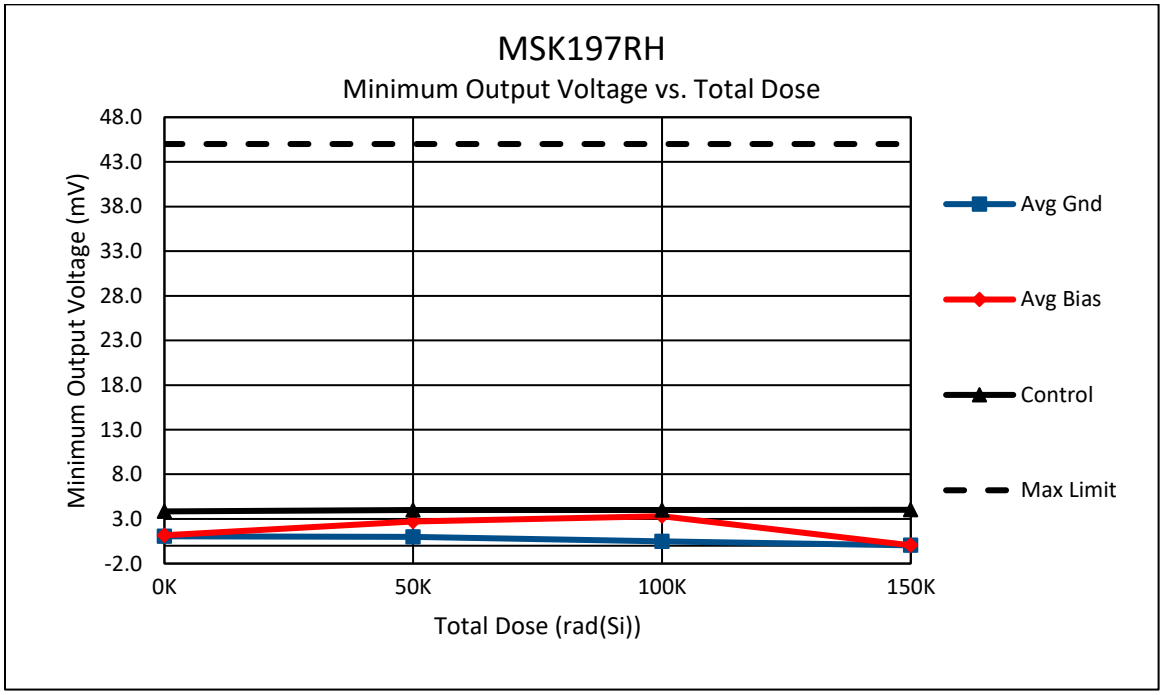

MSK197RH
Common Mode Rejection Ratio vs. Total Dose
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
CMRR (dB)
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Min Limit
Post Rad Min Limit

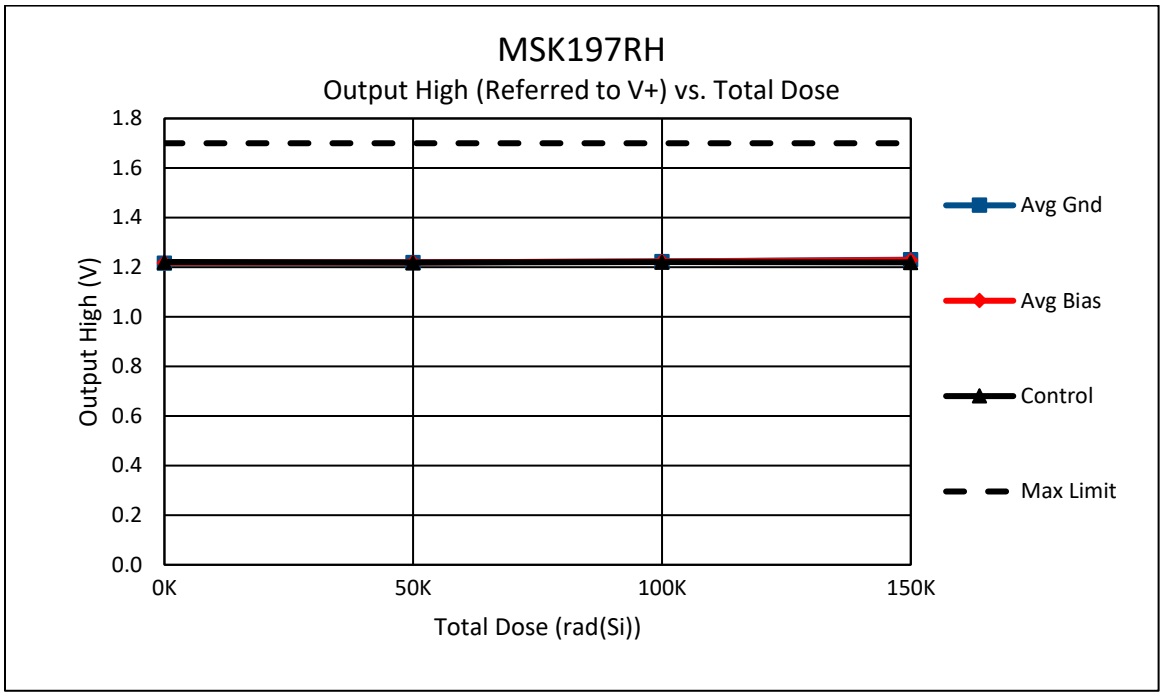

MSK197RH
Power Supply Rejection Ratio vs. Total Dose
140.0
130.0
120.0
110.0
100.0
90.0
80.0
PSRR (dB)
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Min Limit
Post Rad Min Limit

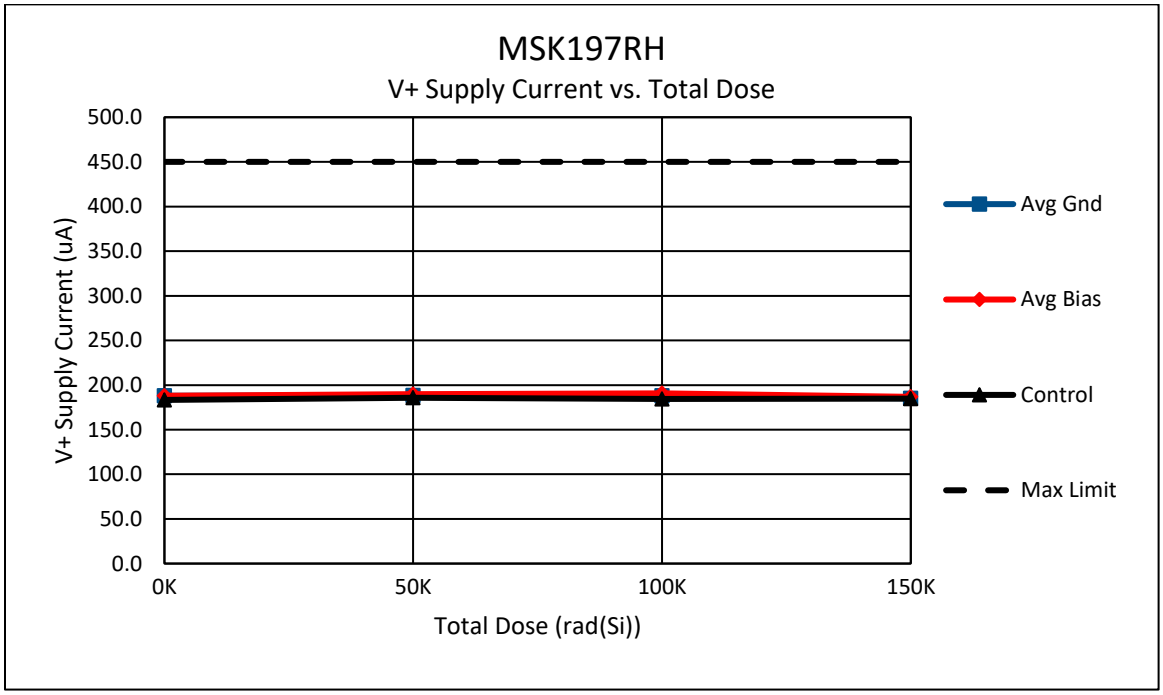

MSK197RH
+ Input Current vs. Total Dose
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
+IB (uA)
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit


MSK197RH
- Input Current vs. Total Dose
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-IB (uA)
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit


MSK197RH
Input Offset Current vs. Total Dose
Input Offset Current (uA)
0.9
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
Control
Max Limit


MSK197RH
Minimum Output Voltage vs. Total Dose
Minimum Output Voltage (mV)
48.0
43.0
38.0
33.0
28.0
23.0
18.0
13.0
8.0
3.0
-2.0
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit


MSK197RH
Output High (Referred to V+) vs. Total Dose
Output High (V)
1.8
1.6
1.4
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
Control
Max Limit


MSK197RH
V+ Supply Current vs. Total Dose
V+ Supply Current (uA)
500.0
450.0
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit

Neutron and Total Ionizing Dose Radiation Test Report

MSK196RH,
MSK197RH,
(MSK496RH)
RAD Hard (QUAD) Precision Rail To Rail Current Sense Amplifier

May 11, 2012 (TID, First Test, WAFER LOT: WD005335.3 WF#5); Updated February 12, 2013
March 26, 2013 (Neutron Irradiation, WAFER LOT: WD005335.3 WF#5)
Revised May 23, 2017
May 25, 2018 (TID, 2nd Test, Wafer Lot: WD34907E.1 Wf#2)
January 19, 2021 (TID, 3rd Test, WAFER LOT: WD34907E.1 WF3);
March 23, 2021 (TID, 4th Test, WAFER LOT: WD005624.3 WF8);

J. Saucier
P. Musil

TTM Technologies

VPT Rad – Radiation Lab & Test Services

I. Introduction:

The total dose radiation test plan for the MSK197RH was developed to qualify the devices as RAD Hard to 100Krads(Si). The testing was performed beyond 100Krads(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 MSK196RH, MSK197RH and MSK496RH use the same active components. The data in this report is from direct measurement of the MSK197RH response to irradiation but it is indicative of the response of all devices and is applicable to all.

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 196RH, MSK197RH and MSK 496RH.

II. Radiation Source:

Total dose was performed at VPT Rad, Chelmsford Massachusetts, using a cobalt 60 radiation source. The dose rate was determined to be 116 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 burn-in per MIL-STD-883 Method 1015 and were fully screened IAW MILPRF-38534 Class K or MIL-PRF-38535 Class V. 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. An operating voltage of +30 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 automatic 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. If required, full test data can be obtained by contacting TTM Technologies – MSK Products.

V. Summary:

Based on the test data recorded during radiation testing and statistical analysis, the MSK196RH, MSK197RH and MSK496RH qualify as a 100KRad(Si) radiation hardened devices. Voltage Gain Error 2 (Vs+=0V), Input Offset voltage, PSRR and CMRR exhibited the most significant shift due to irradiation. All other parameters stayed within pre-irradiation specification up to 150KRad(Si).

MSK197RH Biased/Unbiased Dose Rate Schedule

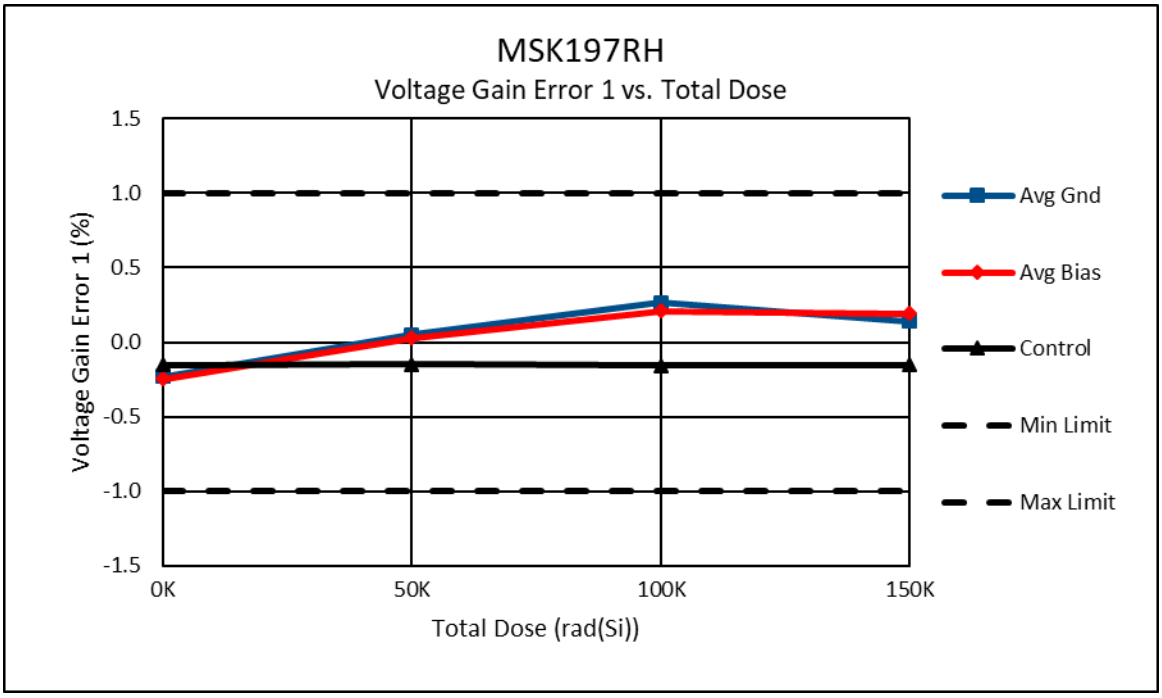
Dosimetry Equipment
Bruker Biospin # SC0424

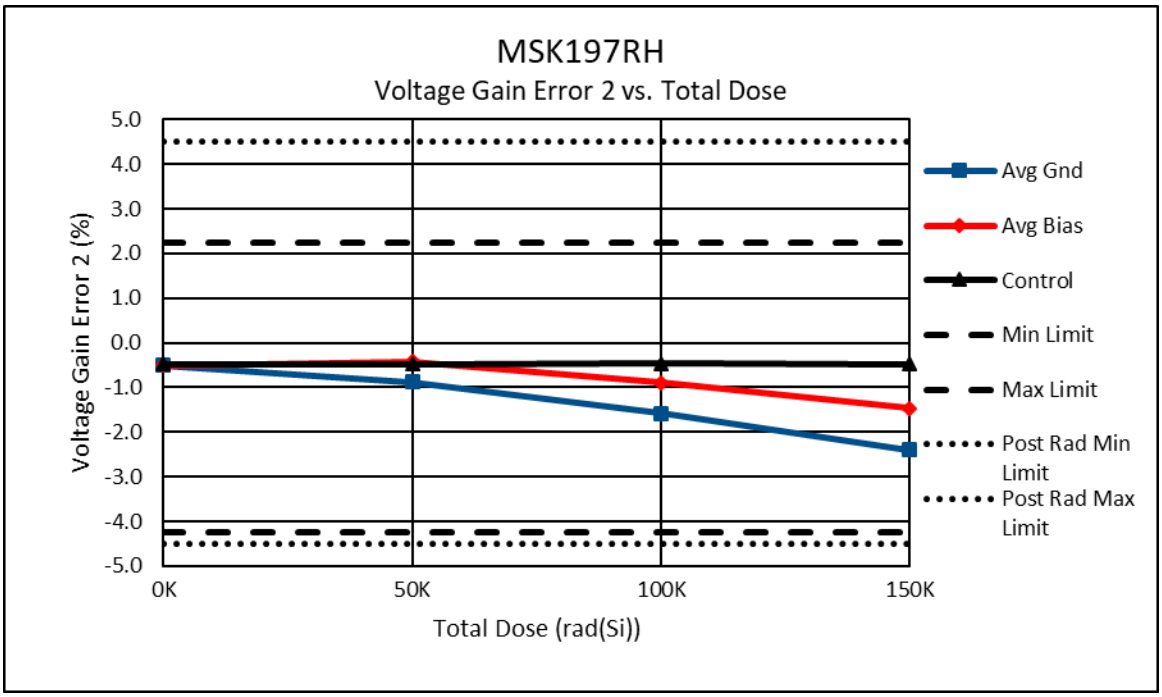
Irradiation Date
3/23/21

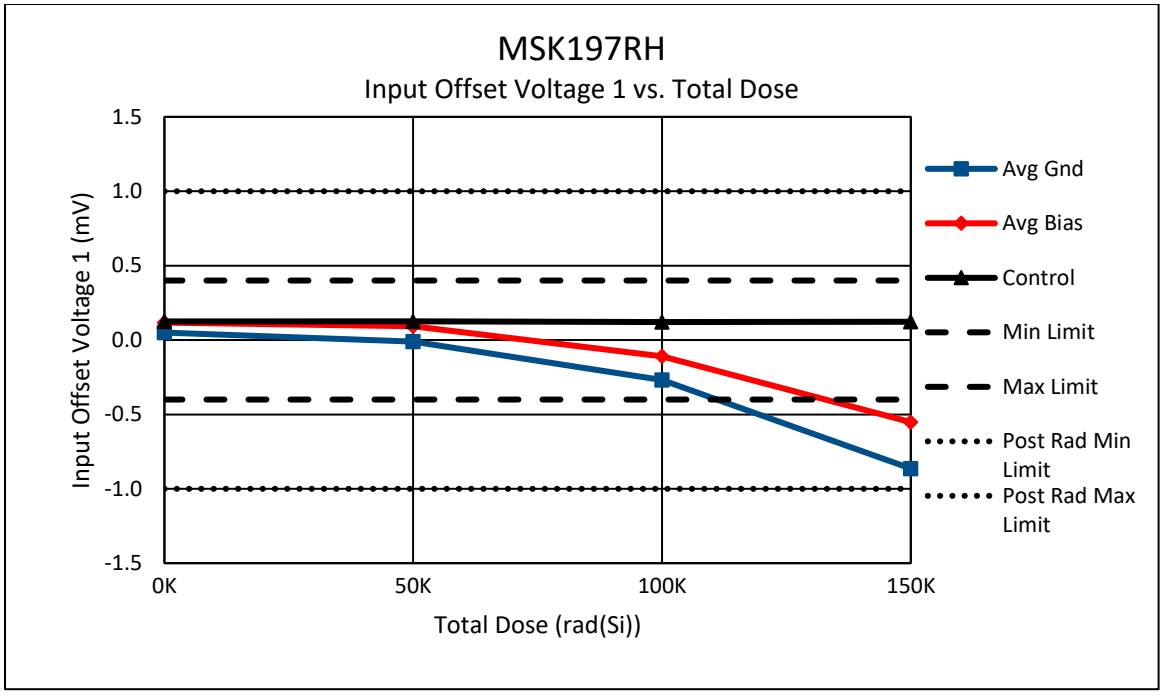
Exposure Length (min:sec)	Incremental Dose rads(Si)	Cumulative Dose rads(Si)
7:24	51,504	51,504
7:24	51,504	103,008
7:24	51,504	154,512

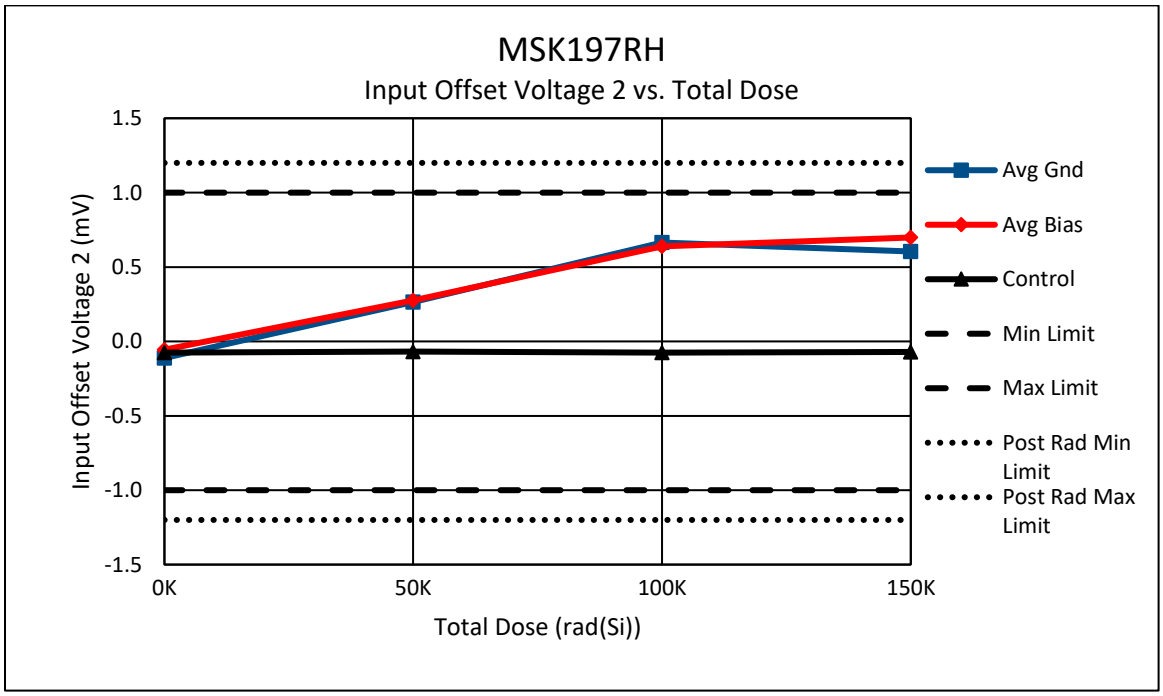
Biased S/N – 0052, 0053, 0054, 0055, 0056

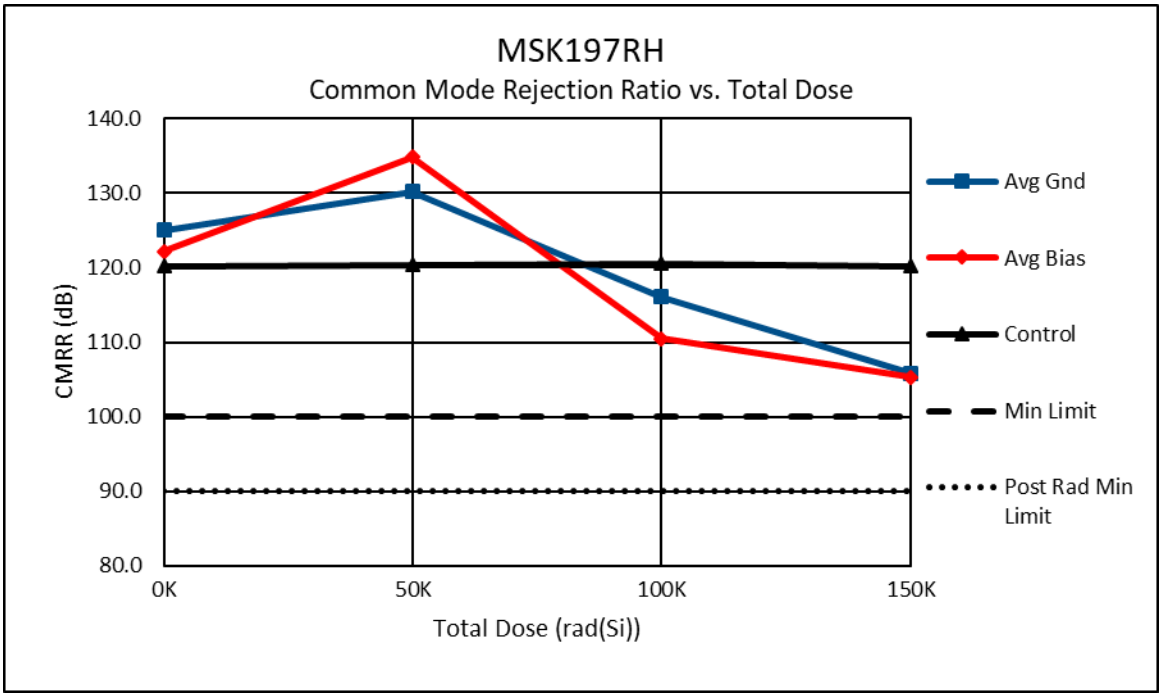
Unbiased S/N – 0057, 0058, 0059, 0060, 0061

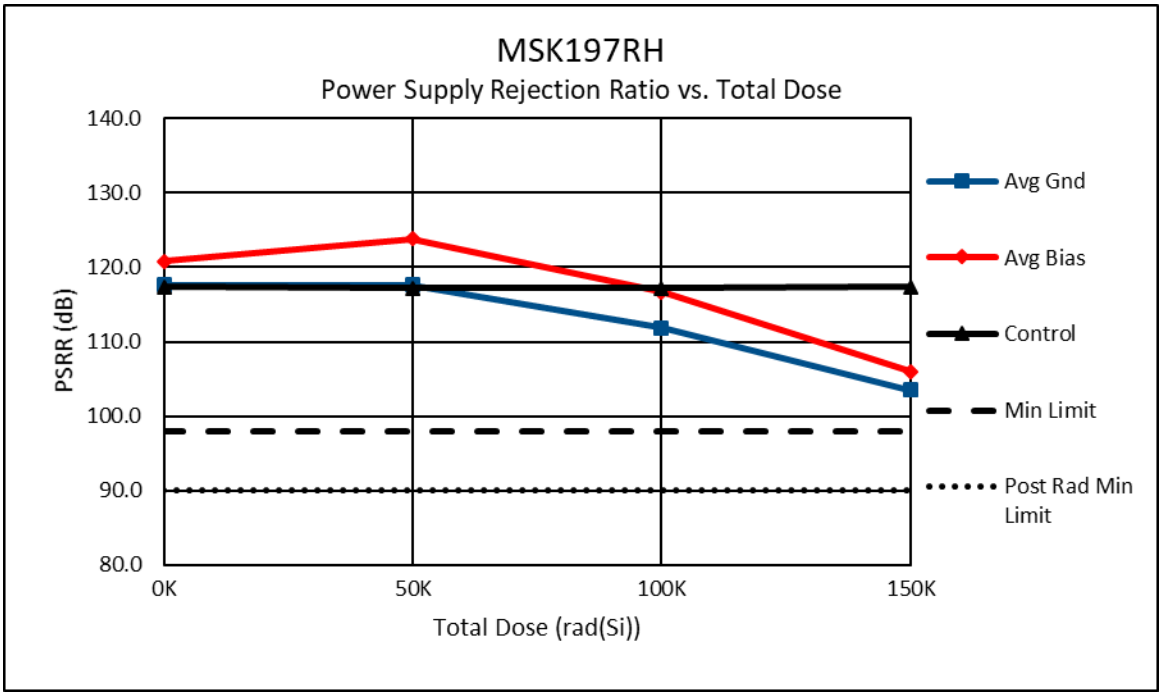

MSK197RH
Voltage Gain Error 1 vs. Total Dose
Voltage Gain Error 1 (%)
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Min Limit
Max Limit

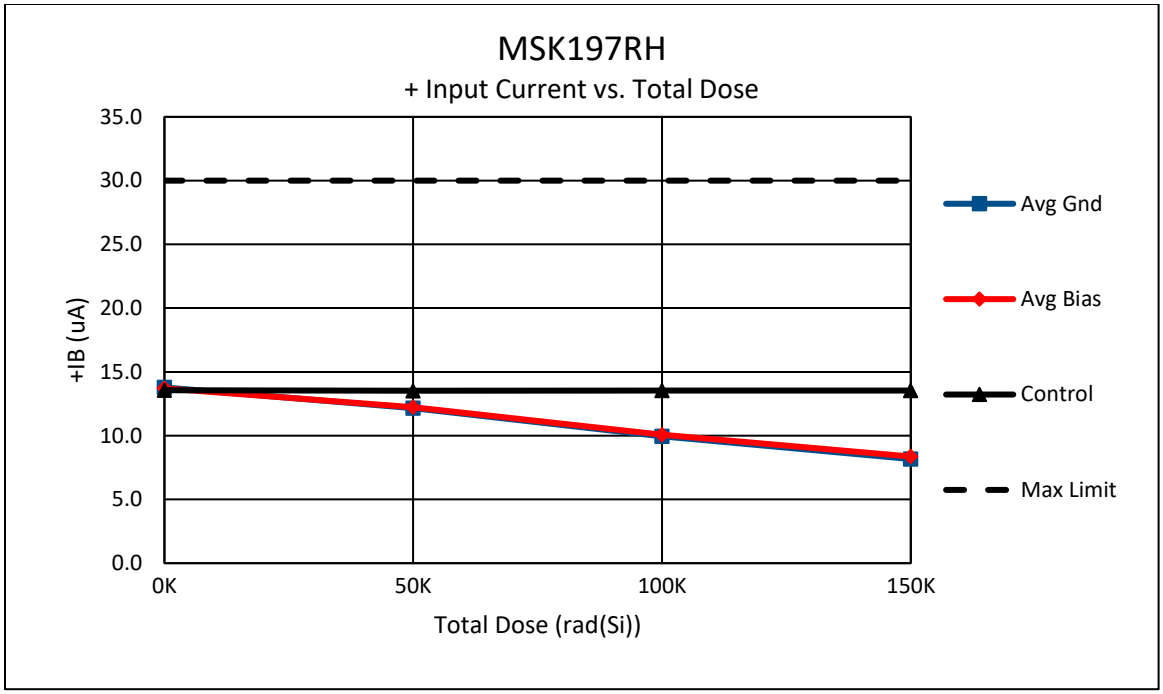

MSK197RH
Voltage Gain Error 2 vs. Total Dose
Voltage Gain Error 2 (%)
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Min Limit
Max Limit
Post Rad Min Limit
Post Rad Max Limit

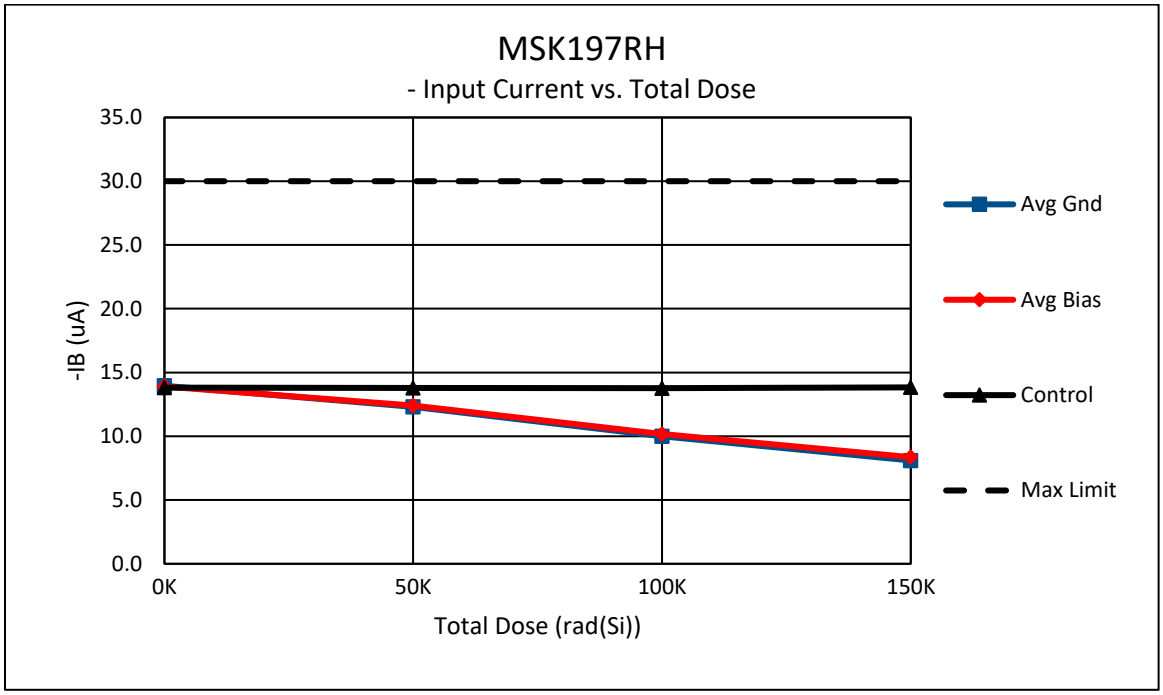

MSK197RH
Input Offset Voltage 1 vs. Total Dose
Input Offset Voltage 1 (mV)
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Min Limit
Max Limit
Post Rad Min Limit
Post Rad Max Limit

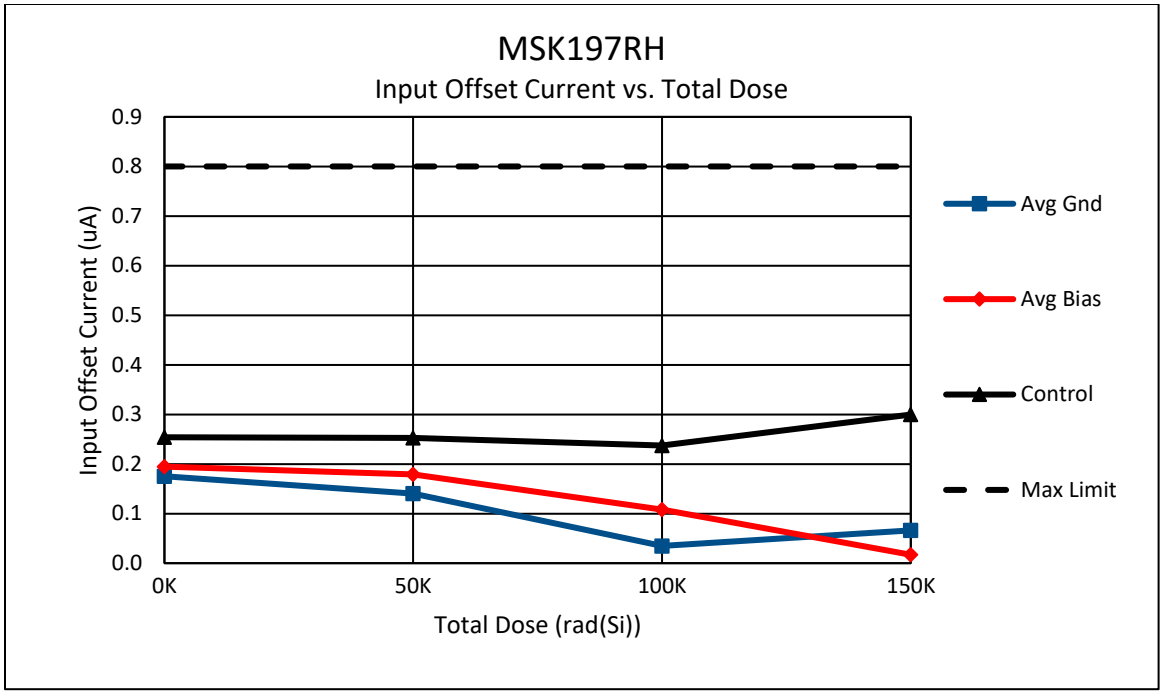

MSK197RH
Input Offset Voltage 2 vs. Total Dose
Input Offset Voltage 2 (mV)
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Min Limit
Max Limit
Post Rad Min Limit
Post Rad Max Limit

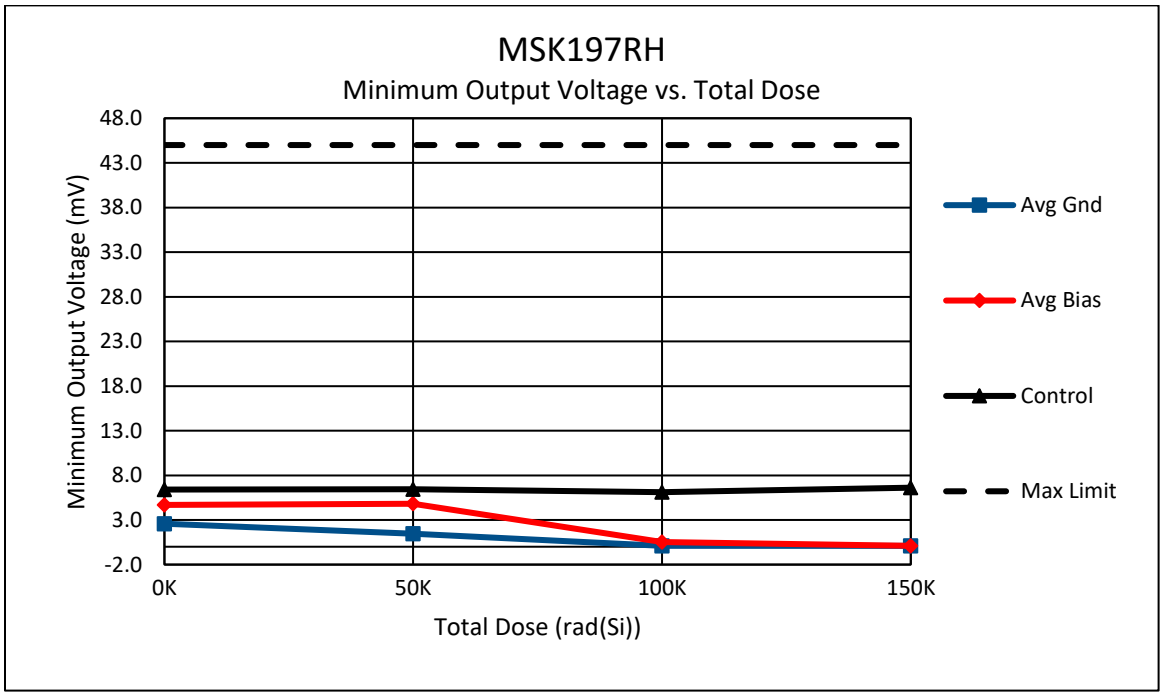

MSK197RH
Common Mode Rejection Ratio vs. Total Dose
140.0
130.0
120.0
110.0
100.0
90.0
80.0
CMRR (dB)
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Min Limit
Post Rad Min Limit

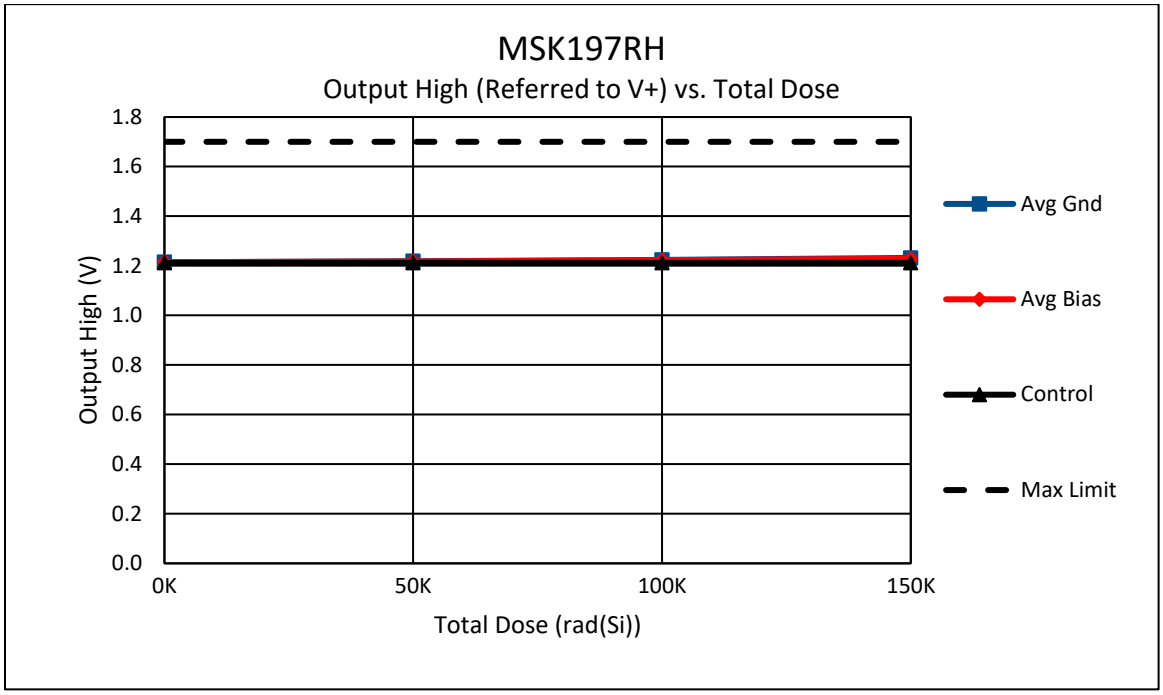

MSK197RH
Power Supply Rejection Ratio vs. Total Dose
140.0
130.0
120.0
110.0
100.0
90.0
80.0
PSRR (dB)
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Min Limit
Post Rad Min Limit

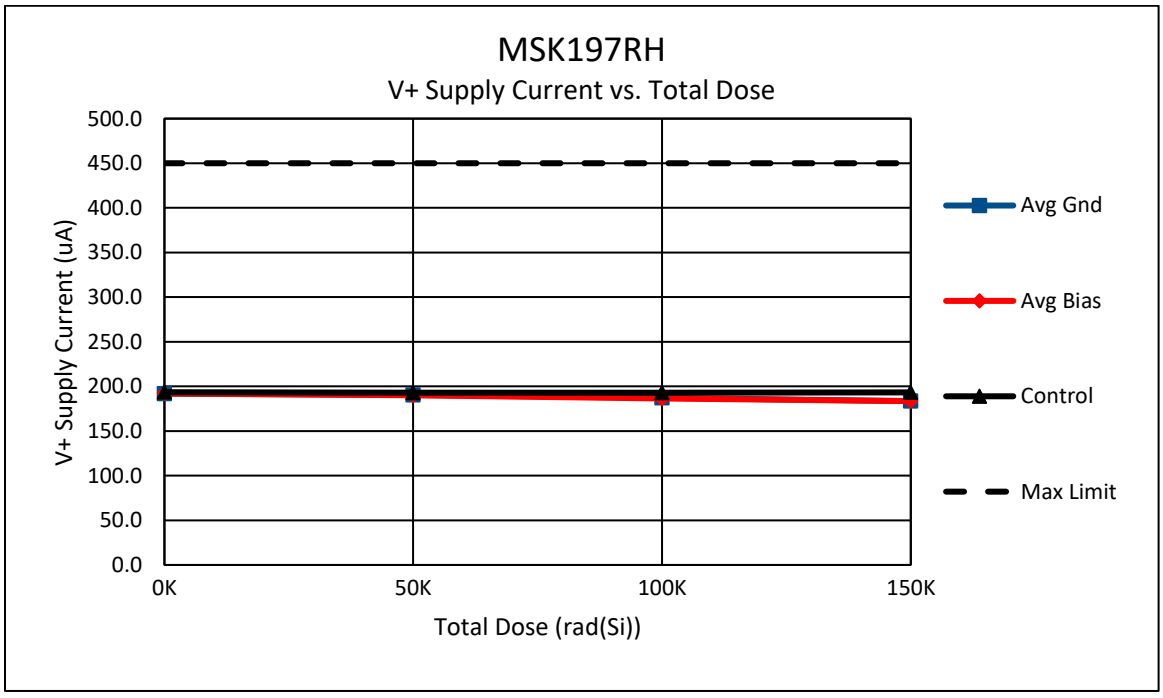

MSK197RH
+ Input Current vs. Total Dose
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
+IB (uA)
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit


MSK197RH
- Input Current vs. Total Dose
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-IB (uA)
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit


MSK197RH
Input Offset Current vs. Total Dose
Input Offset Current (uA)
0.9
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
Control
Max Limit


MSK197RH
Minimum Output Voltage vs. Total Dose
Minimum Output Voltage (mV)
48.0
43.0
38.0
33.0
28.0
23.0
18.0
13.0
8.0
3.0
-2.0
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit


MSK197RH
Output High (Referred to V+) vs. Total Dose
Output High (V)
1.8
1.6
1.4
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
Control
Max Limit


MSK197RH
V+ Supply Current vs. Total Dose
V+ Supply Current (uA)
500.0
450.0
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit

Neutron and Total Ionizing Dose Radiation Test Report

MSK196RH,
MSK197RH,
(MSK496RH)
RAD Hard (QUAD) Precision Rail To Rail Current Sense Amplifier

May 11, 2012 (TID, First Test, WAFER LOT: WD005335.3 WF#5); Updated February 12, 2013
March 26, 2013 (Neutron Irradiation, WAFER LOT: WD005335.3 WF#5)
Revised May 23, 2017
May 25, 2018 (TID, 2nd Test Wafer Lot: WD34907E.1 Wf#2)

N. Kresse
F. Freytag

Anaren, Inc. – MSK Products

I. Introduction:

The total dose radiation test plan for the MSK197RH was developed to qualify the devices as RAD Hard to 100Krads(Si). The testing was performed beyond 100Krads(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 MSK196RH, MSK197RH and MSK496RH use the same active components. The data in this report is from direct measurement of the MSK197RH response to irradiation but it is indicative of the response of all devices and is applicable to all.

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 196RH, MSK197RH and MSK 496RH.

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 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 burn-in per MIL-STD-883 Method 1015 and were fully screened IAW MIL-PRF-38534 Class K or MIL-PRF-38535 Class V. 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. An operating voltage of +30 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 automatic 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. 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 MSK197RH, MSK197RH and MSK496RH qualify as a 100KRad(Si) radiation hardened devices. Voltage Gain Error 2 (Vs+=0V), Input Offset voltage, PSRR and CMRR exhibited the most significant shift due to irradiation. All other parameters stayed within pre-irradiation specification up to 150KRad(Si).

MSK197VRH Biased/Unbiased Dose Rate Schedule

Dosimetry Equipment
Bruker Biospin # 0162

Irradiation Date
5/25/18

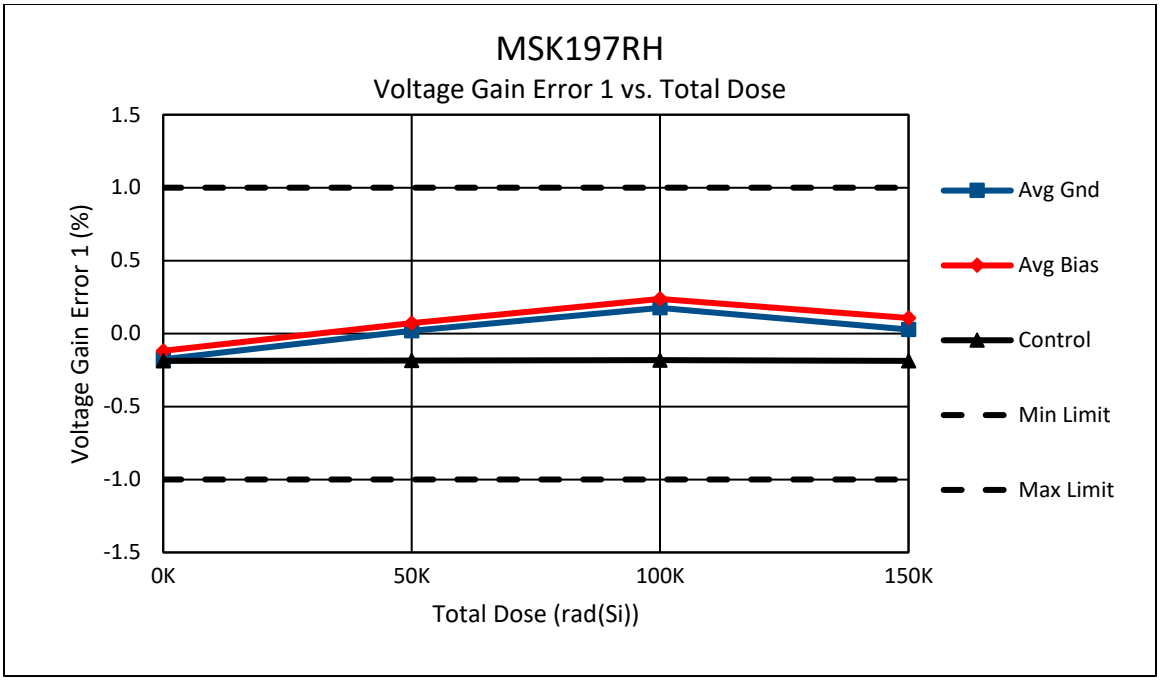
Exposure Length (min:sec)	Incremental Dose rads(Si)	Cumulative Dose rads(Si)
7:05	51,500	51,500
7:05	51,500	103,00
7:05	51,500	154,500

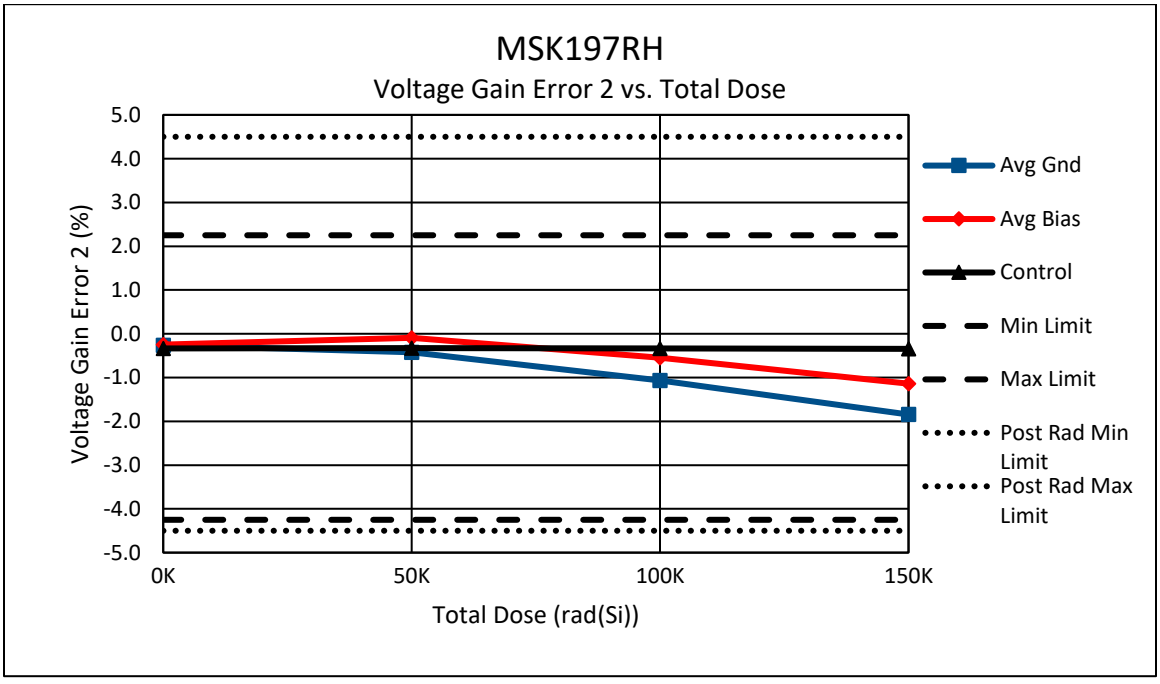
Biased S/N – 0002, 0003, 0004, 0005, 0006

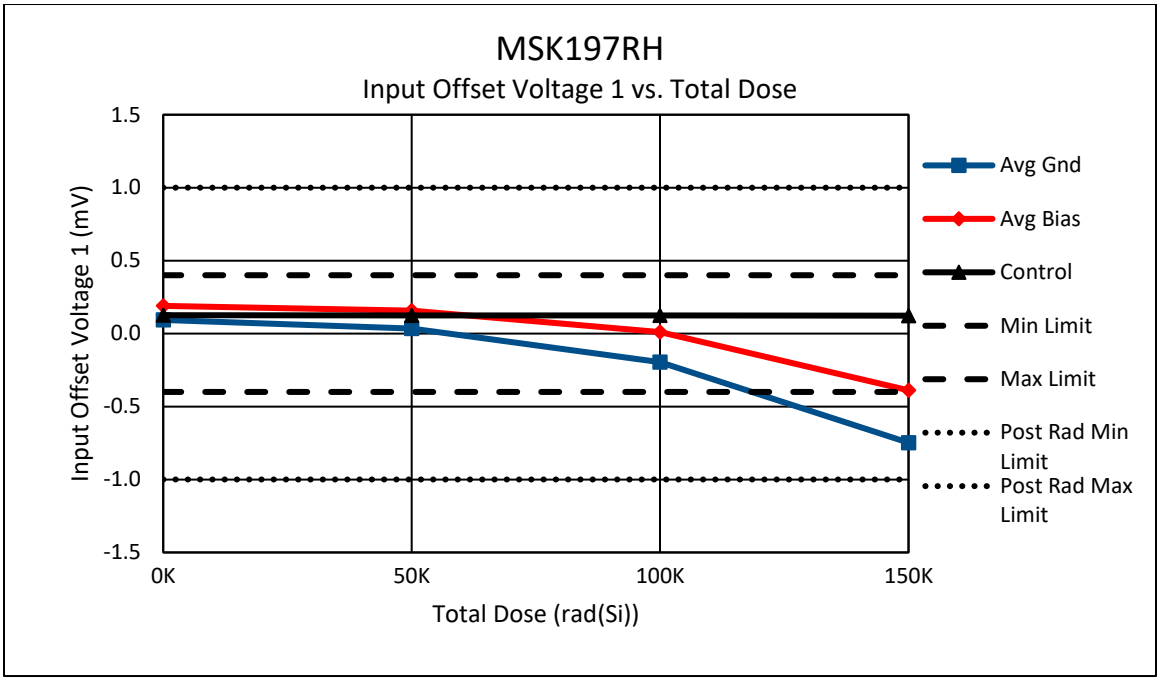
Unbiased S/N – 0007, 0009, 0010, 0011, 0012

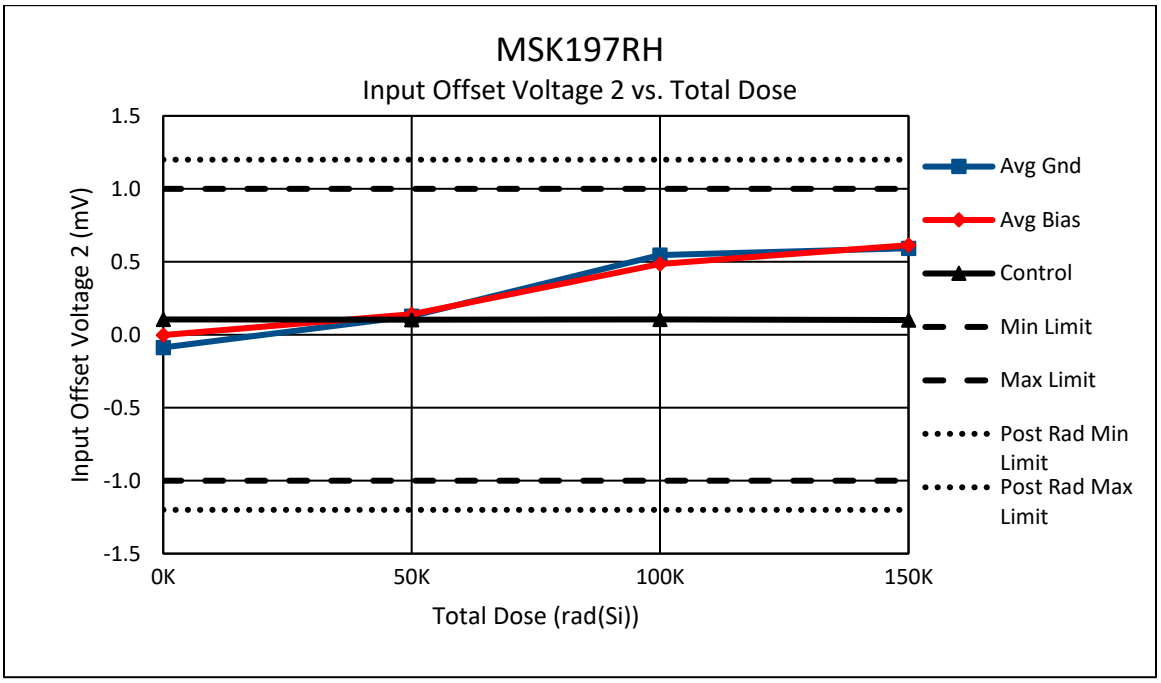
Table 1

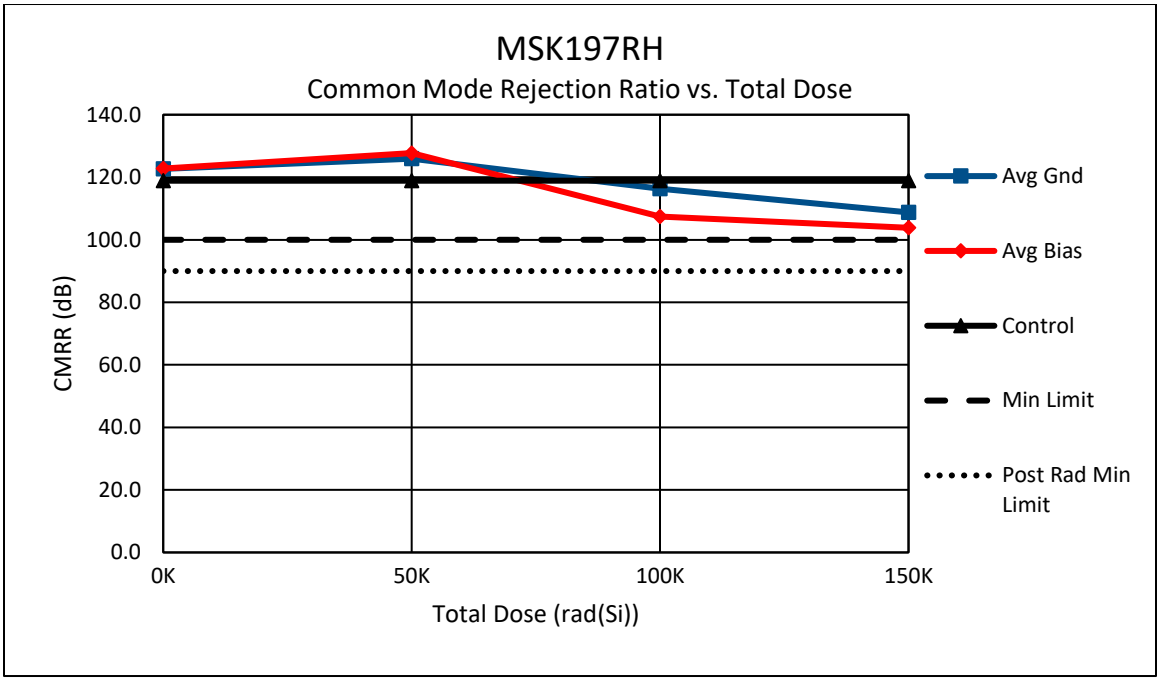
Dose Time, Incremental Dose and Total Cumulative Dose

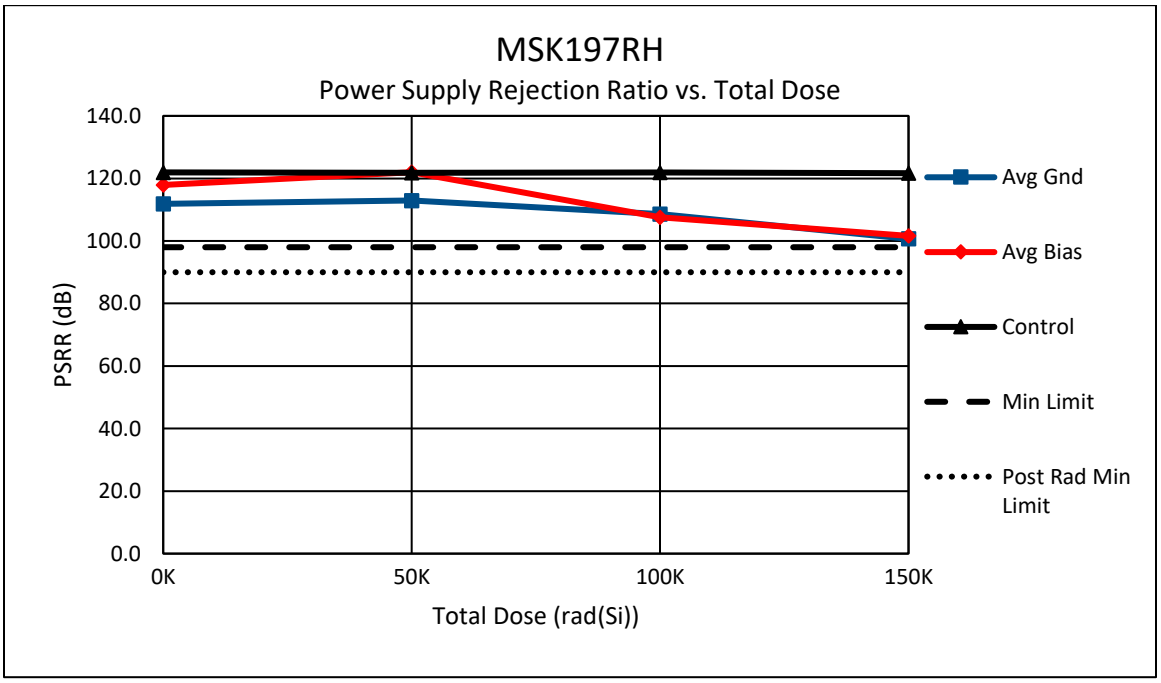

MSK197RH
Voltage Gain Error 1 vs. Total Dose
Voltage Gain Error 1 (%)
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Min Limit
Max Limit

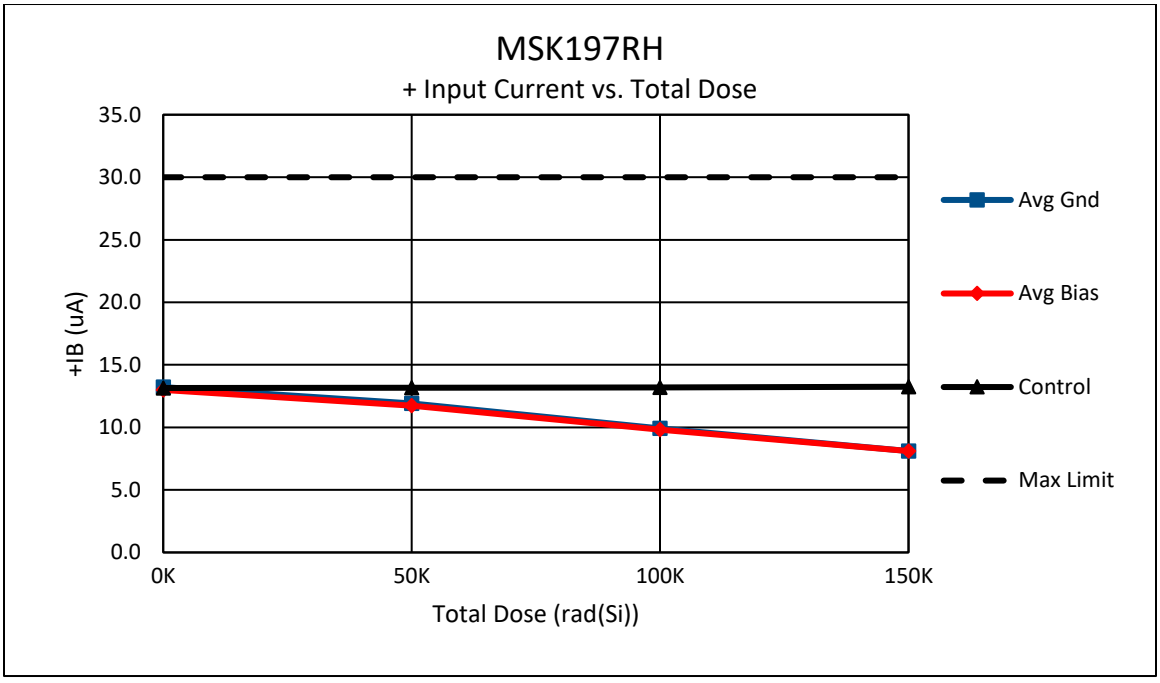

MSK197RH
Voltage Gain Error 2 vs. Total Dose
Voltage Gain Error 2 (%)
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Min Limit
Max Limit
Post Rad Min Limit
Post Rad Max Limit

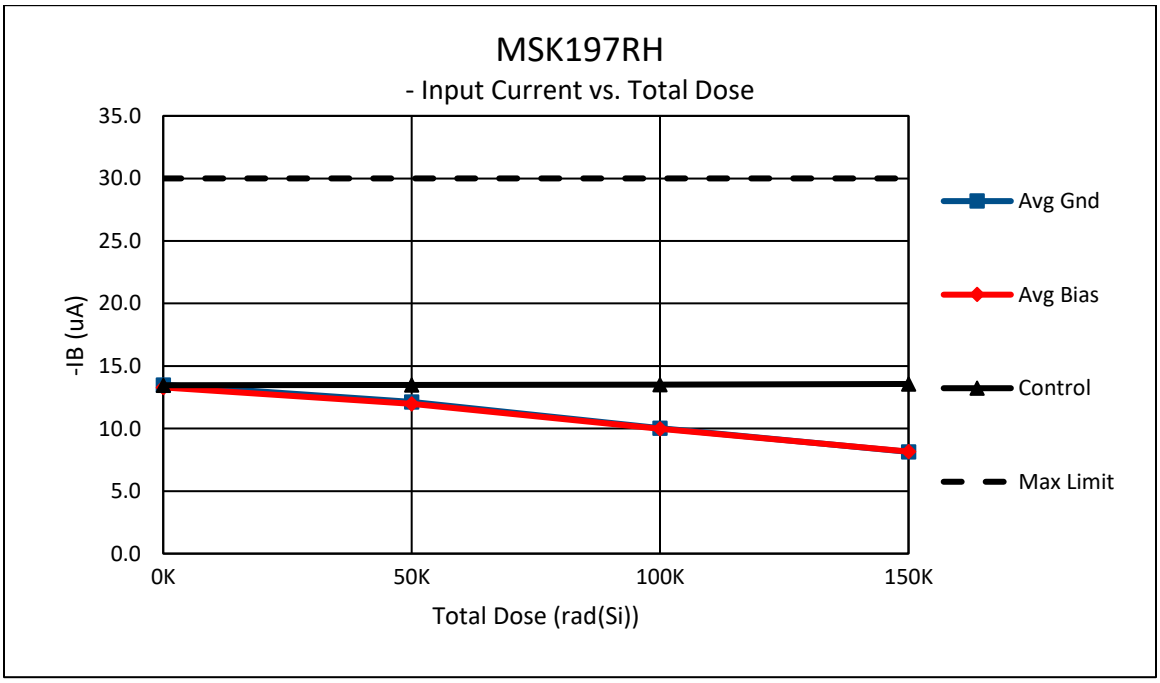

MSK197RH
Input Offset Voltage 1 vs. Total Dose
Input Offset Voltage 1 (mV)
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Min Limit
Max Limit
Post Rad Min Limit
Post Rad Max Limit

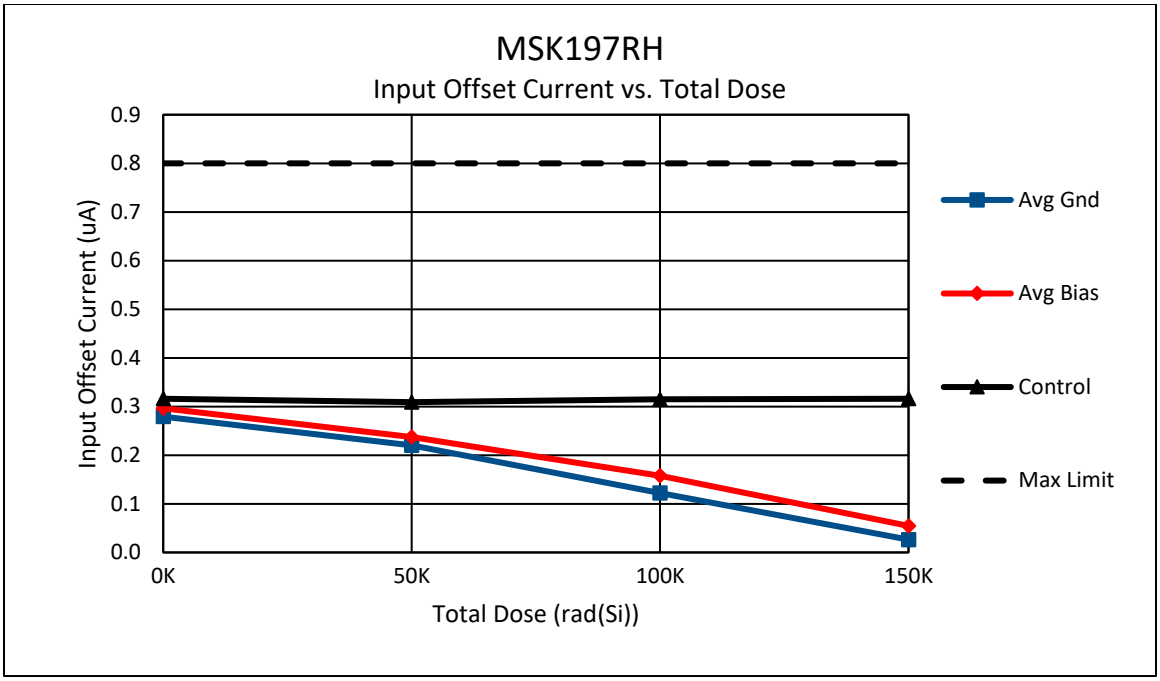

MSK197RH
Input Offset Voltage 2 vs. Total Dose
Input Offset Voltage 2 (mV)
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Min Limit
Max Limit
Post Rad Min Limit
Post Rad Max Limit

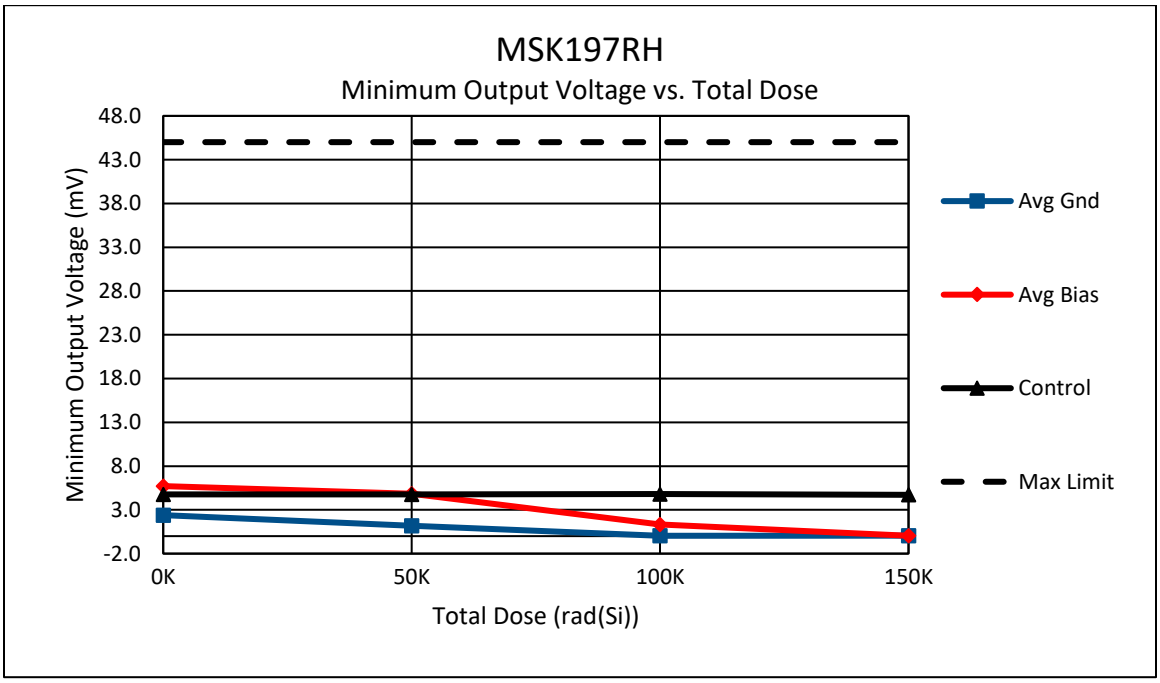

MSK197RH
Common Mode Rejection Ratio vs. Total Dose
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
CMRR (dB)
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Min Limit
Post Rad Min Limit

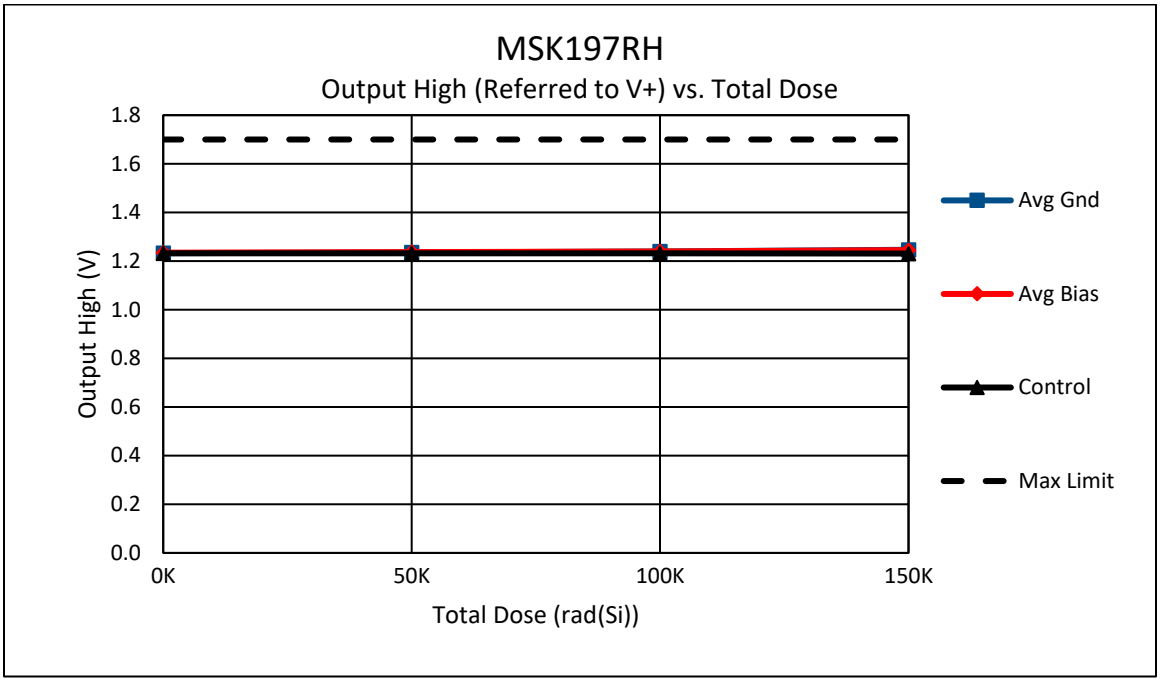

MSK197RH
Power Supply Rejection Ratio vs. Total Dose
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
PSRR (dB)
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Min Limit
Post Rad Min Limit

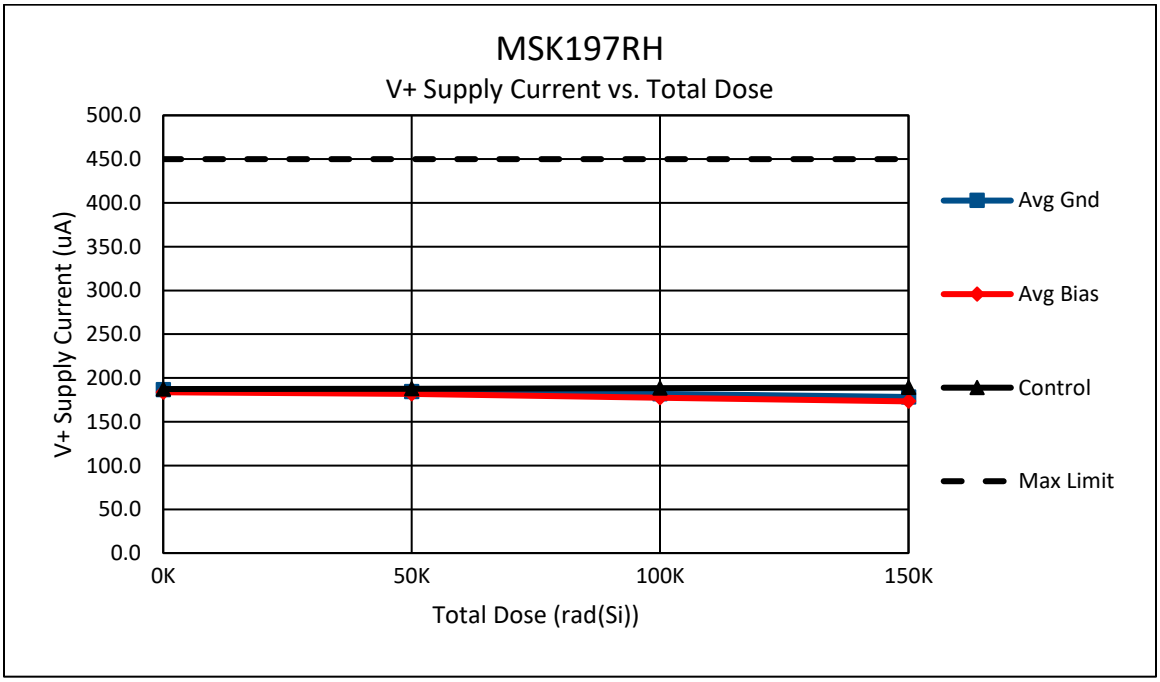

MSK197RH
+ Input Current vs. Total Dose
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
+IB (uA)
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit


MSK197RH
- Input Current vs. Total Dose
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-IB (uA)
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit


MSK197RH
Input Offset Current vs. Total Dose
Input Offset Current (uA)
0.9
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
Control
Max Limit


MSK197RH
Minimum Output Voltage vs. Total Dose
Minimum Output Voltage (mV)
48.0
43.0
38.0
33.0
28.0
23.0
18.0
13.0
8.0
3.0
-2.0
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit


MSK197RH
Output High (Referred to V+) vs. Total Dose
Output High (V)
1.8
1.6
1.4
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
Control
Max Limit


MSK197RH
V+ Supply Current vs. Total Dose
V+ Supply Current (uA)
500.0
450.0
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0K
50K
100K
150K
Total Dose (rad(Si))
Avg Gnd
Avg Bias
Control
Max Limit

Neutron and Total Ionizing Dose Radiation Test Report

MSK196RH,
MSK197RH,
(MSK496RH)
RAD Hard (QUAD) Precision Rail To Rail Current Sense Amplifier

May 11, 2012 (TID, First Test, WAFER LOT: WD005335.3 WF#5); Updated February 12, 2013
March 26, 2013 (Neutron Irradiation, WAFER LOT: WD005335.3 WF#5)
Revised May 23, 2017

B. Horton
R. Wakeman

Anaren, Inc. – MSK Products

I. Introduction:

The Neutron Irradiation test for the MSK196RH 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 MSK196RH, MSK 197RH and the MSK496RH use the same active components. The data herein is from direct measurement of the MSK196RH response to neutron irradiation, but is indicative of the response of all 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 MSK196RH, MSK197RH and MSK496RH.

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 burn-in per MIL-STD-883 Method 1015 and were fully screened IAW MIL-PRF-38534 Class K or MIL-PRF-38535 Class V. 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 automatic electrical test platform. Testing was performed in accordance with the MSK196RH 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. If required, full test data can be obtained by contacting Anaren, Inc. – MSK Products.

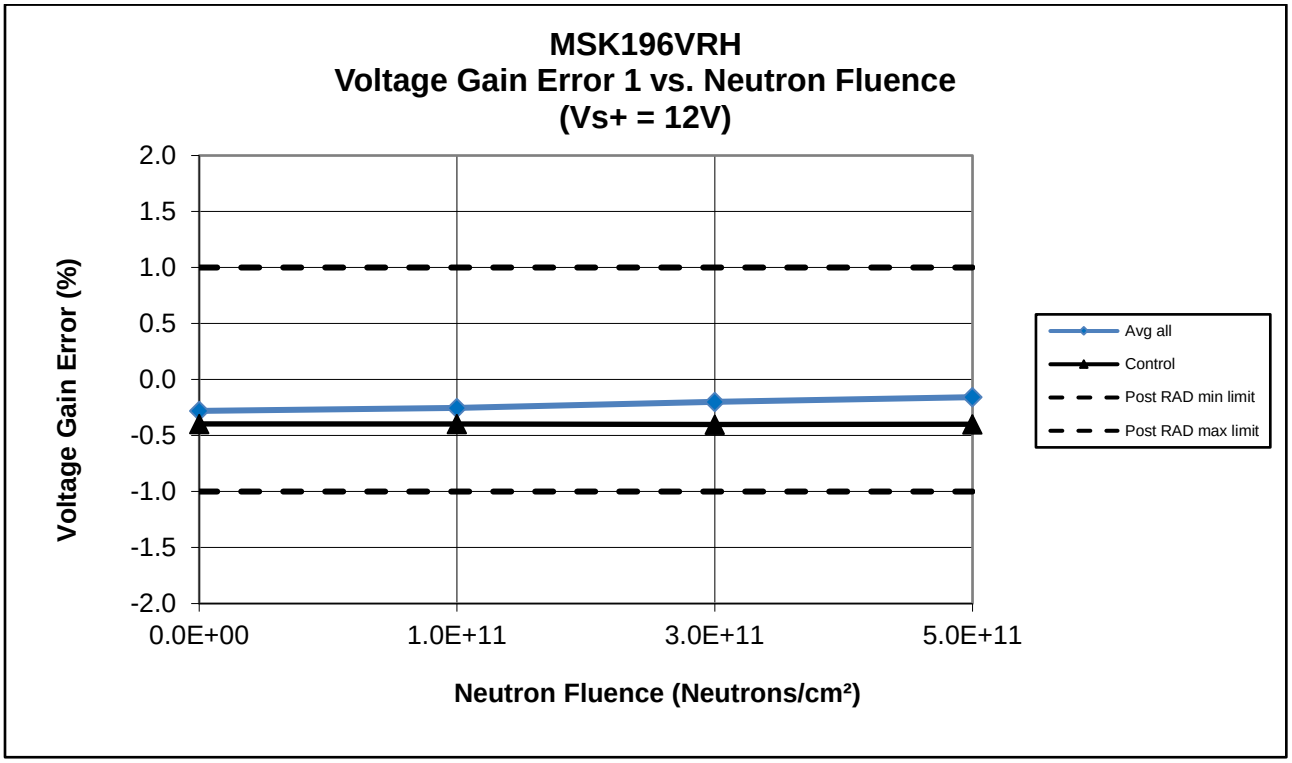
V. Summary:

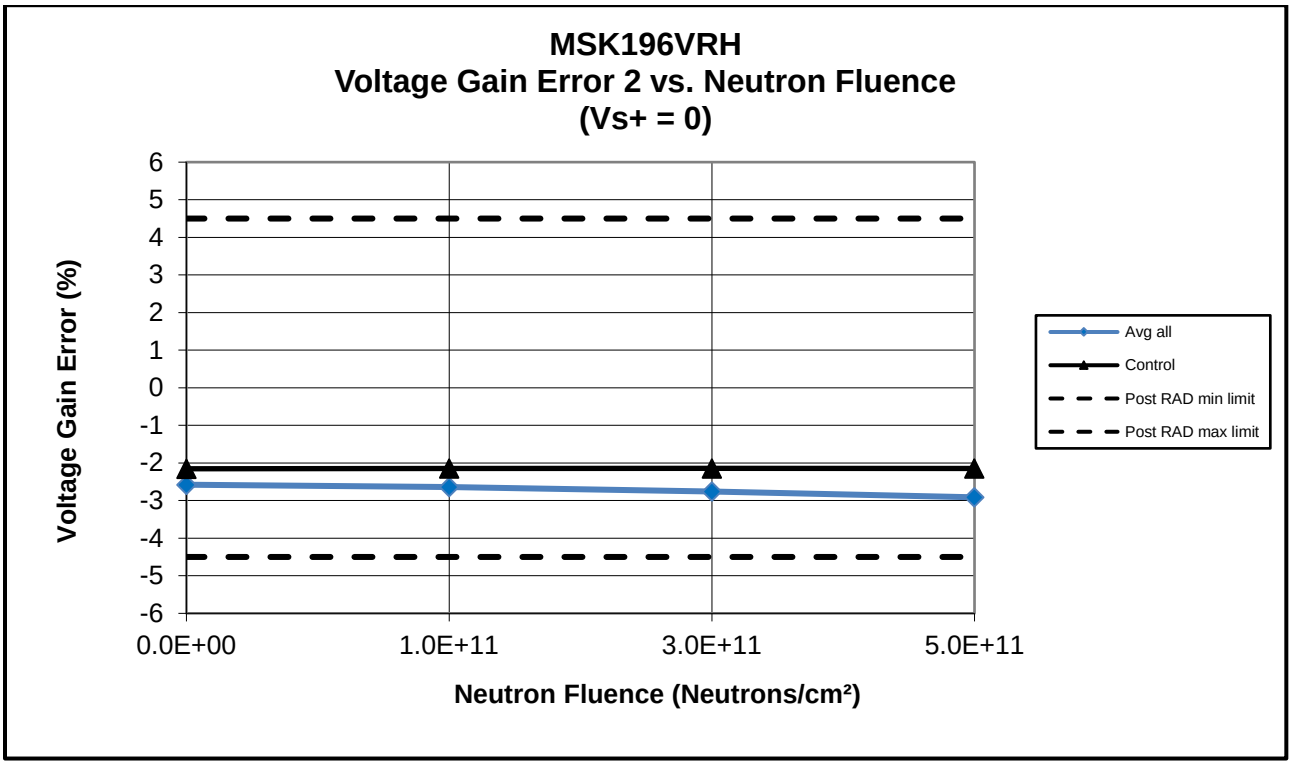
Based on data recorded during neutron irradiation testing and statistical analysis, the MSK196RH, MSK197RH and MSK496RH exhibit low susceptibility to neutron displacement damage. All devices performed well within data sheet specifications throughout all test intervals.

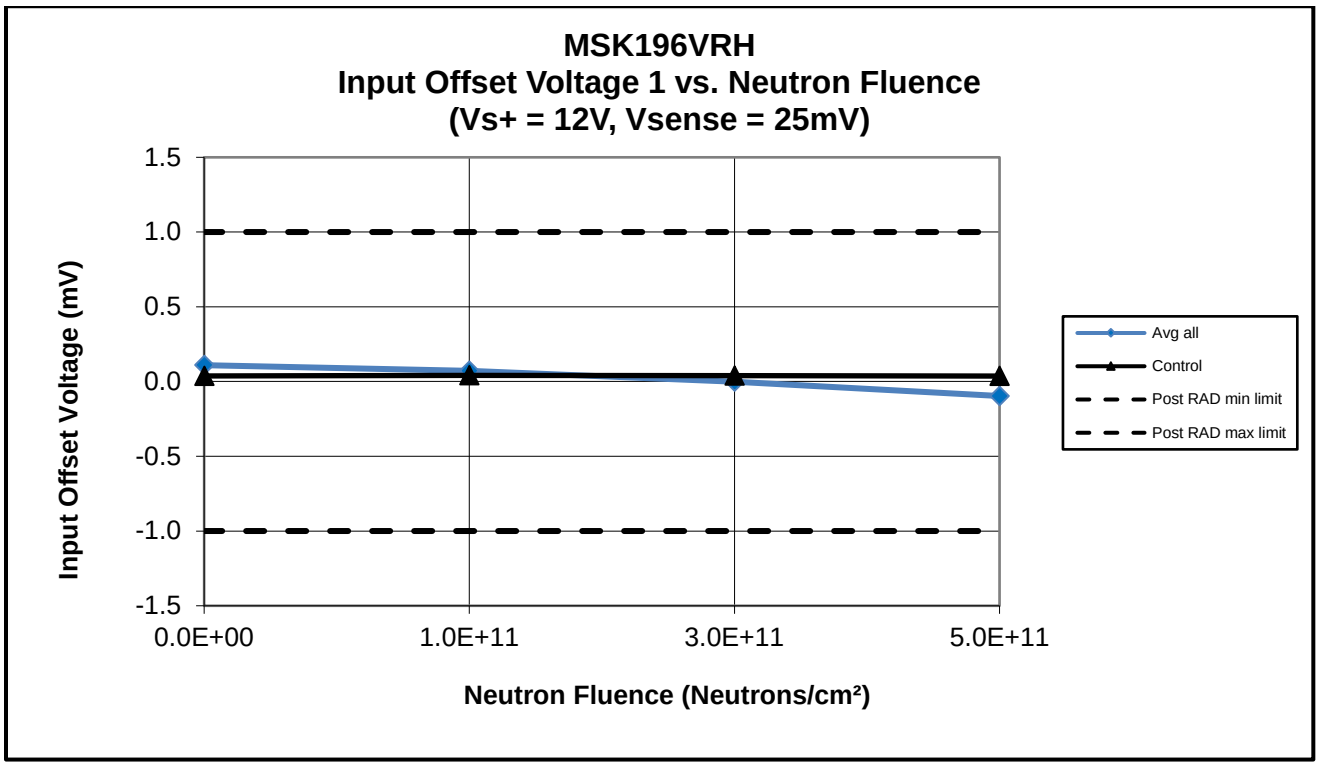
Table 1.

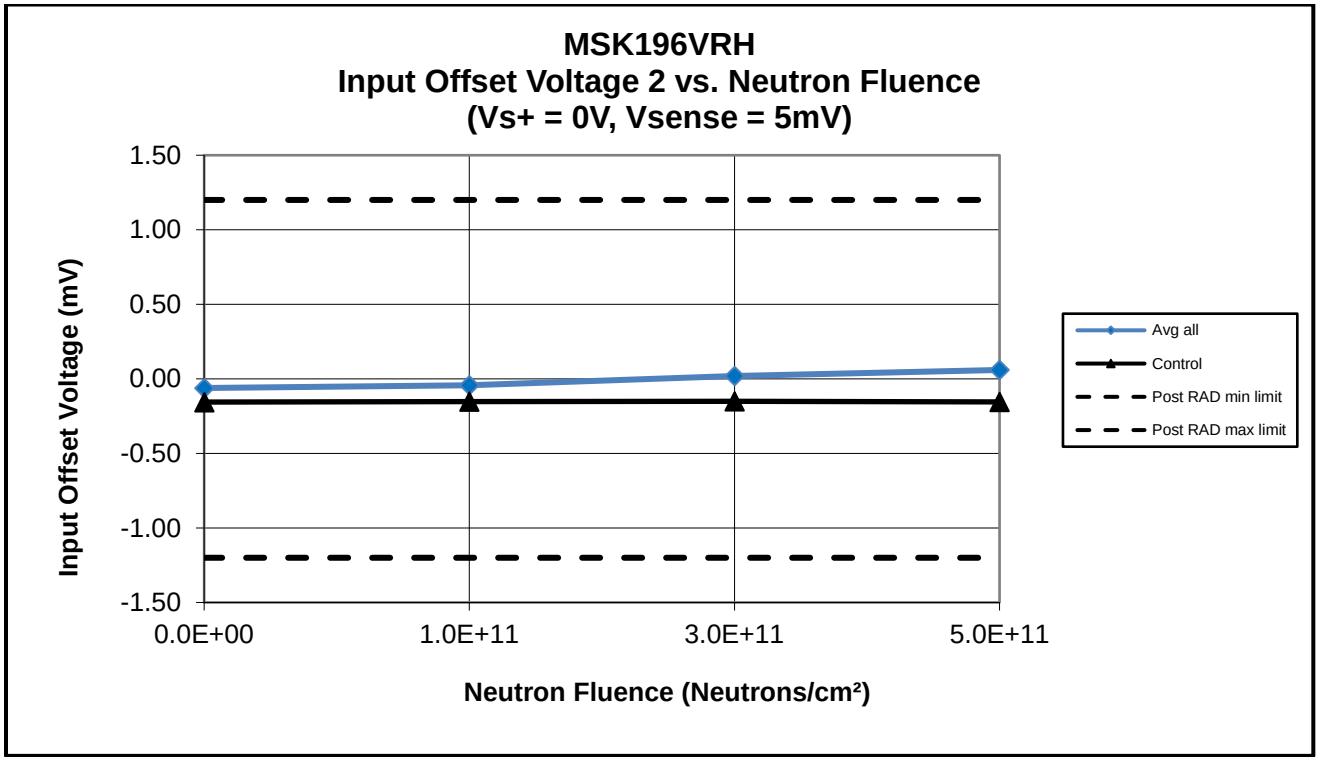
MSK196RH Neutron Irradiation						
Reactor Facility – Fast Neutron Irradiation (FNI) Dosimetry System: S/P-32 (ASTM E-265)						
Exposure Date: 3/26/13						
Irradiation	Reactor Power (kW)	Gamma Dose Rad (Si)	Flux (n/cm^2-S)	Time(s)	Fluence (n/cm^2)	Total Fluence (n/cm^2)
Step 1	5	14	4.05E8	247	1.14E11	1.14E11
Step 2	5	28	4.05E8	494	2.14E11	3.28E11
Step 3	5	28	4.05E8	494	2.10E11	5.38E11

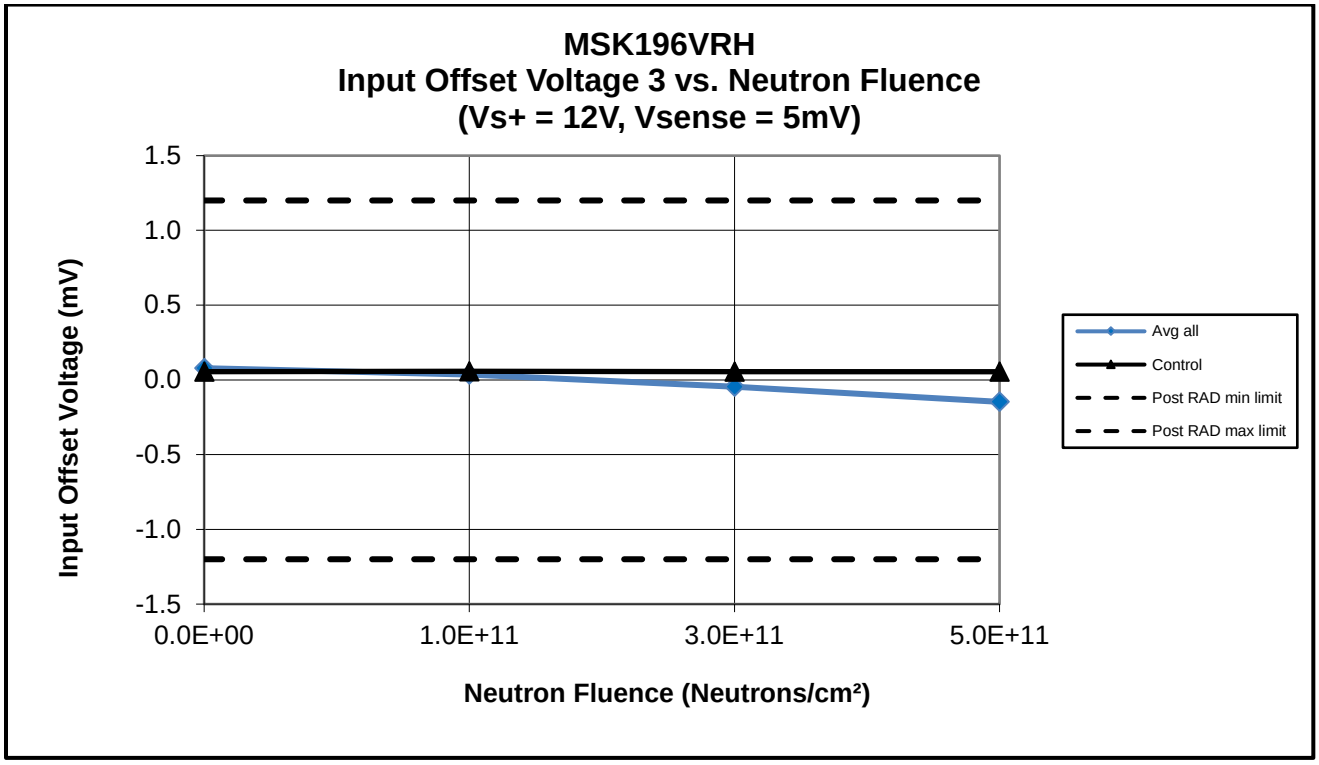
Gamma Dose, Neutron Flux and Total Fluence

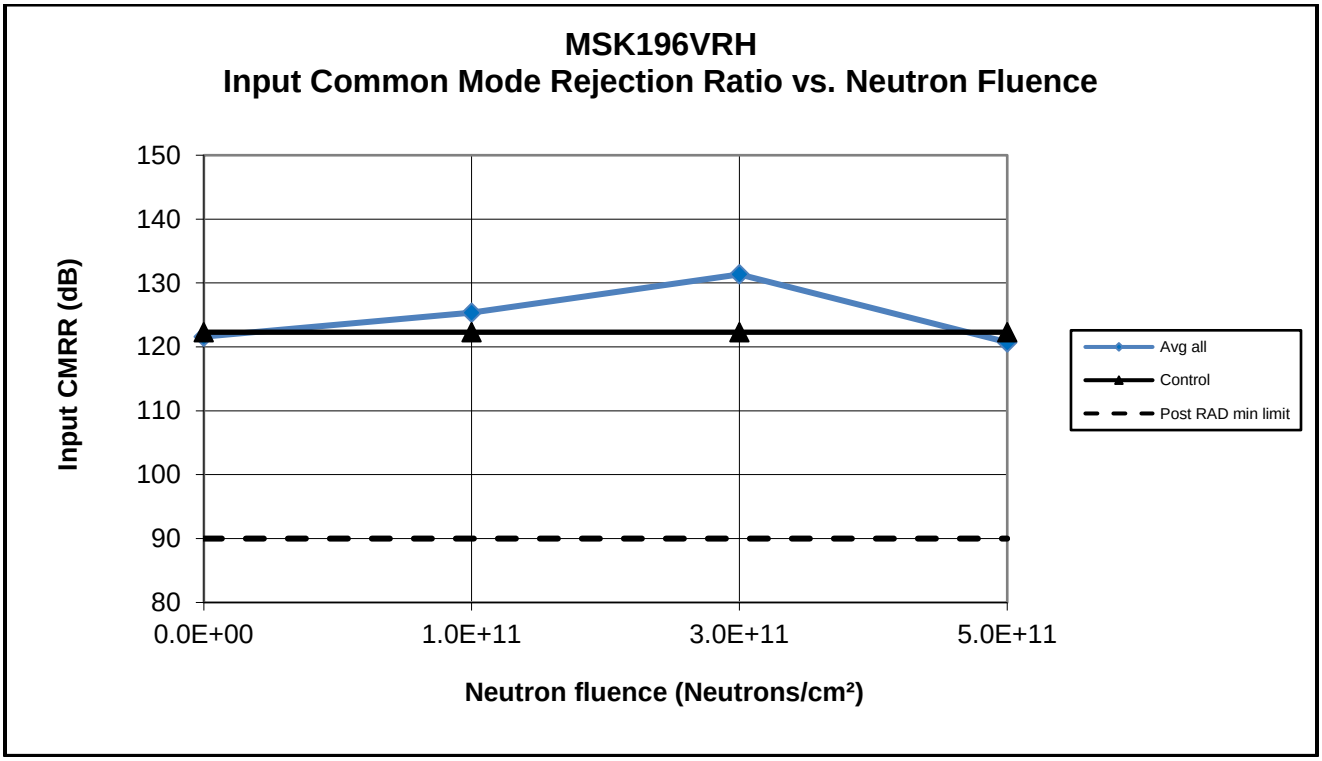

MSK196VRH
Voltage Gain Error 1 vs. Neutron Fluence
(Vs+ = 12V)
Voltage Gain Error (%)
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
0.0E+00
1.0E+11
3.0E+11
5.0E+11
Neutron Fluence (Neutrons/cm²)
Avg all
Control
Post RAD min limit
Post RAD max limit

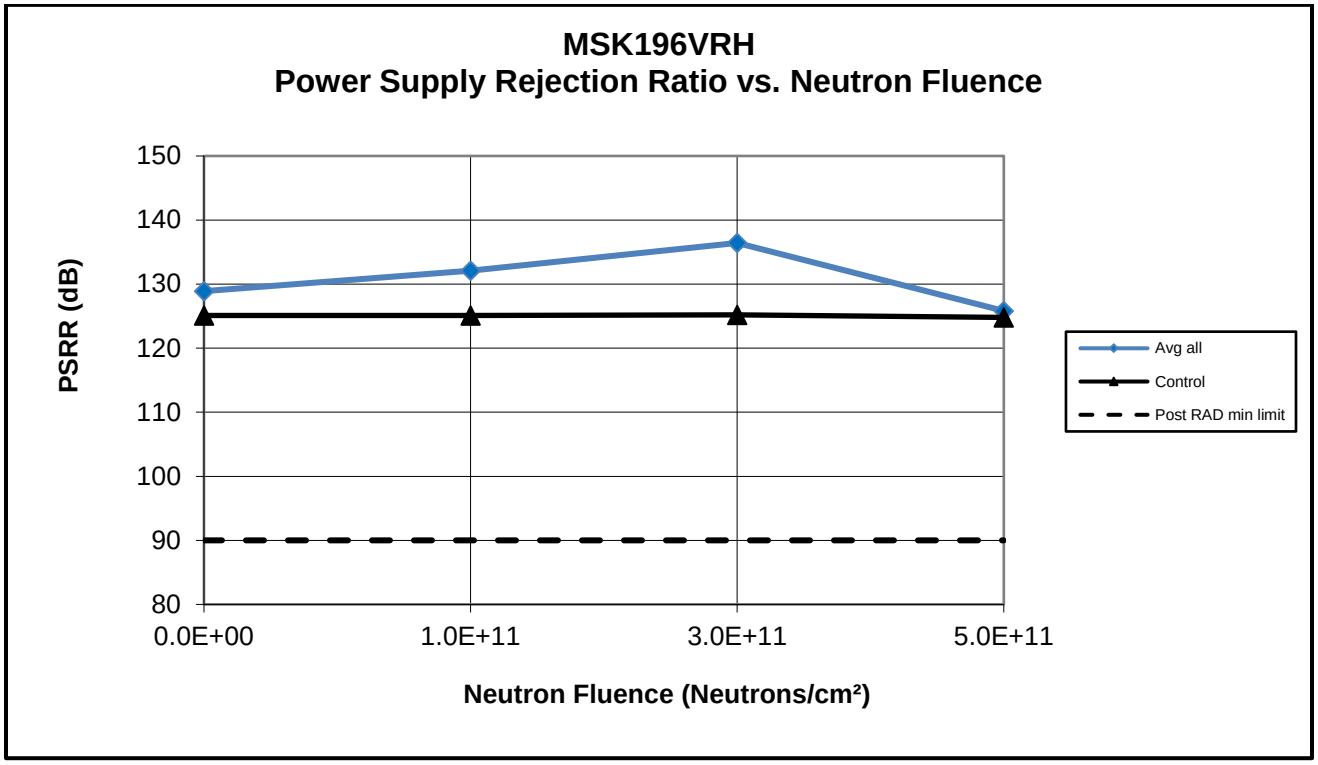

MSK196VRH
Voltage Gain Error 2 vs. Neutron Fluence
(Vs+ = 0)
Voltage Gain Error (%)
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
0.0E+00
1.0E+11
3.0E+11
5.0E+11
Neutron Fluence (Neutrons/cm²)
Avg all
Control
Post RAD min limit
Post RAD max limit

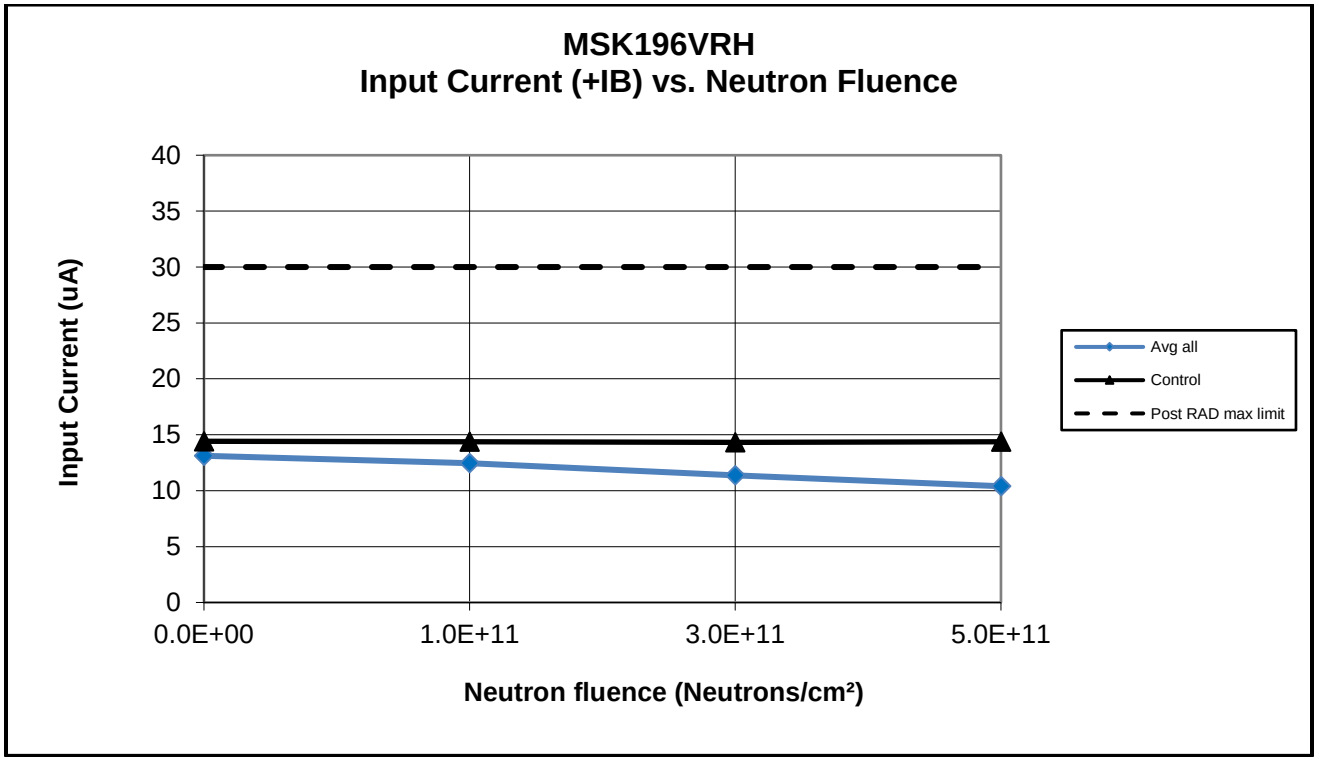

MSK196VRH
Input Offset Voltage 1 vs. Neutron Fluence
(Vs+ = 12V, Vsense = 25mV)
Input Offset Voltage (mV)
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
0.0E+00
1.0E+11
3.0E+11
5.0E+11
Neutron Fluence (Neutrons/cm²)
Avg all
Control
Post RAD min limit
Post RAD max limit

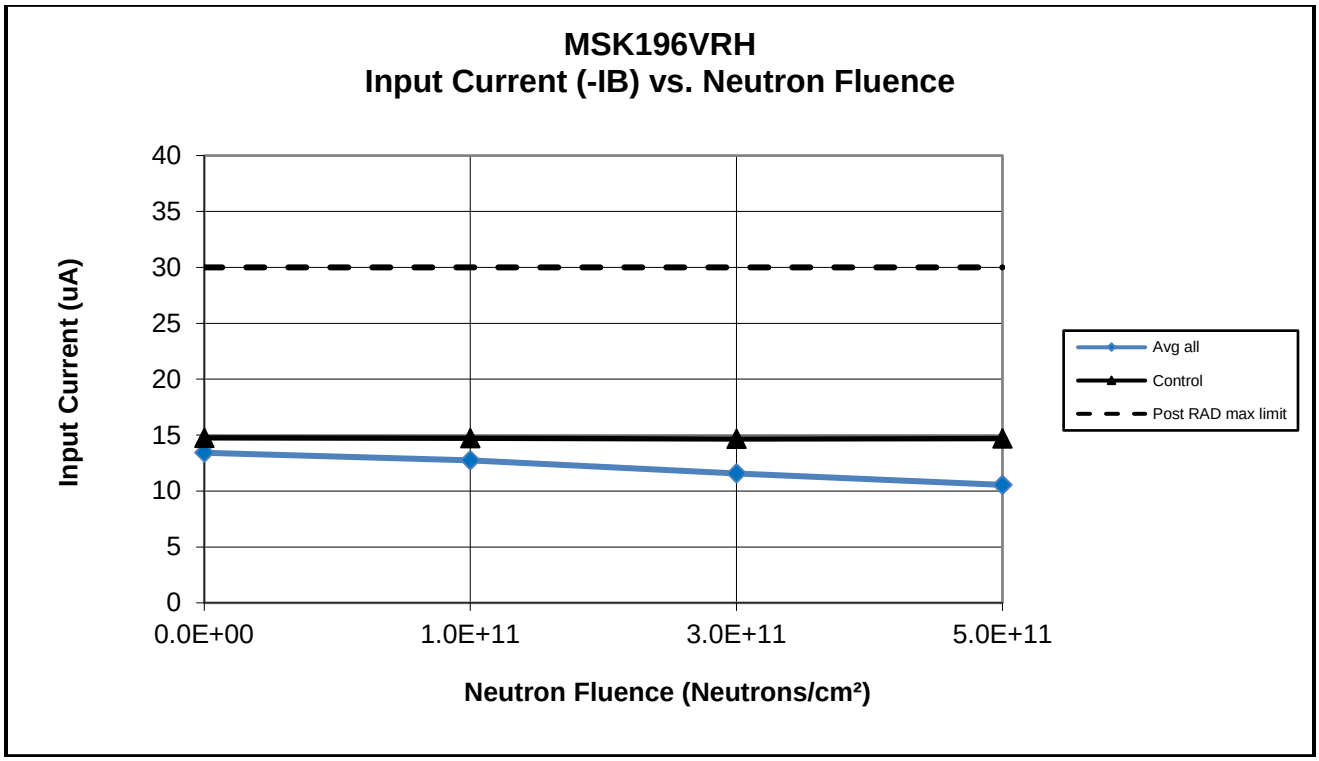

MSK196VRH
Input Offset Voltage 2 vs. Neutron Fluence
(Vs+ = 0V, Vsense = 5mV)
Input Offset Voltage (mV)
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
0.0E+00
1.0E+11
3.0E+11
5.0E+11
Neutron Fluence (Neutrons/cm²)
Avg all
Control
Post RAD min limit
Post RAD max limit

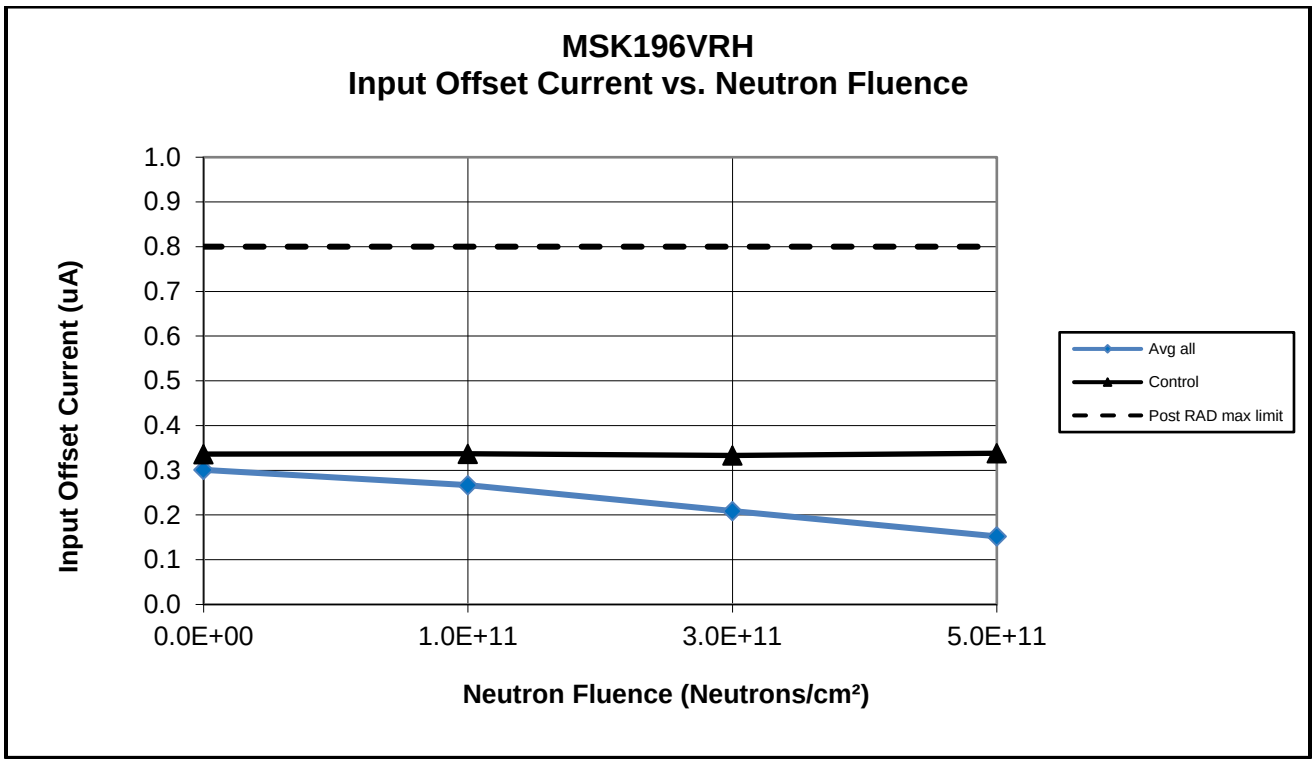

MSK196VRH
Input Offset Voltage 3 vs. Neutron Fluence
(Vs+ = 12V, Vsense = 5mV)
Input Offset Voltage (mV)
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
0.0E+00
1.0E+11
3.0E+11
5.0E+11
Neutron Fluence (Neutrons/cm²)
Avg all
Control
Post RAD min limit
Post RAD max limit

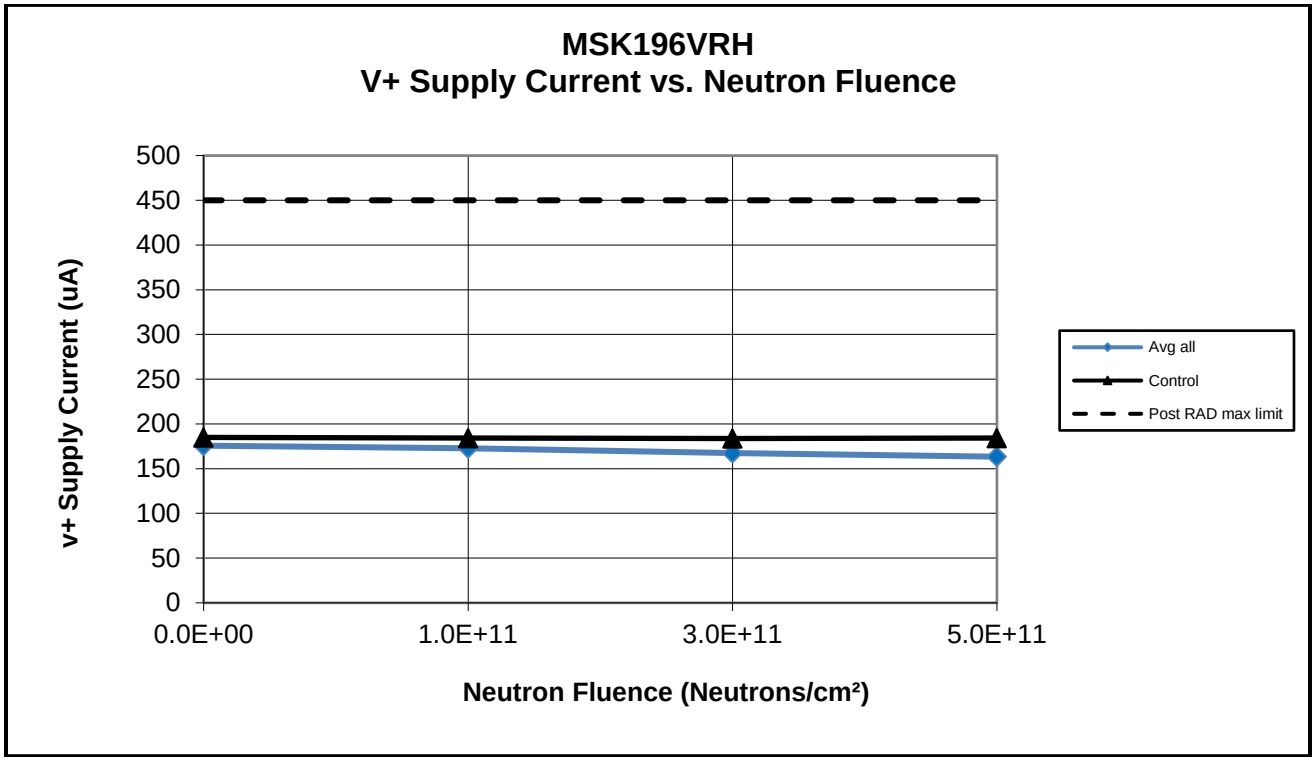

MSK196VRH
Input Common Mode Rejection Ratio vs. Neutron Fluence
Input CMRR (dB)
150
140
130
120
110
100
90
80
0.0E+00
1.0E+11
3.0E+11
5.0E+11
Neutron fluence (Neutrons/cm²)
Avg all
Control
Post RAD min limit

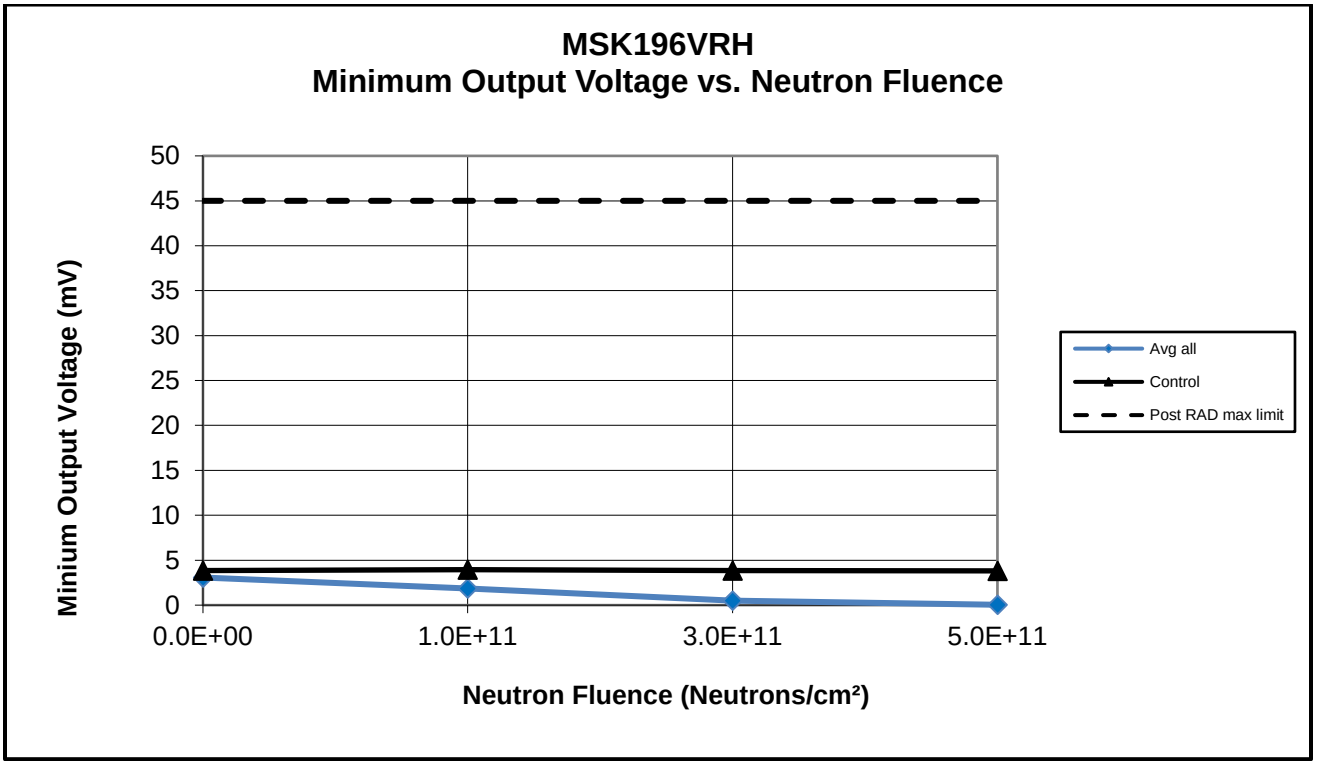

MSK196VRH
Power Supply Rejection Ratio vs. Neutron Fluence
PSRR (dB)
150
140
130
120
110
100
90
80
0.0E+00
1.0E+11
3.0E+11
5.0E+11
Neutron Fluence (Neutrons/cm²)
Avg all
Control
Post RAD min limit

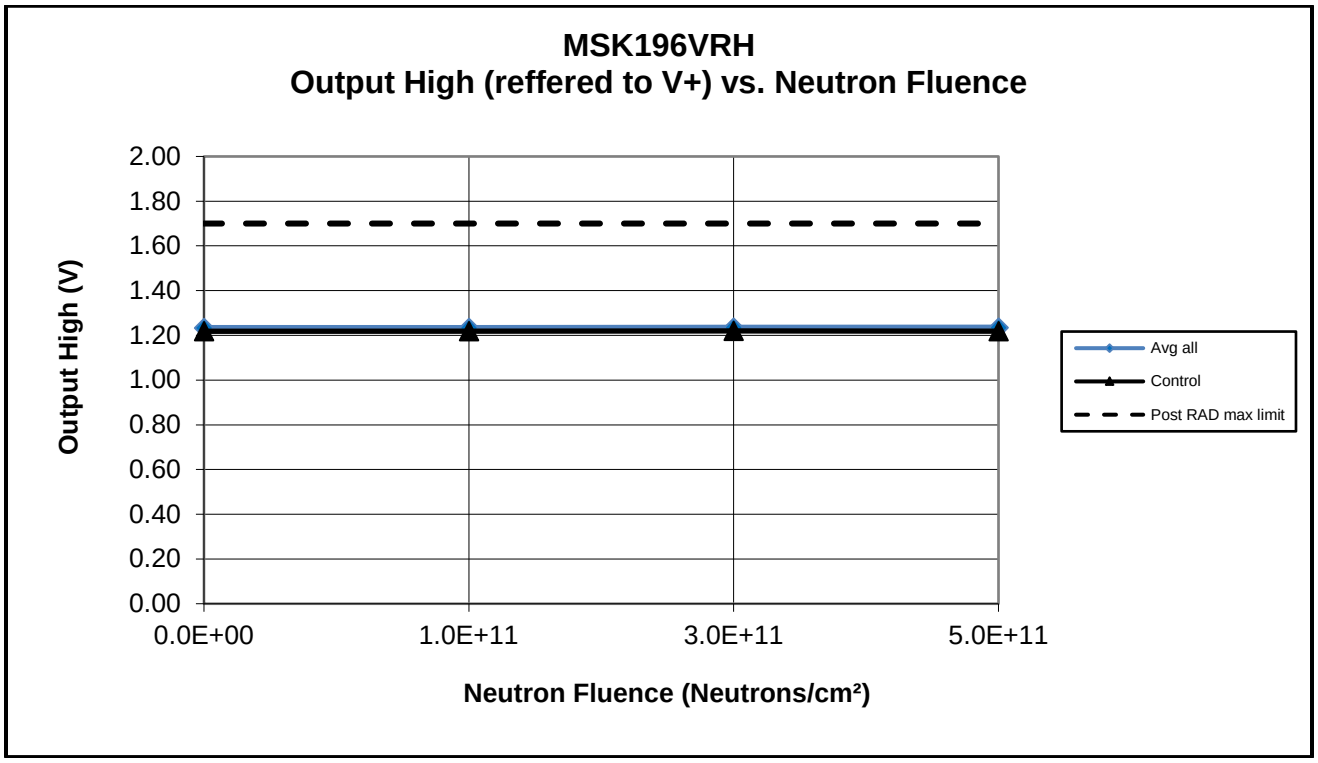

MSK196VRH
Input Current (+IB) vs. Neutron Fluence
Input Current (uA)
40
35
30
25
20
15
10
5
0
0.0E+00
1.0E+11
3.0E+11
5.0E+11
Neutron fluence (Neutrons/cm²)
Avg all
Control
Post RAD max limit


MSK196VRH
Input Current (-IB) vs. Neutron Fluence
Input Current (uA)
40
35
30
25
20
15
10
5
0
0.0E+00
1.0E+11
3.0E+11
5.0E+11
Neutron Fluence (Neutrons/cm²)
Avg all
Control
Post RAD max limit


MSK196VRH
Input Offset Current vs. Neutron Fluence
Input Offset Current (uA)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.0E+00
1.0E+11
3.0E+11
5.0E+11
Neutron Fluence (Neutrons/cm²)
Avg all
Control
Post RAD max limit


MSK196VRH
V+ Supply Current vs. Neutron Fluence
v+ Supply Current (uA)
500
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


MSK196VRH
Minimum Output Voltage vs. Neutron Fluence
Minium Output Voltage (mV)
50
45
40
35
30
25
20
15
10
5
0
0.0E+00
1.0E+11
3.0E+11
5.0E+11
Neutron Fluence (Neutrons/cm²)
Avg all
Control
Post RAD max limit


MSK196VRH
Output High (reffered to V+) vs. Neutron Fluence
Output High (V)
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.0E+00
1.0E+11
3.0E+11
5.0E+11
Neutron Fluence (Neutrons/cm²)
Avg all
Control
Post RAD max limit

Total Dose Radiation Test Report

MSK196RH,
MSK197RH
(MSK496RH)
RAD Hard (QUAD) Precision Rail To Rail Current Sense Amplifier

May 11, 2012 (TID, First Test, WD005335.3 WF#5)
Updated February 12, 2013

B. Horton
K. Conroy
R. Wakeman

Anaren, Inc. – MSK Products

I. Introduction:

The total dose radiation test plan for the MSK 196RH 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. The MSK196RH, MSK197RH and MSK496RH use the same active components. The data in this report is from direct measurement of the MSK196RH response to irradiation but it is indicative of the response of all devices and is applicable to all.

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 196RH, MSK197RH and MSK 496RH.

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 109 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 burn-in per MIL-STD-883 Method 1015 and were fully screened IAW MIL-PRF-38534 Class K or MIL-PRF-38535 Class V. 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. An operating voltage of +30 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 automatic 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. 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 MSK196RH, MSK197RH and MSK496RH qualify as a 100 KRad(Si) radiation hardened devices. Voltage Gain Error 2 (Vs+=0V), Input Offset voltage, PSRR and CMRR exhibited the most significant shift due to irradiation. All other parameters stayed within pre-irradiation specification up to 150KRad(Si).

MSK 196 VRH Biased/Unbiased Dose Rate Schedule

Dosimetry Equipment
Bruker Biospin # 0162

Irradiation Date
5/11/12

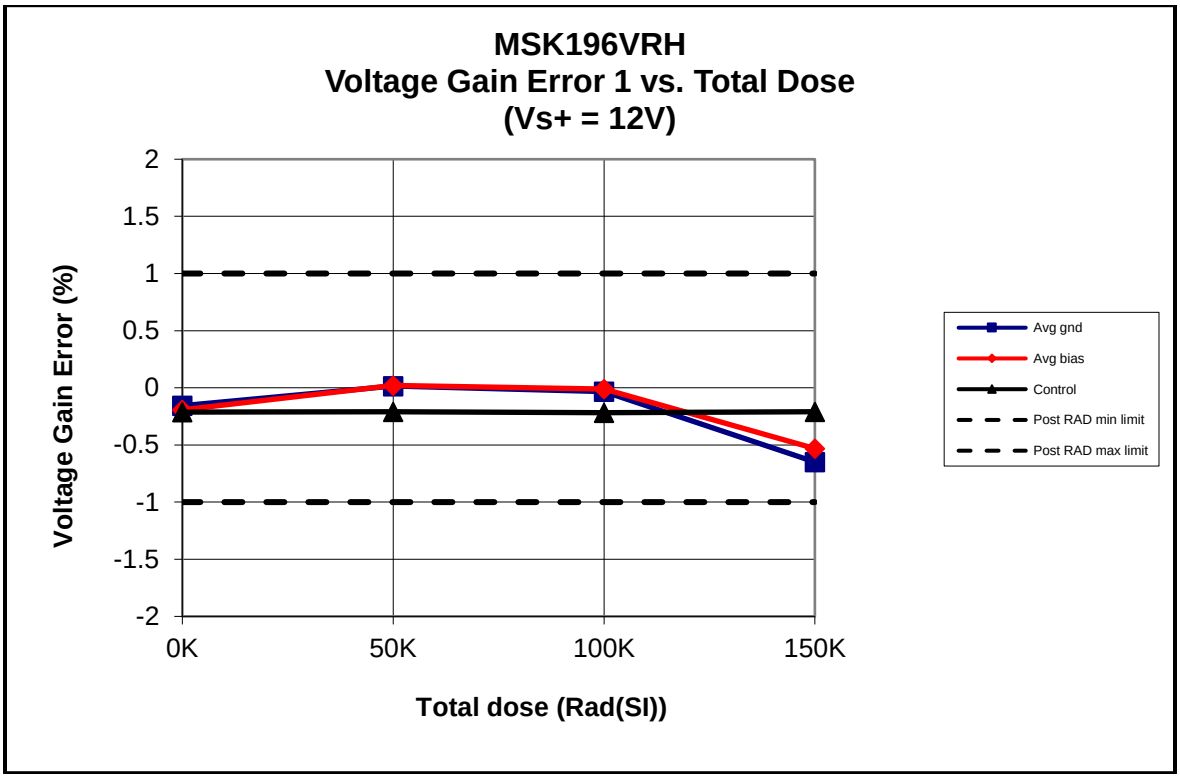
Exposure Length (min:sec)	Incremental Dose rads(Si)	Cumulative Dose rads(Si)
08:00	51,840	51,480
08:00	51,840	103,680
08:00	51,840	155,520

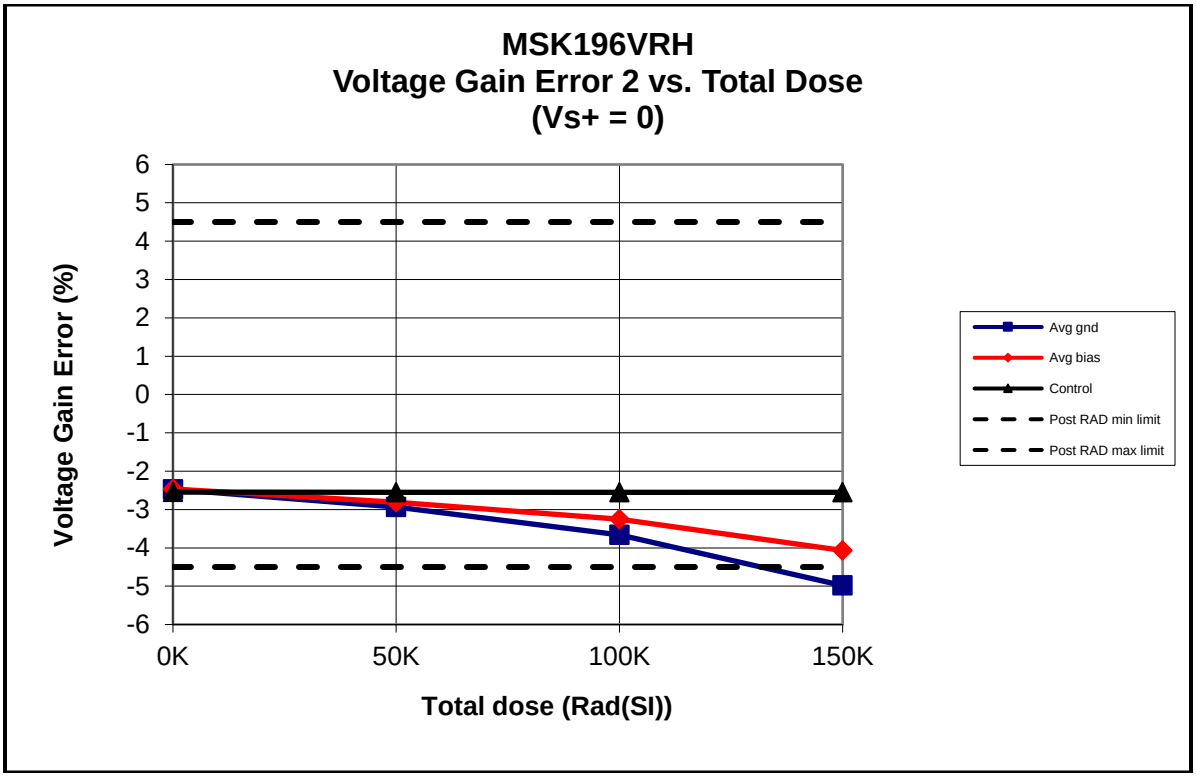
Biased S/N – 0014, 0015, 0016, 0017, 0018

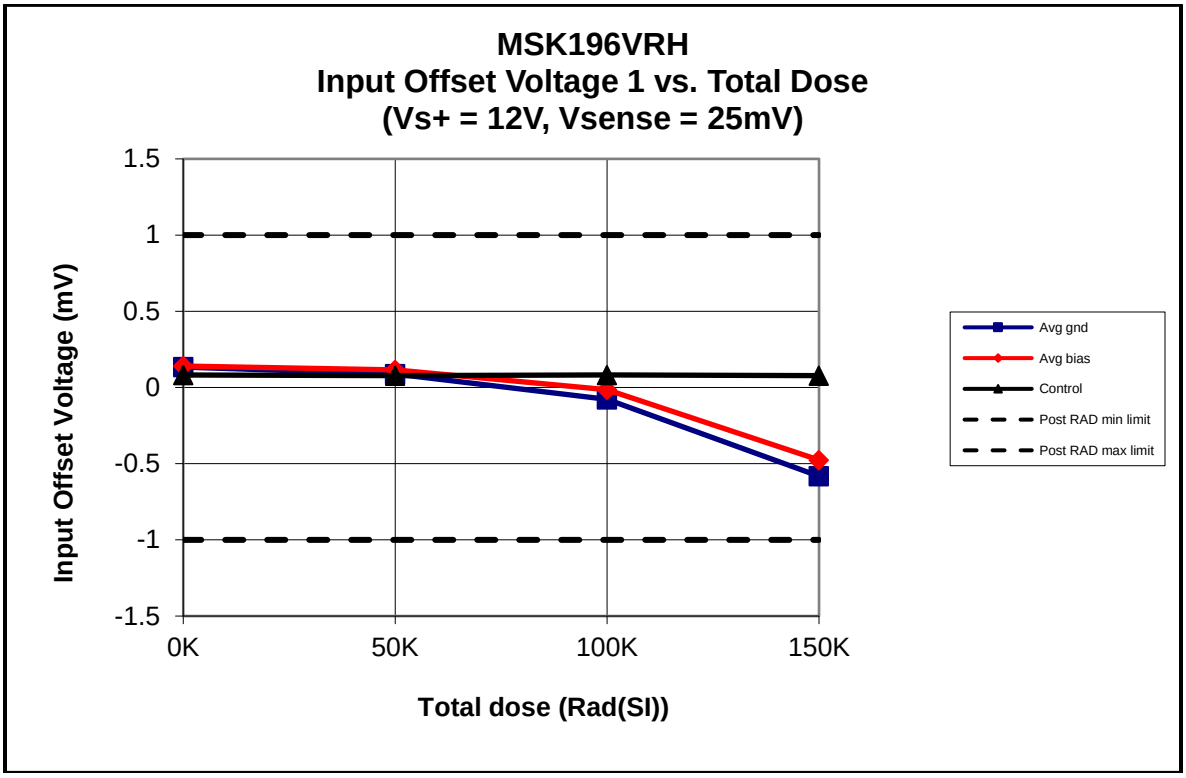
Unbiased S/N – 0019, 0020, 0021, 0023, 0024

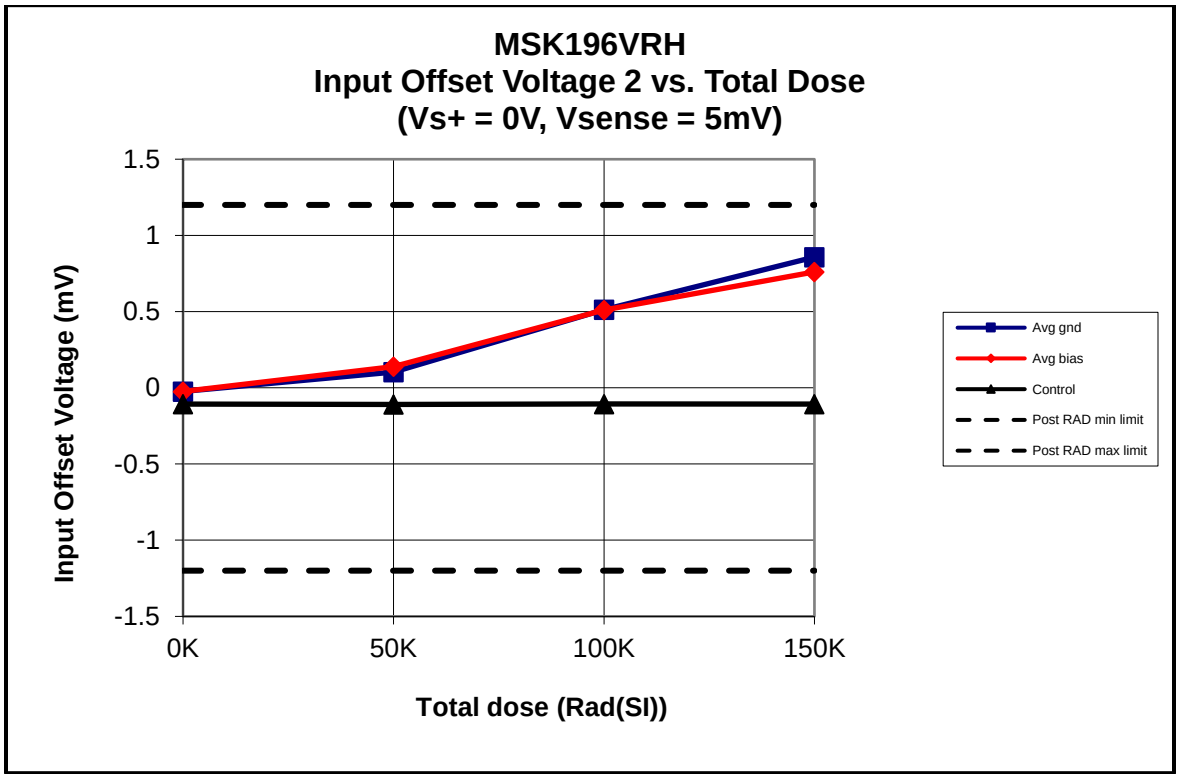
Table 1

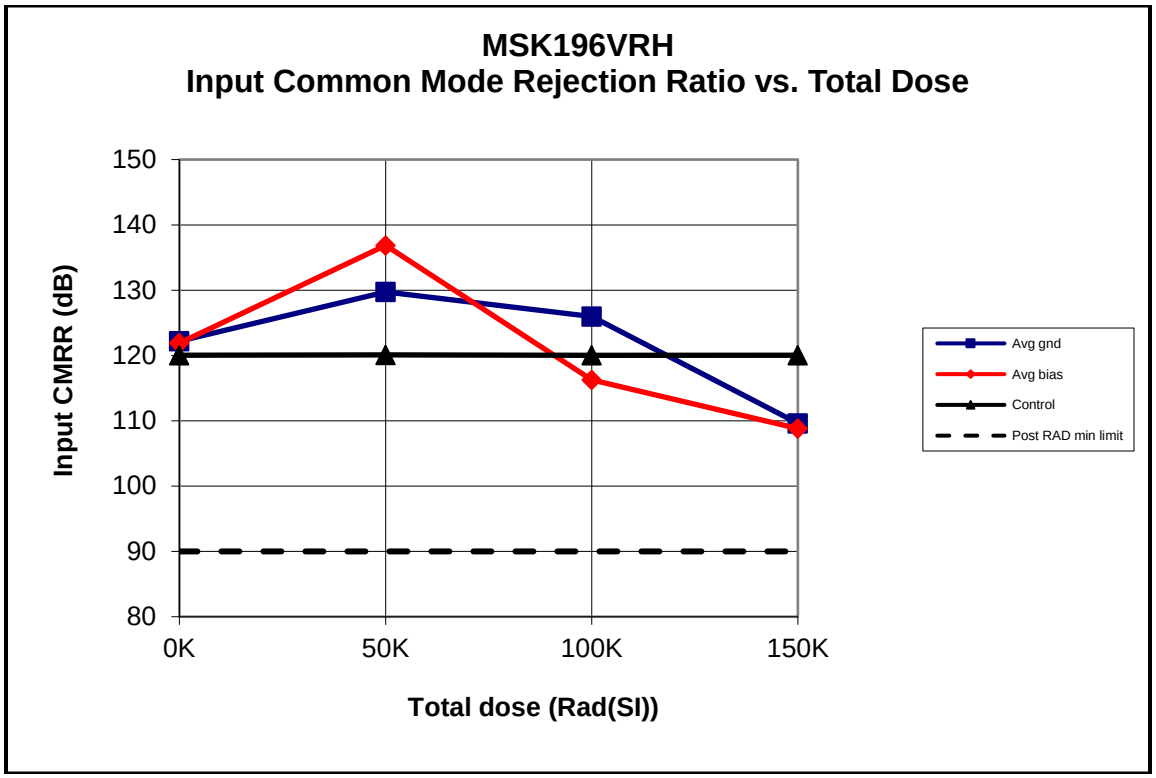
Dose Time, Incremental Dose and Total Cumulative Dose

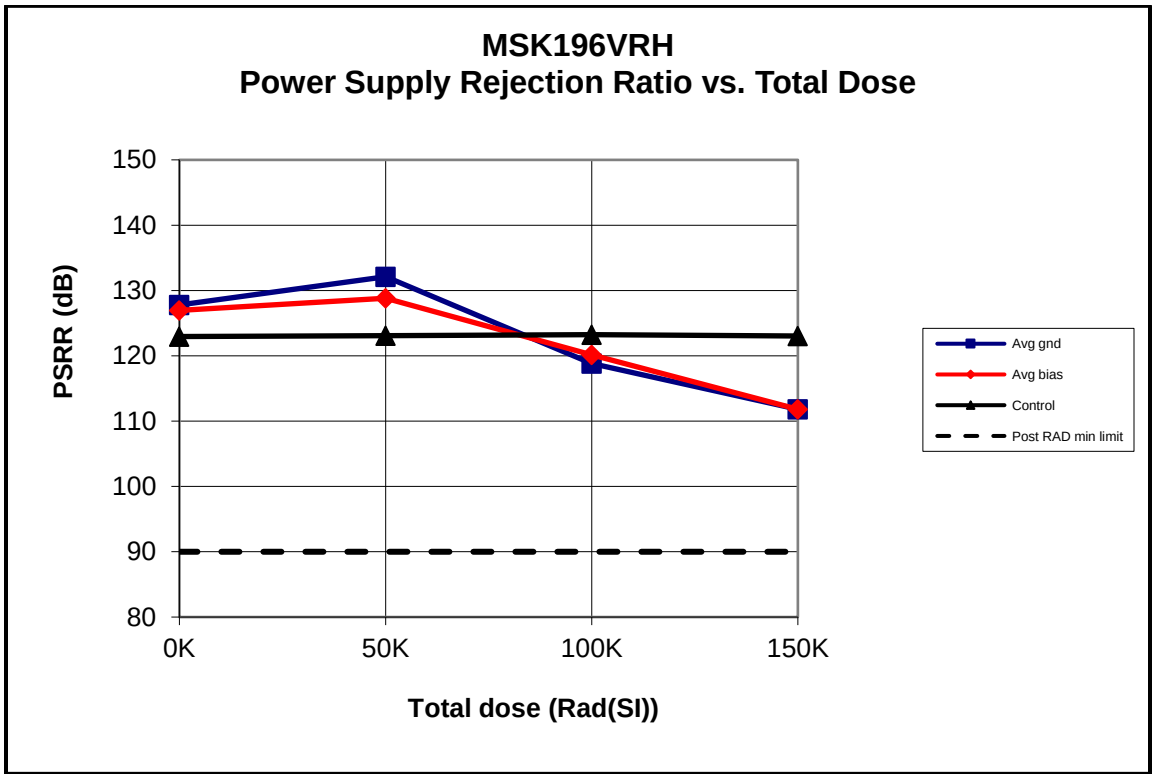

MSK196VRH
Voltage Gain Error 1 vs. Total Dose
(Vs+ = 12V)
Voltage Gain Error (%)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
0K
50K
100K
150K
Total dose (Rad(SI))
Avg gnd
Avg bias
Control
Post RAD min limit
Post RAD max limit

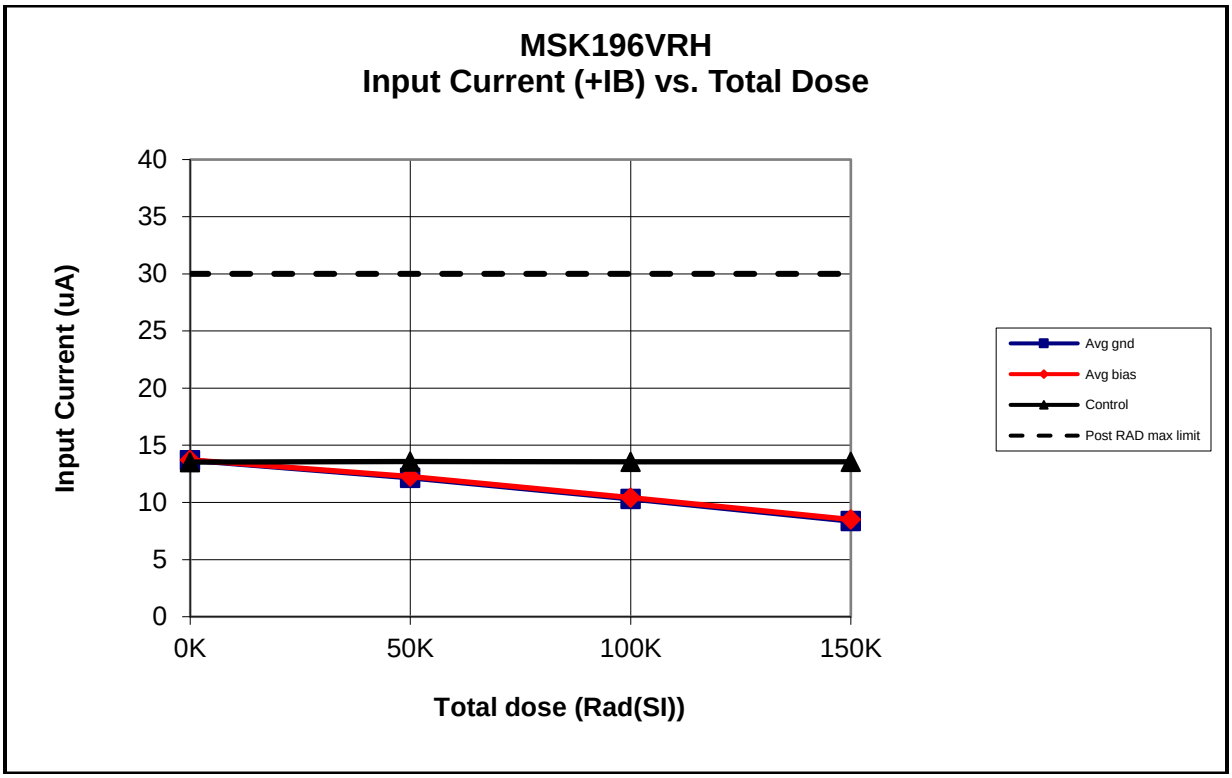

MSK196VRH
Voltage Gain Error 2 vs. Total Dose
(Vs+ = 0)
Voltage Gain Error (%)
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
0K
50K
100K
150K
Total dose (Rad(SI))
Avg gnd
Avg bias
Control
Post RAD min limit
Post RAD max limit

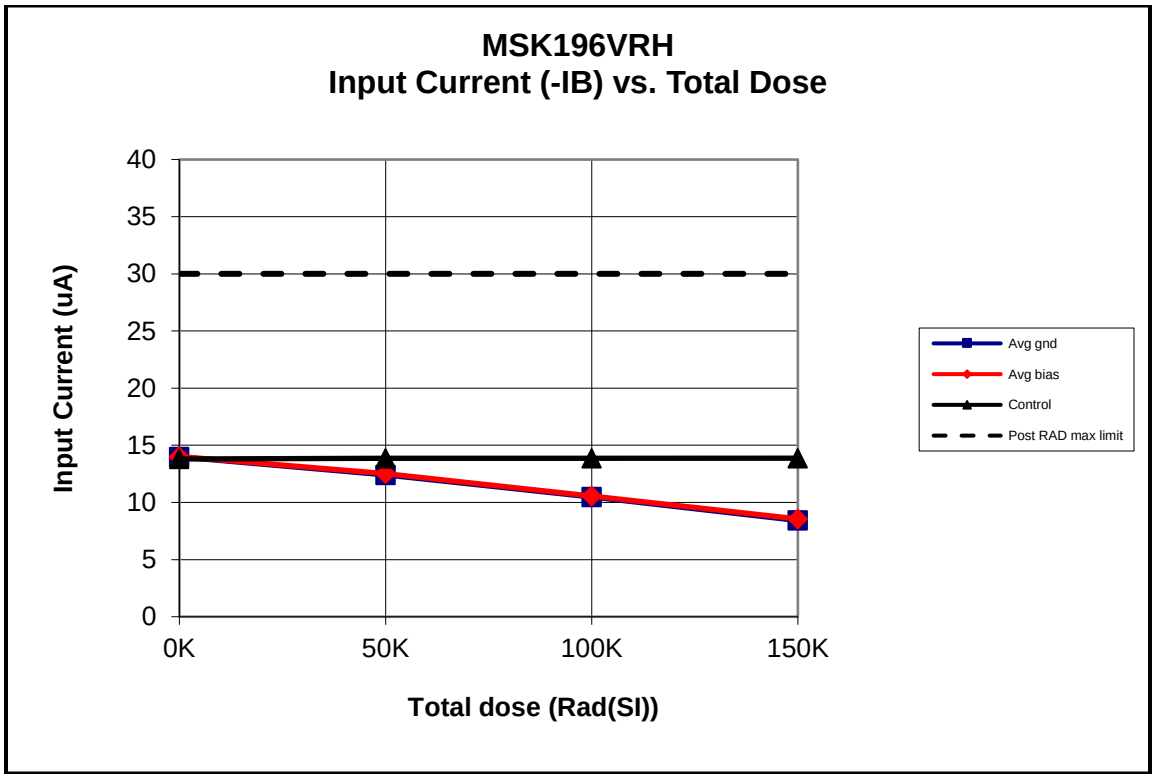

MSK196VRH
Input Offset Voltage 1 vs. Total Dose
(Vs+ = 12V, Vsense = 25mV)
Input Offset Voltage (mV)
1.5
1
0.5
0
-0.5
-1
-1.5
0K
50K
100K
150K
Total dose (Rad(SI))
Avg gnd
Avg bias
Control
Post RAD min limit
Post RAD max limit

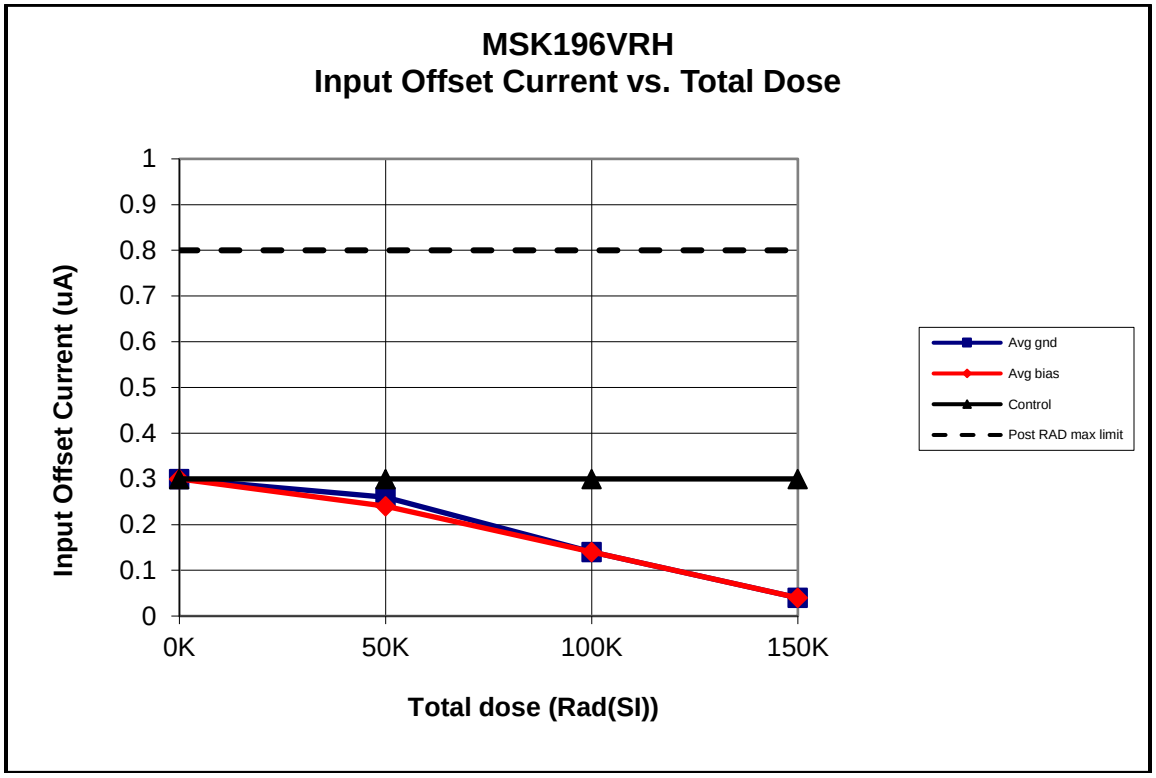

MSK196VRH
Input Offset Voltage 2 vs. Total Dose
(Vs+ = 0V, Vsense = 5mV)
Input Offset Voltage (mV)
1.5
1
0.5
0
-0.5
-1
-1.5
0K
50K
100K
150K
Total dose (Rad(SI))
Avg gnd
Avg bias
Control
Post RAD min limit
Post RAD max limit

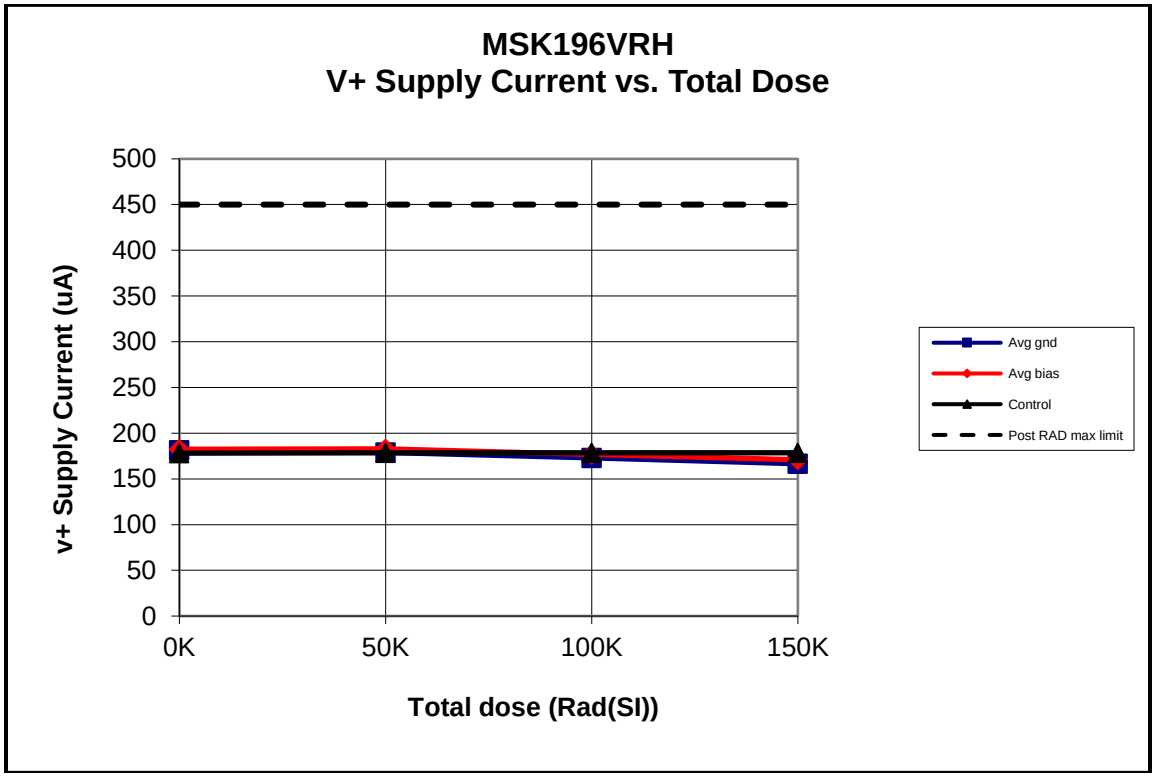

MSK196VRH
Input Common Mode Rejection Ratio vs. Total Dose
Input CMRR (dB)
150
140
130
120
110
100
90
80
0K
50K
100K
150K
Total dose (Rad(SI))
Avg gnd
Avg bias
Control
Post RAD min limit

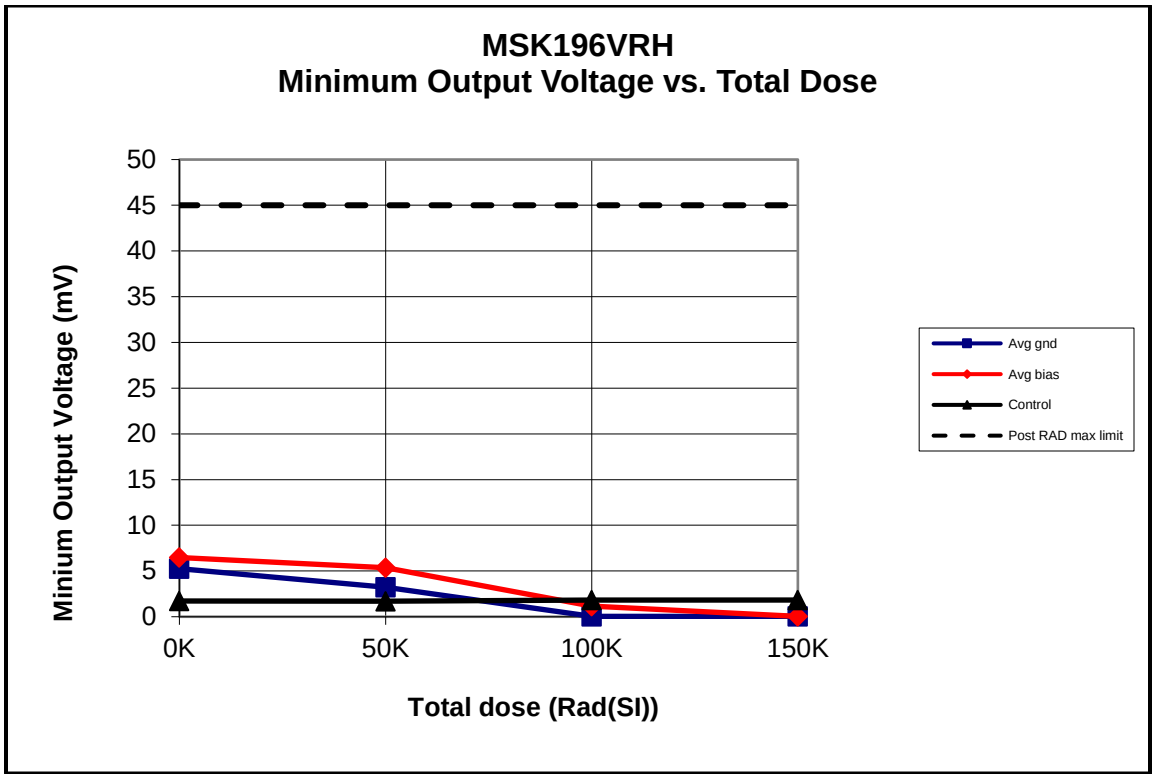

MSK196VRH
Power Supply Rejection Ratio vs. Total Dose
PSRR (dB)
150
140
130
120
110
100
90
80
0K
50K
100K
150K
Total dose (Rad(SI))
Avg gnd
Avg bias
Control
Post RAD min limit

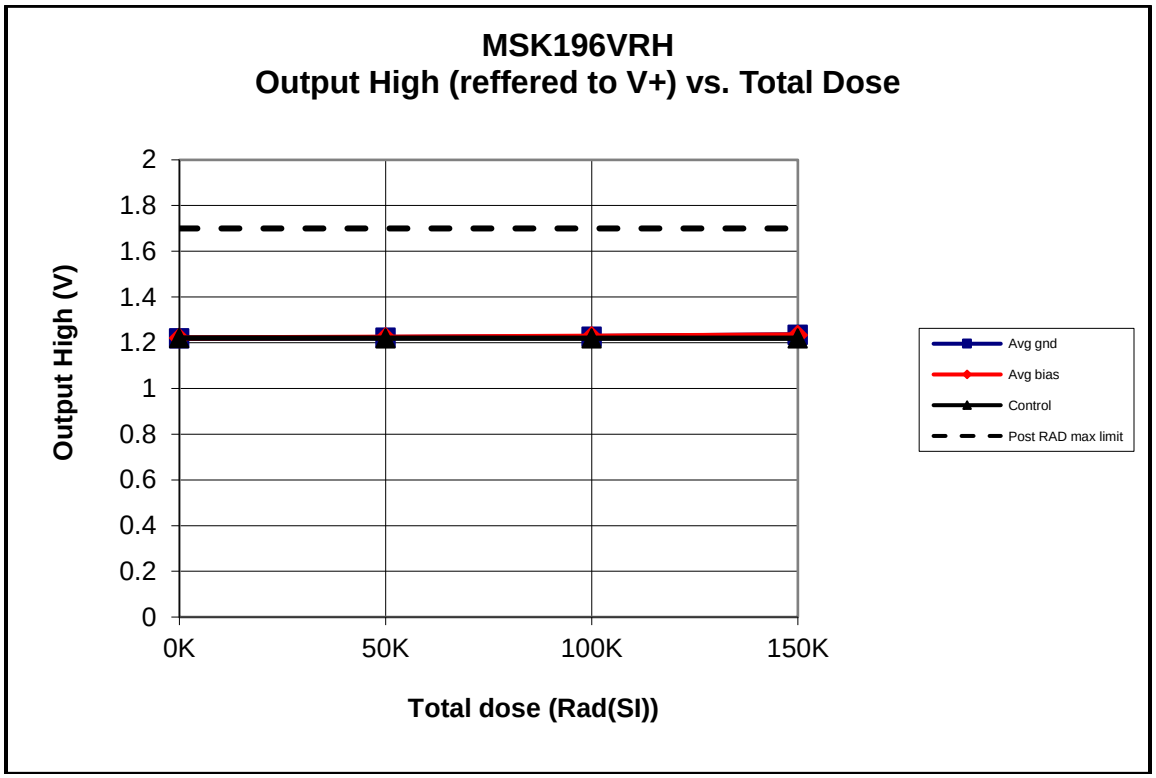

MSK196VRH
Input Current (+IB) vs. Total Dose
Input Current (uA)
40
35
30
25
20
15
10
5
0
0K
50K
100K
150K
Total dose (Rad(SI))
Avg gnd
Avg bias
Control
Post RAD max limit


MSK196VRH
Input Current (-IB) vs. Total Dose
Input Current (uA)
40
35
30
25
20
15
10
5
0
0K
50K
100K
150K
Total dose (Rad(SI))
Avg gnd
Avg bias
Control
Post RAD max limit


MSK196VRH
Input Offset Current vs. Total Dose
Input Offset Current (uA)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0K
50K
100K
150K
Total dose (Rad(Si))
Avg gnd
Avg bias
Control
Post RAD max limit


MSK196VRH
V+ Supply Current vs. Total Dose
v+ Supply Current (uA)
500
450
400
350
300
250
200
150
100
50
0
0K
50K
100K
150K
Total dose (Rad(Si))
Avg gnd
Avg bias
Control
Post RAD max limit


MSK196VRH
Minimum Output Voltage vs. Total Dose
Minium Output Voltage (mV)
50
45
40
35
30
25
20
15
10
5
0
0K
50K
100K
150K
Total dose (Rad(SI))
Avg gnd
Avg bias
Control
Post RAD max limit


MSK196VRH
Output High (reffered to V+) vs. Total Dose
Output High (V)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0K
50K
100K
150K
Total dose (Rad(SI))
Avg gnd
Avg bias
Control
Post RAD max limit