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Total Ionizing Dose (TID) Radiation Testing of the RH1011W Voltage Comparator for Analog Devices Incorporated

Customer: Analog Devices Incorporated, PO# 45862496

Job Number: RTS21-J0140

Part Type Tested: RH1011W Voltage Comparator, Analog Devices RH1011 Datasheet Revision F.

Traceability Information: Manufacturer: Analog Devices, Date Code: 2023A, Wafer Lot Number: A21647.1, Wafer Run Number: 10220414.1, Wafer Number: 23. See photograph of unit under test in Appendix A.

Quantity of Units: 12 units received, 5 units for biased irradiation, 5 units for unbiased irradiation, and 2 units for controls. Serial numbers 1648-1652 were biased during irradiation, serial numbers 1653-1657 were unbiased during irradiation and serial numbers 1658 and 1659 was used as controls. See Appendix B for the radiation bias connection table.

Radiation and Electrical Test Increments: 50rad(Si)/s ionizing radiation with electrical test increments: pre-irradiation, 20krad(Si), 50krad(Si), 100krad(Si) and 200krad(Si)

Pre-Irradiation Burn-In: Burn-In performed by Analog Devices prior to receipt by RTS.

Overtest and Post-Irradiation Anneal: No overtest. 24-hour room temperature anneal followed by a 168-hour 100°C anneal. Both anneals were performed in the same electrical bias condition as the irradiations. Electrical measurements were made following each anneal increment.

Radiation Test Standard: MIL-STD-883 TM1019 Condition A and Analog Devices RH1011 Datasheet Revision F.

Test Hardware and Software: LTS2020 Automated Tester, Entity ID TS03, Calibration Date: 6/26/2020, Calibration Due: 6/26/2021. LTS2101 Family Board, Entity ID FB02. LTS0608 Test Fixture, Entity ID TF09. RH1011FP Entity#: 92 DUT Board. Test Program: RH1011AD.SRC

Facility and Radiation Source: Gamma rays provided by JLSA 81-24 Co60 HDR source at Radiation Test Solutions, Colorado Springs, CO. Dosimetry performed by Air Ionization Chamber (AIC) traceable to NIST. Radiation Test Solutions' dosimetry has been audited by DLA and Radiation Test Solutions has been awarded Laboratory Suitability for MIL-STD-750 and MIL-STD-883 TM 1017 and TM 1019.

Irradiation and Test Temperature: Room temperature controlled to 24°C±6°C per MIL-STD-883.

RLAT Test Result:

- **PASSED the total ionizing dose test to the 200krad(Si) dose level**
- **PASSED following 24-hour room temperature anneal**
- **PASSED following 168-hour 100°C anneal**

1.0. Overview and Background

It is well known that total dose ionizing radiation can cause parametric degradation and ultimately functional failure in electronic devices. The damage occurs via electron-hole pair production, transport and trapping in the dielectric and interface regions. In discrete devices the bulk of the damage is frequently manifested as a reduction in the gain and/or breakdown voltage of the device. The damage will usually anneal with time following the end of the radiation exposure. Due to this annealing, and to ensure a worst-case test condition MIL-STD-883 TM1019 calls out a dose rate of 50 to 300rad(Si)/s as Condition A and further specifies that the time from the end of an incremental radiation exposure and electrical testing shall be 1-hour or less and the total time from the end of one incremental irradiation to the beginning of the next incremental radiation step should be 2-hours or less. The work described in this report was performed to meet MIL-STD-883 TM1019 Condition A.

2.0. Radiation Test Apparatus

The total ionizing dose testing described in this final report was performed using the facilities at Radiation Test Solutions' Longmire Laboratories in Colorado Springs, CO. The high dose rate total ionizing dose (HDR/TID) source is a JLSA 81-24 irradiator modified to provide a panoramic exposure. The Co-60 rods are held in the base of the irradiator heavily shielded by lead. During the radiation exposures the rod is raised by an electronic timer/controller and the exposure is performed in air. The dose rate for this irradiator in this configuration ranges from <1rad(Si)/s to a maximum of approximately 300rad(Si)/s, determined by the distance from the source. For high-dose rate experiments the bias boards are placed in a radial fashion equidistant from the raised Co-60 rods with the distance adjusted to provide the required dose rate. The irradiator calibration is maintained by Radiation Test Solutions Longmire Laboratories using air ionization chamber (AIC) equipment calibrated with traceability to the National Institute of Standards and Technology (NIST). Figure 2.1 shows a photograph of the JLSA 81-24 Co-60 irradiator at Radiation Test Solutions' Longmire Laboratory facility.



Figure 2.1. Radiation Test Solutions' high dose rate Co-60 irradiator. The dose rate is obtained by positioning the device-under-test at a fixed distance from the gamma cell. The dose rate for this irradiator varies from approximately 300rad(Si)/s close to the rods down to 1rad(Si)/s at a distance of approximately 2-feet.

3.0. Radiation Test Conditions

The RH1011W Voltage Comparator described in this final report were irradiated with ionizing radiation under 2 different bias conditions; biased using a split 12V supply and unbiased with all pins tied to ground. See Appendix B for details on the biasing conditions during radiation exposure. In our opinion, this bias circuit satisfies the requirements of MIL-STD-883 TM1019 Section 3.9.3 Bias and Loading Conditions which states "The bias applied to the test devices shall be selected to produce the greatest radiation induced damage or the worst-case damage for the intended application, if known. While maximum voltage is often worst case some bipolar linear device parameters (e.g. input bias current or maximum output load current) exhibit more degradation with 0 V bias."

The devices were irradiated to a maximum total ionizing dose level of 200krad(Si) with incremental measurements at 20krad(Si), 50krad(Si) and 100krad(Si). Electrical testing occurred within one hour following the end of each irradiation segment. For intermediate irradiations, the parts were tested and returned to total dose exposure within two hours from the end of the previous radiation increment.

The TID bias board was positioned in the Co-60 cell to provide the required minimum of 50rad(Si)/s and was located inside a lead-aluminum enclosure. The lead-aluminum enclosure is required under MIL-STD-883 TM1019 Section 3.4 that reads as follows: "Lead/Aluminum (Pb/Al) container. Test specimens shall be enclosed in a Pb/Al container to minimize dose enhancement effects caused by low-energy, scattered radiation. A minimum of 1.5 mm Pb, surrounding an inner shield of at least 0.7 mm Al, is required. This Pb/Al container produces an approximate charged particle equilibrium for Si and for TLDs such as CaF₂. The radiation field intensity shall be measured inside the Pb/Al container (1) initially, (2) when the source is changed, or (3) when the orientation or configuration of the source, container, or test-fixture is changed. This measurement shall be performed by placing a dosimeter (e.g., a TLD) in the device-irradiation container at the approximate test-device position. If it can be demonstrated that low energy scattered radiation is small enough that it will not cause dosimetry errors due to dose enhancement, the Pb/Al container may be omitted."

The final dose rate within the high dose rate lead-aluminum enclosure was determined using calibration calculations based on air ionization chamber (AIC) dosimetry performed just prior to beginning the total dose irradiations. The final dose rate for this work was 51.55rad(Si)/s with a precision of $\pm 5\%$.

4.0. Tested Parameters

During the HDR/TID radiation testing the following electrical parameters were measured pre- and post-irradiation:

1. Pos Supply Current (A) @ $V_S = \pm 15V$
2. Neg Supply Current (A) @ $V_S = \pm 15V$
3. Input Offset Voltage (V) @ $V_S = \pm 15V$, $V_O = 0$, $I_{SINK} = 1.5mA$
4. Input Offset Current (A) @ $V_S = \pm 15V$, $V_O = 0$, $I_{SINK} = 1.5mA$
5. Pos Input Bias Current (A) @ $V_S = \pm 15V$, $V_O = 0$, $I_{SINK} = 1.5mA$
6. Neg Input Bias Current (A) @ $V_S = \pm 15V$, $V_O = 0$, $I_{SINK} = 1.5mA$
7. Large Signal Voltage Gain (V/mV) @ $V_S = \pm 15V$, $R_L = 1kW$, $-10V < V_O < 14.5V$
8. Common Mode Rejection Ratio (dB) @ $V_{CM} = -14.5V$ to $13V$
9. Strobe Current (A) @ $V_{GND} = 0$
10. Output Saturation Voltage 1 (V) @ $V_S = \pm 15V$, $V_{IN} = -5mV$, $I_{SINK} = 8mA$
11. Output Saturation Voltage 2 (V) @ $V_S = \pm 15V$, $V_{IN} = -5mV$, $I_{SINK} = 50mA$
12. Output Leakage Current (A) @ $V_S = \pm 15V$, $V_{IN} = 5mV$, $V_{GND} = -15V$, $V_O = 20V$

Appendix C details the measured parameters, test conditions, pre-irradiation specification and measurement resolution for each of the measurements.

The parametric data was obtained as "read and record" and all the raw data plus an attributes summary are contained in this report as well as in a separate Excel file. The attributes data contains the average, standard deviation and the average with the KTL values applied. The KTL value used in this work is 2.742 per MIL-HDBK-814 using one sided tolerance limits of 90/90 and a 5-piece sample size. The 90/90 KTL values were selected to match the statistical levels specified in the MIL-PRF-38535 sampling plan for the qualification of a radiation hardness assured (RHA) component. Note that the following criteria must be met for a device to pass the high dose rate test: following the radiation exposure each of the 5 pieces irradiated under electrical bias shall pass the specification value. The units irradiated without electrical bias and the KTL statistics are included in this report for reference only. If any of the 5 pieces irradiated under electrical bias exceed the device post radiation data sheet specification limits, then the lot could be logged as a failure.

5.0. HDR-TID Test Results

Based on this criterion the RH1011W Voltage Comparator (from the lot traceability information provided on the first page of this test report) PASSED the high dose rate total ionizing dose test to the maximum tested dose level of 200krad(Si) with all parameters remaining within their datasheet specifications.

Figures 5.1 through 5. 12 show plots of all the measured parameters versus total ionizing dose while Tables 5.1 - 5. 12 show the corresponding raw data for each of these parameters. In the data plots the solid diamonds are the average of the measured data points for the sample irradiated under electrical bias while the shaded diamonds are the average of the measured data points for the units irradiated with all pins tied to ground. The black lines (solid or dashed) are the upper and/or lower confidence limits, as determined by KTL statistics, on the sample irradiated in the biased condition while the shaded lines (solid or dashed) are the upper and/or lower confidence limits, as determined by KTL statistics, on the sample irradiated in the unbiased condition. The red dotted line(s) are the pre- and/or post-irradiation minimum and/or maximum specification value as defined in the datasheet and/or test plan.

The control units, as expected, show no significant changes to any of the parameters. Therefore we can conclude that the electrical testing remained in control throughout the duration of the tests and the observed degradation was due to the radiation exposure. Appendix D lists the figures used in this section to facilitate the location of a particular parameter.

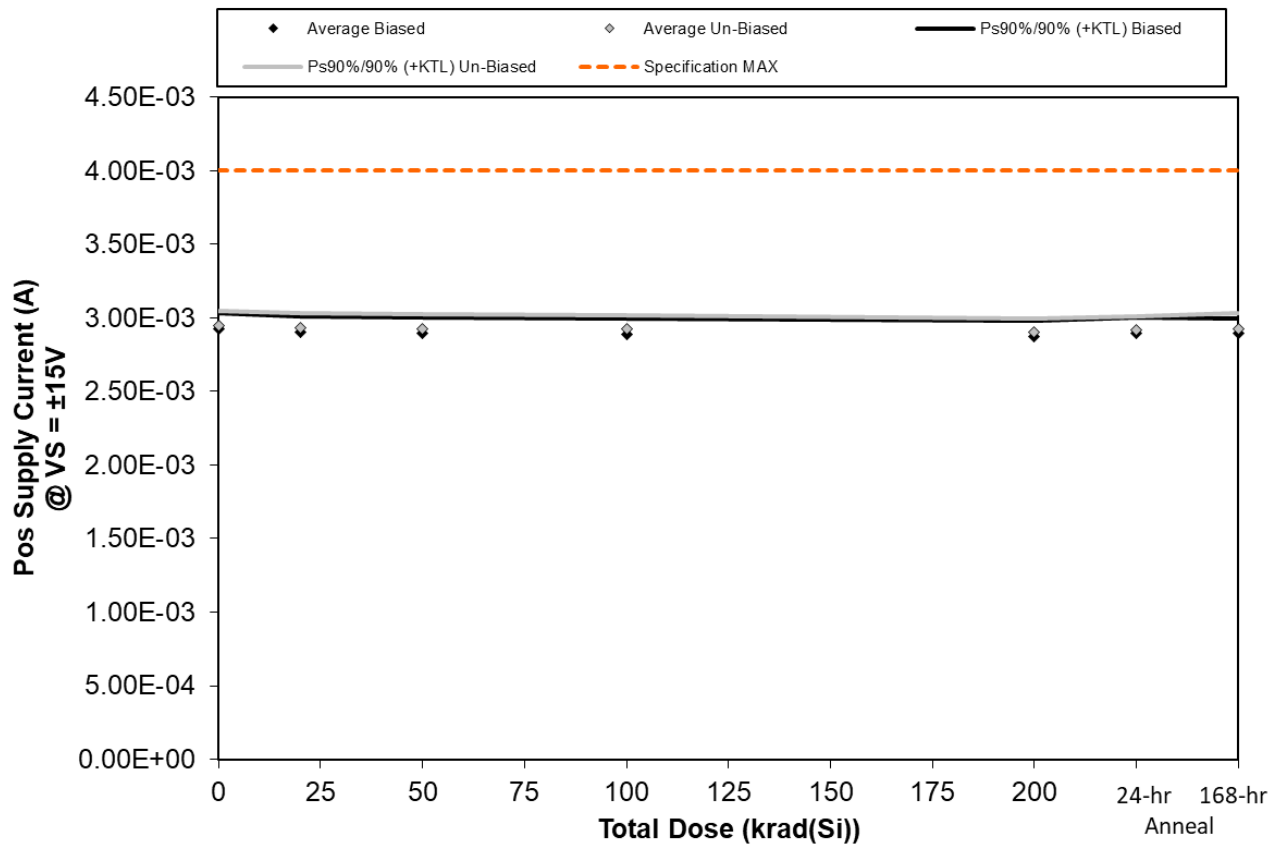


Figure 5.1. Plot of Pos Supply Current (A) @ VS = ±15V versus total dose. The solid diamonds are the average of the measured data points for the samples irradiated under electrical bias while the shaded diamonds are the average of the measured data points for the samples irradiated with all pins tied to ground. The black lines (solid and/or dashed) are the upper and/or lower confidence limits, as determined by KTL statistics, on the samples irradiated under electrical bias while the gray lines (solid and/or dashed) are the upper and/or lower confidence limits, as determined by KTL statistics, on the samples irradiated in the unbiased condition. The red dotted line(s) are the pre- and/or post-irradiation minimum and/or maximum specification value as defined in the datasheet and/or test plan.

Table 5.1. Raw data for Pos Supply Current (A) @ VS = ±15V versus total dose, including the statistical analysis, specification and the status of the testing (pass/fail).

Pos Supply Current (A) @ VS = ±15V	Total Dose (krad(Si))					24-hr Anneal	168-hr Anneal
Device	0	20	50	100	200		
1648	2.90E-03	2.88E-03	2.87E-03	2.87E-03	2.83E-03	2.87E-03	2.88E-03
1649	2.98E-03	2.96E-03	2.96E-03	2.95E-03	2.93E-03	2.95E-03	2.95E-03
1650	2.91E-03	2.89E-03	2.88E-03	2.88E-03	2.86E-03	2.88E-03	2.88E-03
1651	2.88E-03	2.87E-03	2.86E-03	2.85E-03	2.84E-03	2.85E-03	2.86E-03
1652	2.94E-03	2.92E-03	2.91E-03	2.90E-03	2.89E-03	2.91E-03	2.91E-03
1653	2.97E-03	2.96E-03	2.95E-03	2.94E-03	2.92E-03	2.94E-03	2.95E-03
1654	2.91E-03	2.89E-03	2.89E-03	2.88E-03	2.87E-03	2.88E-03	2.87E-03
1655	2.92E-03	2.90E-03	2.90E-03	2.89E-03	2.87E-03	2.89E-03	2.89E-03
1656	2.99E-03	2.97E-03	2.96E-03	2.96E-03	2.94E-03	2.95E-03	2.96E-03
1657	2.97E-03	2.95E-03	2.95E-03	2.94E-03	2.92E-03	2.93E-03	2.94E-03
1658	3.01E-03	3.00E-03	3.01E-03	3.01E-03	3.01E-03	3.01E-03	3.01E-03
1659	2.98E-03	2.97E-03	2.98E-03	2.98E-03	2.98E-03	2.98E-03	2.98E-03
Biased Statistics							
Average Biased	2.92E-03	2.90E-03	2.90E-03	2.89E-03	2.87E-03	2.89E-03	2.90E-03
Std Dev Biased	3.92E-05	3.72E-05	3.79E-05	3.82E-05	4.07E-05	4.08E-05	3.59E-05
Ps90%/90% (+KTL) Biased	3.03E-03	3.01E-03	3.00E-03	2.99E-03	2.98E-03	3.00E-03	2.99E-03
Ps90%/90% (-KTL) Biased	2.81E-03	2.80E-03	2.79E-03	2.78E-03	2.76E-03	2.78E-03	2.80E-03
Un-Biased Statistics							
Average Un-Biased	2.95E-03	2.93E-03	2.93E-03	2.92E-03	2.90E-03	2.92E-03	2.92E-03
Std Dev Un-Biased	3.53E-05	3.60E-05	3.41E-05	3.47E-05	3.19E-05	3.33E-05	3.87E-05
Ps90%/90% (+KTL) Un-Biased	3.05E-03	3.03E-03	3.02E-03	3.02E-03	2.99E-03	3.01E-03	3.03E-03
Ps90%/90% (-KTL) Un-Biased	2.85E-03	2.84E-03	2.83E-03	2.83E-03	2.82E-03	2.83E-03	2.82E-03
Specification MAX	4.00E-03	4.00E-03	4.00E-03	4.00E-03	4.00E-03	4.00E-03	4.00E-03
Status	PASS	PASS	PASS	PASS	PASS	PASS	PASS

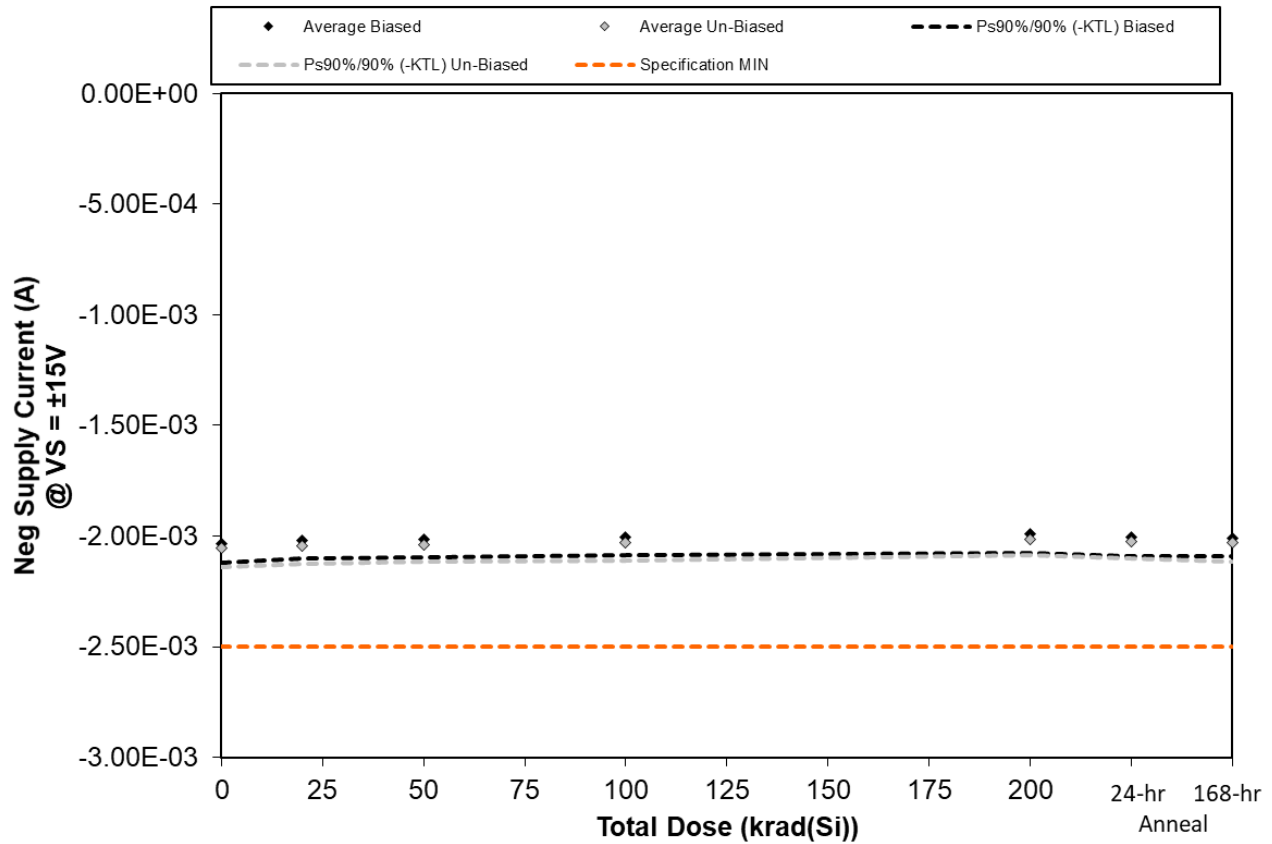


Figure 5.2. Plot of Neg Supply Current (A) @ VS = ±15V versus total dose. The solid diamonds are the average of the measured data points for the samples irradiated under electrical bias while the shaded diamonds are the average of the measured data points for the samples irradiated with all pins tied to ground. The black lines (solid and/or dashed) are the upper and/or lower confidence limits, as determined by KTL statistics, on the samples irradiated under electrical bias while the gray lines (solid and/or dashed) are the upper and/or lower confidence limits, as determined by KTL statistics, on the samples irradiated in the unbiased condition. The red dotted line(s) are the pre- and/or post-irradiation minimum and/or maximum specification value as defined in the datasheet and/or test plan.

Table 5.2. Raw data for Neg Supply Current (A) @ VS = ±15V versus total dose, including the statistical analysis, specification and the status of the testing (pass/fail).

Neg Supply Current (A) @ VS = ±15V	Total Dose (krad(Si))					24-hr Anneal	168-hr Anneal
Device	0	20	50	100	200		
1648	-2.01E-03	-2.00E-03	-1.99E-03	-1.99E-03	-1.96E-03	-1.99E-03	-1.99E-03
1649	-2.08E-03	-2.07E-03	-2.06E-03	-2.05E-03	-2.04E-03	-2.05E-03	-2.05E-03
1650	-2.02E-03	-2.01E-03	-2.00E-03	-1.99E-03	-1.98E-03	-1.99E-03	-2.00E-03
1651	-2.00E-03	-1.99E-03	-1.99E-03	-1.97E-03	-1.97E-03	-1.97E-03	-1.98E-03
1652	-2.05E-03	-2.03E-03	-2.03E-03	-2.02E-03	-2.01E-03	-2.02E-03	-2.02E-03
1653	-2.08E-03	-2.06E-03	-2.06E-03	-2.05E-03	-2.03E-03	-2.04E-03	-2.05E-03
1654	-2.02E-03	-2.01E-03	-2.00E-03	-1.99E-03	-1.98E-03	-1.99E-03	-1.99E-03
1655	-2.03E-03	-2.02E-03	-2.01E-03	-2.01E-03	-1.99E-03	-2.00E-03	-2.01E-03
1656	-2.09E-03	-2.08E-03	-2.07E-03	-2.06E-03	-2.04E-03	-2.05E-03	-2.06E-03
1657	-2.07E-03	-2.06E-03	-2.05E-03	-2.04E-03	-2.02E-03	-2.03E-03	-2.04E-03
1658	-2.11E-03	-2.10E-03	-2.11E-03	-2.11E-03	-2.11E-03	-2.11E-03	-2.11E-03
1659	-2.08E-03	-2.08E-03	-2.08E-03	-2.08E-03	-2.08E-03	-2.08E-03	-2.08E-03
Biased Statistics							
Average Biased	-2.03E-03	-2.02E-03	-2.01E-03	-2.00E-03	-1.99E-03	-2.00E-03	-2.01E-03
Std Dev Biased	3.20E-05	3.03E-05	3.05E-05	3.06E-05	3.17E-05	3.16E-05	2.92E-05
Ps90%/90% (+KTL) Biased	-1.94E-03	-1.94E-03	-1.93E-03	-1.92E-03	-1.90E-03	-1.92E-03	-1.93E-03
Ps90%/90% (-KTL) Biased	-2.12E-03	-2.10E-03	-2.10E-03	-2.09E-03	-2.08E-03	-2.09E-03	-2.09E-03
Un-Biased Statistics							
Average Un-Biased	-2.06E-03	-2.04E-03	-2.04E-03	-2.03E-03	-2.01E-03	-2.02E-03	-2.03E-03
Std Dev Un-Biased	3.02E-05	3.03E-05	2.81E-05	2.90E-05	2.69E-05	2.79E-05	3.08E-05
Ps90%/90% (+KTL) Un-Biased	-1.97E-03	-1.96E-03	-1.96E-03	-1.95E-03	-1.94E-03	-1.95E-03	-1.95E-03
Ps90%/90% (-KTL) Un-Biased	-2.14E-03	-2.13E-03	-2.11E-03	-2.11E-03	-2.09E-03	-2.10E-03	-2.12E-03
Specification MIN	-2.50E-03	-2.50E-03	-2.50E-03	-2.50E-03	-2.50E-03	-2.50E-03	-2.50E-03
Status	PASS	PASS	PASS	PASS	PASS	PASS	PASS

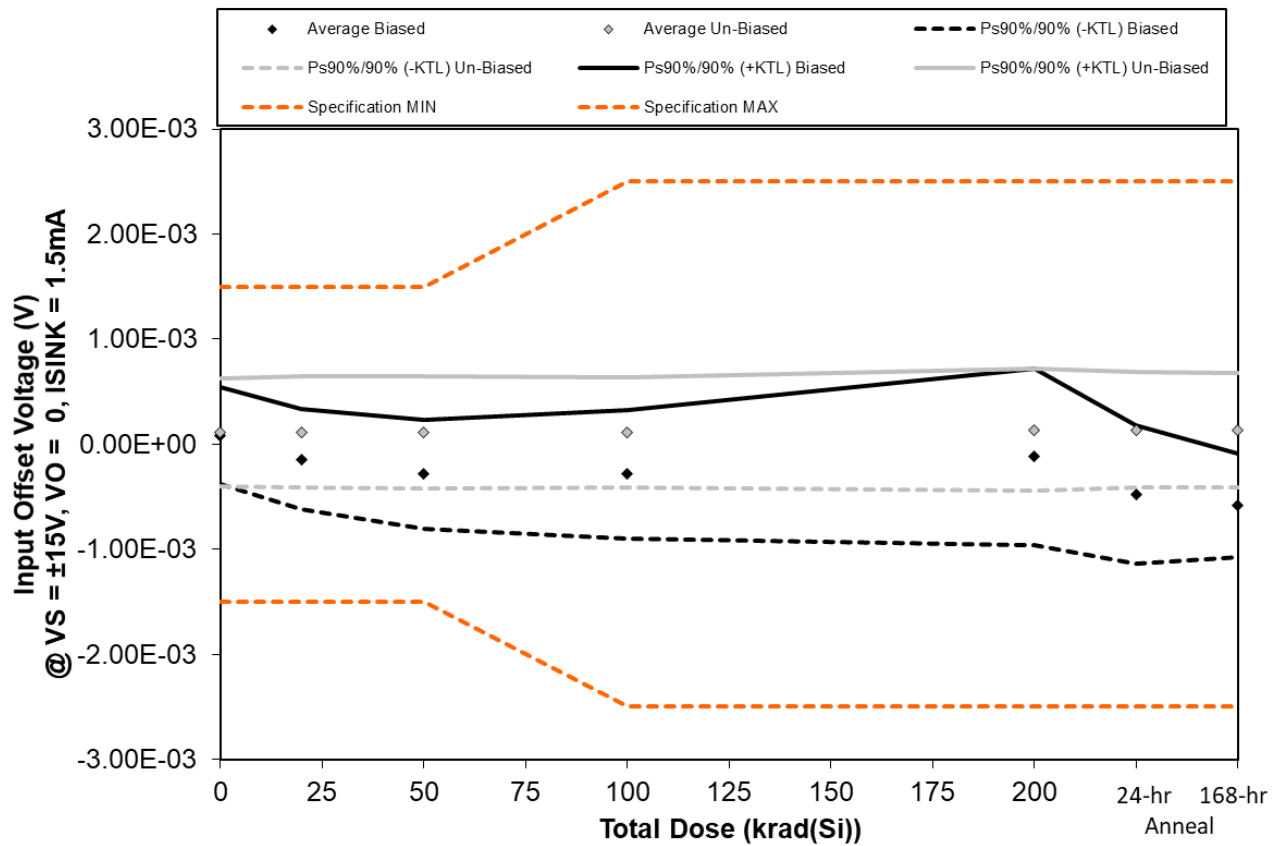


Figure 5.3. Plot of Input Offset Voltage (V) @ VS = ±15V, VO = 0, ISINK = 1.5mA versus total dose. The solid diamonds are the average of the measured data points for the samples irradiated under electrical bias while the shaded diamonds are the average of the measured data points for the samples irradiated with all pins tied to ground. The black lines (solid and/or dashed) are the upper and/or lower confidence limits, as determined by KTL statistics, on the samples irradiated under electrical bias while the gray lines (solid and/or dashed) are the upper and/or lower confidence limits, as determined by KTL statistics, on the samples irradiated in the unbiased condition. The red dotted line(s) are the pre- and/or post-irradiation minimum and/or maximum specification value as defined in the datasheet and/or test plan.

Table 5.3. Raw data for Input Offset Voltage (V) @ VS = ±15V, VO = 0, ISINK = 1.5mA versus total dose, including the statistical analysis, specification and the status of the testing (pass/fail).

Input Offset Voltage (V) @ VS = ±15V, VO = 0, ISINK = 1.5mA	Total Dose (krad(Si))					24-hr Anneal	168-hr Anneal
	0	20	50	100	200		
Device							
1648	2.81E-04	4.40E-05	-7.90E-05	-3.20E-05	2.35E-04	-2.09E-04	-3.55E-04
1649	-1.43E-04	-3.95E-04	-5.59E-04	-6.18E-04	-5.85E-04	-8.45E-04	-8.26E-04
1650	5.30E-05	-1.65E-04	-3.11E-04	-3.29E-04	-2.06E-04	-5.40E-04	-6.31E-04
1651	1.90E-05	-2.03E-04	-3.32E-04	-3.17E-04	-5.70E-05	-4.73E-04	-6.38E-04
1652	2.15E-04	-8.00E-06	-1.38E-04	-1.31E-04	2.50E-05	-3.34E-04	-4.70E-04
1653	1.29E-04	1.22E-04	1.27E-04	1.26E-04	1.04E-04	1.13E-04	1.30E-04
1654	2.20E-05	2.60E-05	9.00E-06	2.70E-05	3.90E-05	6.30E-05	5.50E-05
1655	-1.13E-04	-1.02E-04	-9.20E-05	-9.50E-05	-7.40E-05	-7.30E-05	-8.50E-05
1656	1.25E-04	1.15E-04	1.05E-04	8.60E-05	1.16E-04	1.11E-04	1.26E-04
1657	4.00E-04	4.20E-04	4.27E-04	4.16E-04	4.88E-04	4.72E-04	4.57E-04
1658	1.90E-05	2.00E-05	1.60E-05	2.00E-05	1.70E-05	1.80E-05	1.90E-05
1659	-2.91E-04	-2.90E-04	-2.88E-04	-2.87E-04	-2.90E-04	-2.85E-04	-2.89E-04
Biased Statistics							
Average Biased	8.50E-05	-1.45E-04	-2.84E-04	-2.85E-04	-1.18E-04	-4.80E-04	-5.84E-04
Std Dev Biased	1.68E-04	1.74E-04	1.88E-04	2.24E-04	3.06E-04	2.41E-04	1.80E-04
Ps90%/90% (+KTL) Biased	5.45E-04	3.31E-04	2.33E-04	3.30E-04	7.22E-04	1.80E-04	-9.13E-05
Ps90%/90% (-KTL) Biased	-3.75E-04	-6.22E-04	-8.00E-04	-9.01E-04	-9.57E-04	-1.14E-03	-1.08E-03
Un-Biased Statistics							
Average Un-Biased	1.13E-04	1.16E-04	1.15E-04	1.12E-04	1.35E-04	1.37E-04	1.37E-04
Std Dev Un-Biased	1.88E-04	1.92E-04	1.95E-04	1.89E-04	2.11E-04	2.02E-04	1.99E-04
Ps90%/90% (+KTL) Un-Biased	6.29E-04	6.44E-04	6.49E-04	6.31E-04	7.14E-04	6.91E-04	6.83E-04
Ps90%/90% (-KTL) Un-Biased	-4.04E-04	-4.11E-04	-4.19E-04	-4.07E-04	-4.45E-04	-4.16E-04	-4.09E-04
Specification MIN	-1.50E-03	-1.50E-03	-1.50E-03	-2.50E-03	-2.50E-03	-2.50E-03	-2.50E-03
Status	PASS	PASS	PASS	PASS	PASS	PASS	PASS
Specification MAX	1.50E-03	1.50E-03	1.50E-03	2.50E-03	2.50E-03	2.50E-03	2.50E-03
Status	PASS	PASS	PASS	PASS	PASS	PASS	PASS

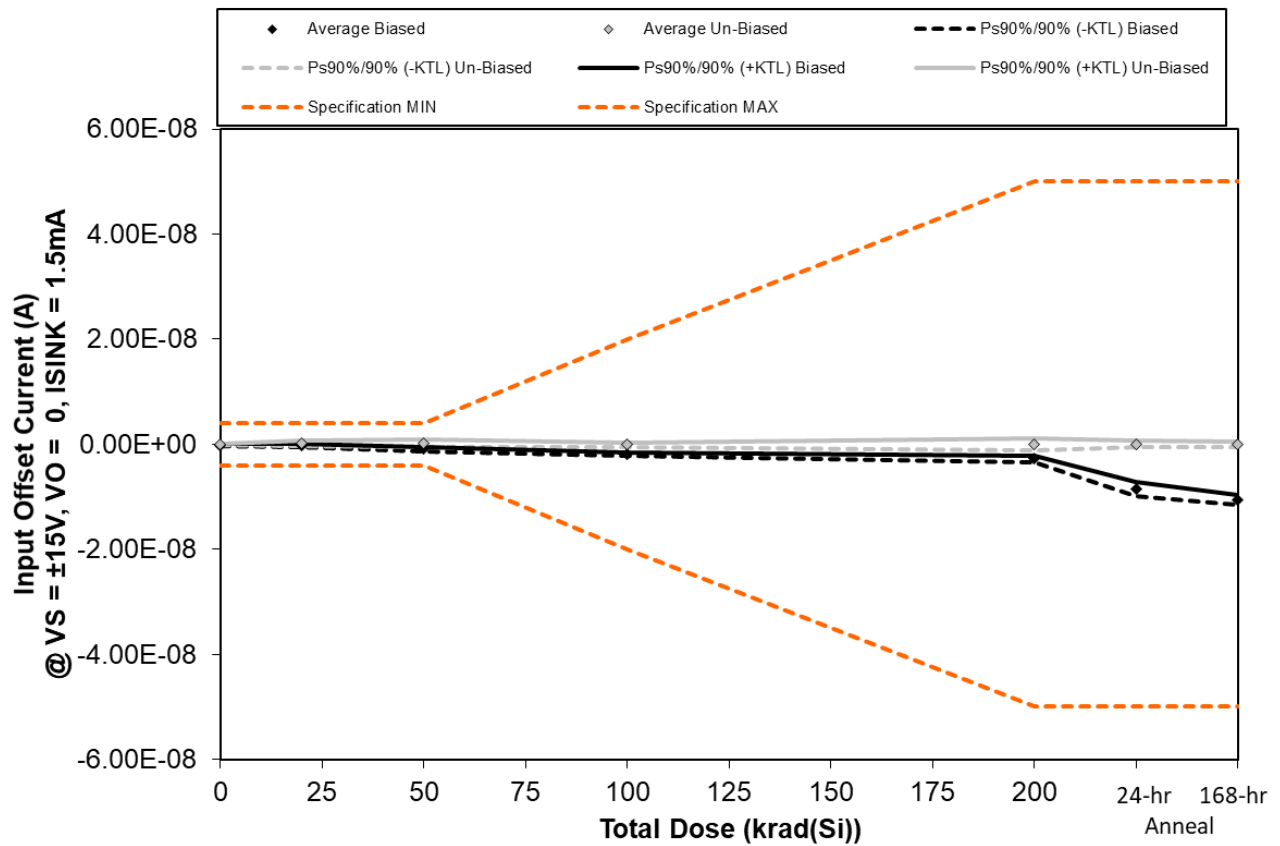


Figure 5.4. Plot of Input Offset Current (A) @ $V_S = \pm 15V$, $V_O = 0$, $I_{SINK} = 1.5mA$ versus total dose. The solid diamonds are the average of the measured data points for the samples irradiated under electrical bias while the shaded diamonds are the average of the measured data points for the samples irradiated with all pins tied to ground. The black lines (solid and/or dashed) are the upper and/or lower confidence limits, as determined by KTL statistics, on the samples irradiated under electrical bias while the gray lines (solid and/or dashed) are the upper and/or lower confidence limits, as determined by KTL statistics, on the samples irradiated in the unbiased condition. The red dotted line(s) are the pre- and/or post-irradiation minimum and/or maximum specification value as defined in the datasheet and/or test plan.

Table 5.4. Raw data for Input Offset Current (A) @ VS = ±15V, VO = 0, ISINK = 1.5mA versus total dose, including the statistical analysis, specification and the status of the testing (pass/fail).

Input Offset Current (A) @ VS = ±15V, VO = 0, ISINK = 1.5mA	Total Dose (krad(Si))					24-hr Anneal	168-hr Anneal
Device	0	20	50	100	200		
1648	-1.70E-10	-2.50E-10	-1.03E-09	-1.85E-09	-2.57E-09	-7.67E-09	-1.03E-08
1649	-2.00E-10	-1.50E-10	-1.04E-09	-1.74E-09	-2.54E-09	-8.61E-09	-1.12E-08
1650	-1.50E-10	-4.40E-10	-7.10E-10	-1.79E-09	-2.85E-09	-8.61E-09	-1.06E-08
1651	-3.20E-10	-3.10E-10	-8.30E-10	-1.99E-09	-3.07E-09	-8.87E-09	-1.03E-08
1652	-1.00E-10	-2.40E-10	-1.00E-09	-1.97E-09	-2.85E-09	-8.89E-09	-1.07E-08
1653	-5.00E-11	2.00E-10	5.50E-10	4.00E-11	4.40E-10	4.00E-11	1.20E-10
1654	-6.00E-11	2.00E-11	7.00E-11	2.00E-11	3.10E-10	-9.00E-11	-1.30E-10
1655	-4.00E-11	-1.30E-10	-1.70E-10	-2.20E-10	-6.40E-10	-1.80E-10	-2.20E-10
1656	-2.00E-11	1.40E-10	0.00E+00	8.00E-11	-1.20E-10	3.10E-10	3.00E-11
1657	-1.00E-10	3.30E-10	1.70E-10	-2.30E-10	0.00E+00	1.80E-10	2.50E-10
1658	-5.00E-11	-6.00E-11	2.00E-11	0.00E+00	-3.00E-11	-3.00E-11	-3.00E-11
1659	-1.40E-10	-1.40E-10	-1.10E-10	-7.00E-11	-1.20E-10	-1.10E-10	-1.20E-10
Biased Statistics							
Average Biased	-1.88E-10	-2.78E-10	-9.22E-10	-1.87E-09	-2.78E-09	-8.53E-09	-1.06E-08
Std Dev Biased	8.23E-11	1.07E-10	1.46E-10	1.10E-10	2.21E-10	4.99E-10	3.55E-10
Ps90%/90% (+KTL) Biased	3.76E-11	1.57E-11	-5.22E-10	-1.57E-09	-2.17E-09	-7.16E-09	-9.62E-09
Ps90%/90% (-KTL) Biased	-4.14E-10	-5.72E-10	-1.32E-09	-2.17E-09	-3.38E-09	-9.90E-09	-1.16E-08
Un-Biased Statistics							
Average Un-Biased	-5.40E-11	1.12E-10	1.24E-10	-6.20E-11	-2.00E-12	5.20E-11	1.00E-11
Std Dev Un-Biased	2.97E-11	1.75E-10	2.68E-10	1.50E-10	4.22E-10	1.98E-10	1.89E-10
Ps90%/90% (+KTL) Un-Biased	2.73E-11	5.93E-10	8.60E-10	3.50E-10	1.16E-09	5.95E-10	5.28E-10
Ps90%/90% (-KTL) Un-Biased	-1.35E-10	-3.69E-10	-6.12E-10	-4.74E-10	-1.16E-09	-4.91E-10	-5.08E-10
Specification MIN	-4.00E-09	-4.00E-09	-4.00E-09	-2.00E-08	-5.00E-08	-5.00E-08	-5.00E-08
Status	PASS	PASS	PASS	PASS	PASS	PASS	PASS
Specification MAX	4.00E-09	4.00E-09	4.00E-09	2.00E-08	5.00E-08	5.00E-08	5.00E-08
Status	PASS	PASS	PASS	PASS	PASS	PASS	PASS

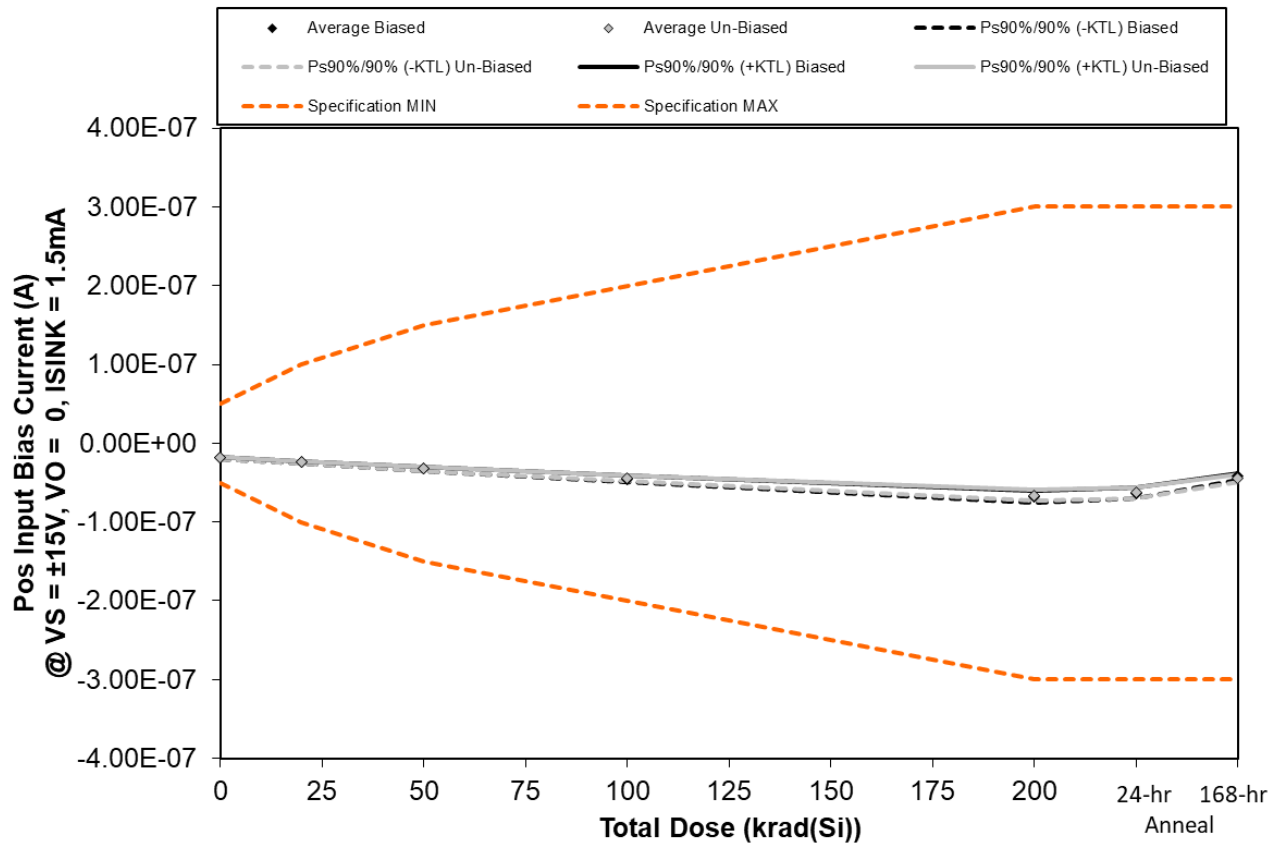


Figure 5.5. Plot of Pos Input Bias Current (A) @ VS = ±15V, VO = 0, ISINK = 1.5mA versus total dose. The solid diamonds are the average of the measured data points for the samples irradiated under electrical bias while the shaded diamonds are the average of the measured data points for the samples irradiated with all pins tied to ground. The black lines (solid and/or dashed) are the upper and/or lower confidence limits, as determined by KTL statistics, on the samples irradiated under electrical bias while the gray lines (solid and/or dashed) are the upper and/or lower confidence limits, as determined by KTL statistics, on the samples irradiated in the unbiased condition. The red dotted line(s) are the pre- and/or post-irradiation minimum and/or maximum specification value as defined in the datasheet and/or test plan.

Table 5.5. Raw data for Pos Input Bias Current (A) @ VS = ±15V, VO = 0, ISINK = 1.5mA versus total dose, including the statistical analysis, specification and the status of the testing (pass/fail).

Pos Input Bias Current (A) @ VS = ±15V, VO = 0, ISINK = 1.5mA	Total Dose (krad(Si))					24-hr Anneal	168-hr Anneal
Device	0	20	50	100	200		
1648	-1.83E-08	-2.36E-08	-3.18E-08	-4.45E-08	-6.64E-08	-6.21E-08	-4.16E-08
1649	-1.82E-08	-2.42E-08	-3.37E-08	-4.81E-08	-7.26E-08	-6.76E-08	-4.51E-08
1650	-1.88E-08	-2.42E-08	-3.23E-08	-4.45E-08	-6.67E-08	-6.16E-08	-4.16E-08
1651	-1.87E-08	-2.36E-08	-3.20E-08	-4.41E-08	-6.60E-08	-6.07E-08	-4.09E-08
1652	-1.91E-08	-2.46E-08	-3.33E-08	-4.57E-08	-6.87E-08	-6.37E-08	-4.27E-08
1653	-1.93E-08	-2.43E-08	-3.30E-08	-4.51E-08	-6.57E-08	-6.20E-08	-4.44E-08
1654	-1.88E-08	-2.39E-08	-3.19E-08	-4.35E-08	-6.47E-08	-6.07E-08	-4.22E-08
1655	-1.86E-08	-2.38E-08	-3.15E-08	-4.33E-08	-6.37E-08	-6.05E-08	-4.29E-08
1656	-1.92E-08	-2.47E-08	-3.40E-08	-4.67E-08	-7.01E-08	-6.64E-08	-4.70E-08
1657	-1.81E-08	-2.35E-08	-3.22E-08	-4.46E-08	-6.75E-08	-6.39E-08	-4.50E-08
1658	-1.99E-08	-1.99E-08	-1.98E-08	-1.98E-08	-1.99E-08	-1.99E-08	-1.99E-08
1659	-1.93E-08	-1.93E-08	-1.94E-08	-1.93E-08	-1.94E-08	-1.95E-08	-1.94E-08
Biased Statistics							
Average Biased	-1.86E-08	-2.40E-08	-3.26E-08	-4.54E-08	-6.81E-08	-6.31E-08	-4.24E-08
Std Dev Biased	3.70E-10	4.34E-10	8.35E-10	1.63E-09	2.73E-09	2.72E-09	1.65E-09
Ps90%/90% (+KTL) Biased	-1.76E-08	-2.29E-08	-3.03E-08	-4.09E-08	-6.06E-08	-5.57E-08	-3.79E-08
Ps90%/90% (-KTL) Biased	-1.96E-08	-2.52E-08	-3.49E-08	-4.99E-08	-7.56E-08	-7.06E-08	-4.69E-08
Un-Biased Statistics							
Average Un-Biased	-1.88E-08	-2.40E-08	-3.25E-08	-4.46E-08	-6.63E-08	-6.27E-08	-4.43E-08
Std Dev Un-Biased	4.85E-10	4.67E-10	9.93E-10	1.37E-09	2.53E-09	2.47E-09	1.88E-09
Ps90%/90% (+KTL) Un-Biased	-1.75E-08	-2.28E-08	-2.98E-08	-4.09E-08	-5.94E-08	-5.59E-08	-3.91E-08
Ps90%/90% (-KTL) Un-Biased	-2.01E-08	-2.53E-08	-3.52E-08	-4.84E-08	-7.33E-08	-6.95E-08	-4.95E-08
Specification MIN	-5.00E-08	-1.00E-07	-1.50E-07	-2.00E-07	-3.00E-07	-3.00E-07	-3.00E-07
Status	PASS	PASS	PASS	PASS	PASS	PASS	PASS
Specification MAX	5.00E-08	1.00E-07	1.50E-07	2.00E-07	3.00E-07	3.00E-07	3.00E-07
Status	PASS	PASS	PASS	PASS	PASS	PASS	PASS

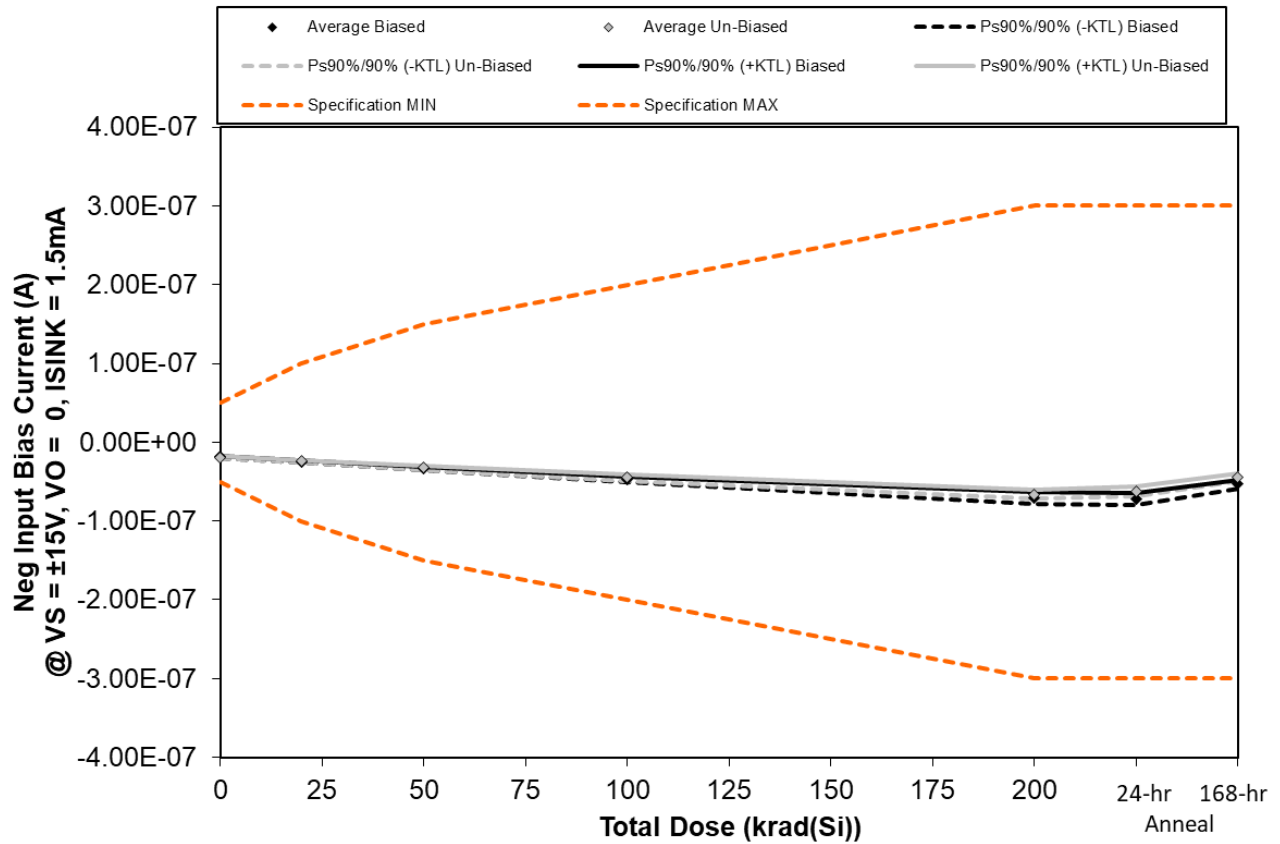


Figure 5.6. Plot of Neg Input Bias Current (A) @ VS = ±15V, VO = 0, ISINK = 1.5mA versus total dose. The solid diamonds are the average of the measured data points for the samples irradiated under electrical bias while the shaded diamonds are the average of the measured data points for the samples irradiated with all pins tied to ground. The black lines (solid and/or dashed) are the upper and/or lower confidence limits, as determined by KTL statistics, on the samples irradiated under electrical bias while the gray lines (solid and/or dashed) are the upper and/or lower confidence limits, as determined by KTL statistics, on the samples irradiated in the unbiased condition. The red dotted line(s) are the pre- and/or post-irradiation minimum and/or maximum specification value as defined in the datasheet and/or test plan.

Table 5.6. Raw data for Neg Input Bias Current (A) @ VS = ±15V, VO = 0, ISINK = 1.5mA versus total dose, including the statistical analysis, specification and the status of the testing (pass/fail).

Neg Input Bias Current (A) @ VS = ±15V, VO = 0, ISINK = 1.5mA	Total Dose (krad(Si))					24-hr Anneal	168-hr Anneal
	0	20	50	100	200		
Device							
1648	-1.84E-08	-2.39E-08	-3.28E-08	-4.65E-08	-6.94E-08	-7.01E-08	-5.17E-08
1649	-1.84E-08	-2.47E-08	-3.47E-08	-4.97E-08	-7.53E-08	-7.63E-08	-5.62E-08
1650	-1.92E-08	-2.45E-08	-3.34E-08	-4.63E-08	-6.95E-08	-7.04E-08	-5.23E-08
1651	-1.88E-08	-2.41E-08	-3.29E-08	-4.62E-08	-6.90E-08	-6.96E-08	-5.16E-08
1652	-1.92E-08	-2.50E-08	-3.43E-08	-4.75E-08	-7.17E-08	-7.25E-08	-5.37E-08
1653	-1.95E-08	-2.42E-08	-3.27E-08	-4.50E-08	-6.57E-08	-6.20E-08	-4.42E-08
1654	-1.91E-08	-2.41E-08	-3.19E-08	-4.37E-08	-6.49E-08	-6.07E-08	-4.29E-08
1655	-1.92E-08	-2.39E-08	-3.17E-08	-4.33E-08	-6.48E-08	-6.09E-08	-4.33E-08
1656	-1.92E-08	-2.47E-08	-3.39E-08	-4.75E-08	-6.96E-08	-6.59E-08	-4.71E-08
1657	-1.81E-08	-2.36E-08	-3.24E-08	-4.50E-08	-6.74E-08	-6.40E-08	-4.51E-08
1658	-1.99E-08	-1.99E-08	-1.99E-08	-1.98E-08	-1.98E-08	-2.00E-08	-1.99E-08
1659	-1.96E-08	-1.95E-08	-1.96E-08	-1.95E-08	-1.96E-08	-1.97E-08	-1.96E-08
Biased Statistics							
Average Biased	-1.88E-08	-2.44E-08	-3.36E-08	-4.72E-08	-7.10E-08	-7.18E-08	-5.31E-08
Std Dev Biased	4.00E-10	4.45E-10	8.47E-10	1.47E-09	2.64E-09	2.76E-09	1.92E-09
Ps90%/90% (+KTL) Biased	-1.77E-08	-2.32E-08	-3.13E-08	-4.32E-08	-6.38E-08	-6.42E-08	-4.78E-08
Ps90%/90% (-KTL) Biased	-1.99E-08	-2.57E-08	-3.59E-08	-5.13E-08	-7.82E-08	-7.93E-08	-5.84E-08
Un-Biased Statistics							
Average Un-Biased	-1.90E-08	-2.41E-08	-3.25E-08	-4.49E-08	-6.65E-08	-6.27E-08	-4.45E-08
Std Dev Un-Biased	5.36E-10	4.06E-10	8.67E-10	1.64E-09	2.03E-09	2.22E-09	1.67E-09
Ps90%/90% (+KTL) Un-Biased	-1.76E-08	-2.30E-08	-3.01E-08	-4.04E-08	-6.09E-08	-5.66E-08	-3.99E-08
Ps90%/90% (-KTL) Un-Biased	-2.05E-08	-2.52E-08	-3.49E-08	-4.94E-08	-7.21E-08	-6.88E-08	-4.91E-08
Specification MIN	-5.00E-08	-1.00E-07	-1.50E-07	-2.00E-07	-3.00E-07	-3.00E-07	-3.00E-07
Status	PASS	PASS	PASS	PASS	PASS	PASS	PASS
Specification MAX	5.00E-08	1.00E-07	1.50E-07	2.00E-07	3.00E-07	3.00E-07	3.00E-07
Status	PASS	PASS	PASS	PASS	PASS	PASS	PASS

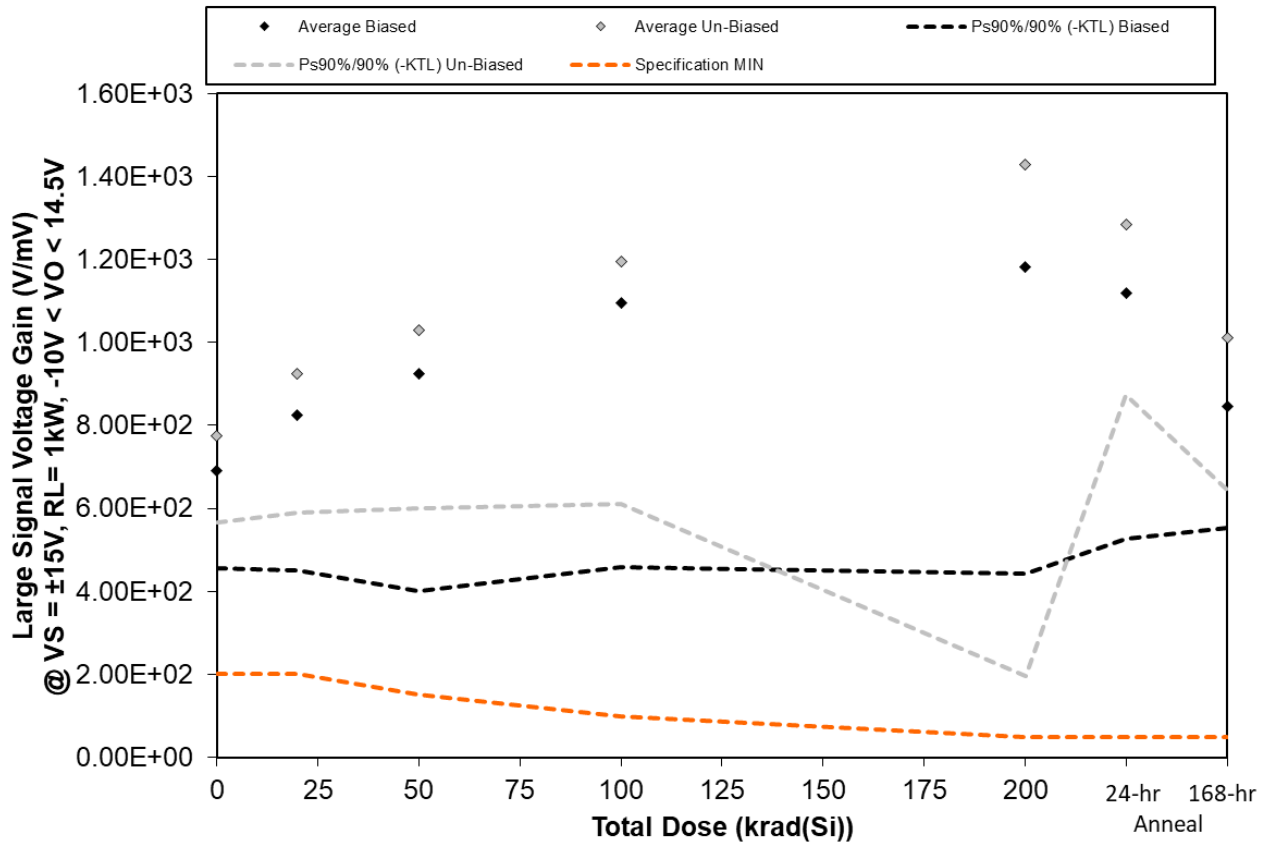


Figure 5.7. Plot of Large Signal Voltage Gain (V/mV) @ VS = ±15V, RL= 1kW, -10V < VO < 14.5V versus total dose. The solid diamonds are the average of the measured data points for the samples irradiated under electrical bias while the shaded diamonds are the average of the measured data points for the samples irradiated with all pins tied to ground. The black lines (solid and/or dashed) are the upper and/or lower confidence limits, as determined by KTL statistics, on the samples irradiated under electrical bias while the gray lines (solid and/or dashed) are the upper and/or lower confidence limits, as determined by KTL statistics, on the samples irradiated in the unbiased condition. The red dotted line(s) are the pre- and/or post-irradiation minimum and/or maximum specification value as defined in the datasheet and/or test plan.

Table 5.7. Raw data for Large Signal Voltage Gain (V/mV) @ VS = ±15V, RL= 1kW, -10V < VO < 14.5V versus total dose, including the statistical analysis, specification and the status of the testing (pass/fail).

Large Signal Voltage Gain (V/mV) @ VS = ±15V, RL= 1kW, -10V < VO < 14.5V	Total Dose (krad(Si))					24-hr Anneal	168-hr Anneal
	0	20	50	100	200		
Device							
1648	6.09E+02	6.98E+02	7.60E+02	9.43E+02	1.00E+03	9.05E+02	7.47E+02
1649	8.22E+02	1.06E+03	1.26E+03	1.51E+03	1.65E+03	1.47E+03	1.02E+03
1650	6.84E+02	7.87E+02	8.46E+02	1.04E+03	1.11E+03	1.10E+03	8.13E+02
1651	7.20E+02	7.98E+02	8.85E+02	1.00E+03	1.12E+03	1.14E+03	8.66E+02
1652	6.21E+02	7.80E+02	8.76E+02	9.86E+02	1.02E+03	9.82E+02	7.87E+02
1653	7.39E+02	9.40E+02	9.54E+02	1.17E+03	1.37E+03	1.22E+03	9.22E+02
1654	7.23E+02	7.78E+02	8.84E+02	9.91E+02	1.05E+03	1.15E+03	8.84E+02
1655	7.43E+02	8.43E+02	9.35E+02	1.07E+03	1.22E+03	1.18E+03	9.44E+02
1656	7.57E+02	9.66E+02	1.11E+03	1.20E+03	1.29E+03	1.37E+03	1.13E+03
1657	9.07E+02	1.10E+03	1.27E+03	1.54E+03	2.20E+03	1.51E+03	1.19E+03
1658	7.36E+02	7.30E+02	7.56E+02	7.21E+02	7.57E+02	7.59E+02	7.19E+02
1659	8.36E+02	8.44E+02	8.02E+02	7.63E+02	8.60E+02	8.77E+02	7.72E+02
Biased Statistics							
Average Biased	6.91E+02	8.24E+02	9.25E+02	1.10E+03	1.18E+03	1.12E+03	8.47E+02
Std Dev Biased	8.61E+01	1.36E+02	1.91E+02	2.33E+02	2.69E+02	2.15E+02	1.07E+02
Ps90%/90% (+KTL) Biased	9.27E+02	1.20E+03	1.45E+03	1.73E+03	1.92E+03	1.71E+03	1.14E+03
Ps90%/90% (-KTL) Biased	4.55E+02	4.51E+02	4.00E+02	4.58E+02	4.42E+02	5.27E+02	5.54E+02
Un-Biased Statistics							
Average Un-Biased	7.74E+02	9.25E+02	1.03E+03	1.19E+03	1.43E+03	1.28E+03	1.01E+03
Std Dev Un-Biased	7.55E+01	1.22E+02	1.57E+02	2.12E+02	4.49E+02	1.50E+02	1.34E+02
Ps90%/90% (+KTL) Un-Biased	9.81E+02	1.26E+03	1.46E+03	1.78E+03	2.66E+03	1.70E+03	1.38E+03
Ps90%/90% (-KTL) Un-Biased	5.67E+02	5.91E+02	6.01E+02	6.12E+02	1.96E+02	8.73E+02	6.44E+02
Specification MIN	2.00E+02	2.00E+02	1.50E+02	1.00E+02	5.00E+01	5.00E+01	5.00E+01
Status	PASS	PASS	PASS	PASS	PASS	PASS	PASS

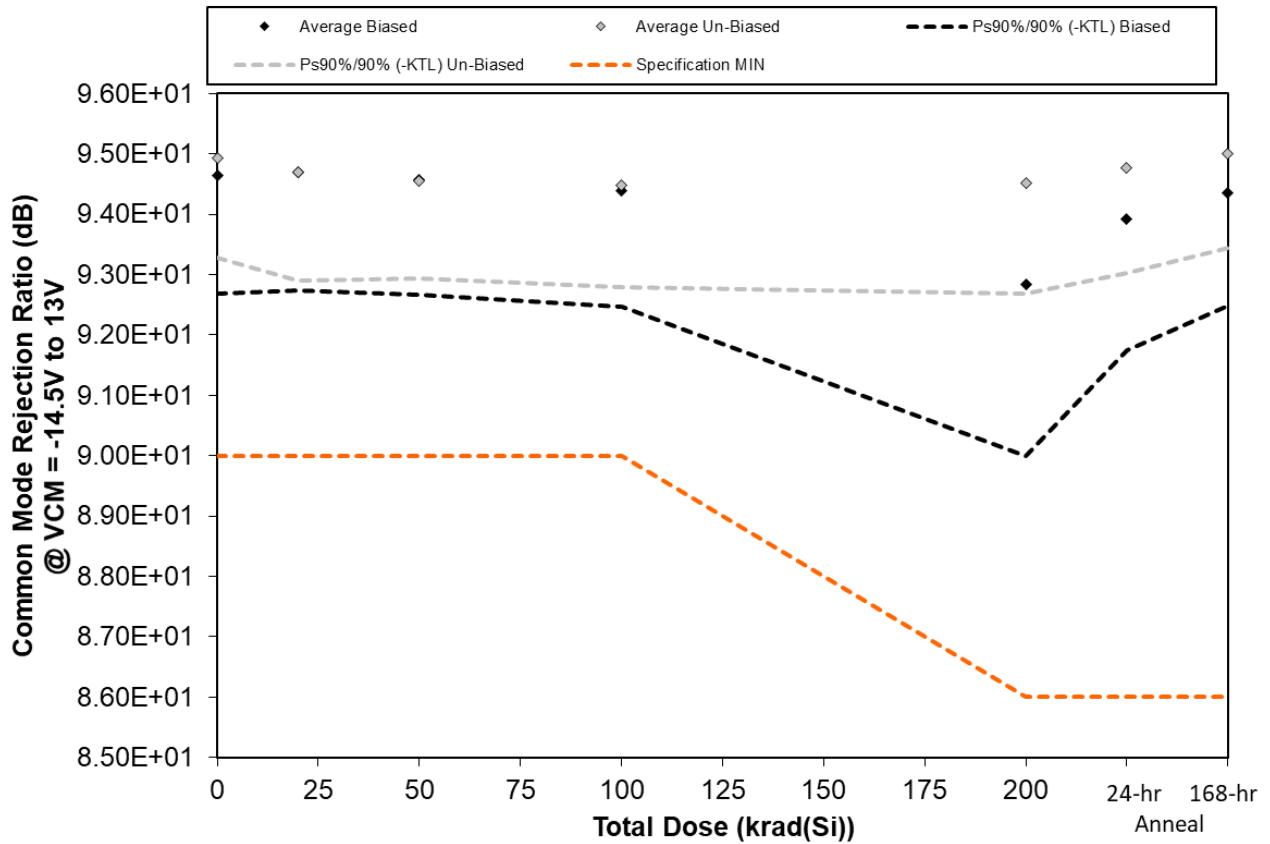


Figure 5.8. Plot of Common Mode Rejection Ratio (dB) @ VCM = -14.5V to 13V versus total dose. The solid diamonds are the average of the measured data points for the samples irradiated under electrical bias while the shaded diamonds are the average of the measured data points for the samples irradiated with all pins tied to ground. The black lines (solid and/or dashed) are the upper and/or lower confidence limits, as determined by KTL statistics, on the samples irradiated under electrical bias while the gray lines (solid and/or dashed) are the upper and/or lower confidence limits, as determined by KTL statistics, on the samples irradiated in the unbiased condition. The red dotted line(s) are the pre- and/or post-irradiation minimum and/or maximum specification value as defined in the datasheet and/or test plan.

Table 5.8. Raw data for Common Mode Rejection Ratio (dB) @ VCM = -14.5V to 13V versus total dose, including the statistical analysis, specification and the status of the testing (pass/fail).

Common Mode Rejection Ratio (dB) @ VCM = -14.5V to 13V		Total Dose (krad(Si))					24-hr Anneal	168-hr Anneal
Device		0	20	50	100	200		
1648	9.43E+01	9.43E+01	9.42E+01	9.39E+01	9.18E+01	9.32E+01	9.40E+01	
1649	9.50E+01	9.50E+01	9.49E+01	9.48E+01	9.42E+01	9.47E+01	9.48E+01	
1650	9.48E+01	9.49E+01	9.48E+01	9.46E+01	9.31E+01	9.42E+01	9.45E+01	
1651	9.56E+01	9.56E+01	9.54E+01	9.52E+01	9.32E+01	9.46E+01	9.51E+01	
1652	9.37E+01	9.37E+01	9.36E+01	9.35E+01	9.18E+01	9.30E+01	9.34E+01	
1653	9.46E+01	9.43E+01	9.41E+01	9.41E+01	9.38E+01	9.41E+01	9.45E+01	
1654	9.60E+01	9.58E+01	9.55E+01	9.55E+01	9.55E+01	9.58E+01	9.60E+01	
1655	9.50E+01	9.48E+01	9.48E+01	9.46E+01	9.48E+01	9.50E+01	9.50E+01	
1656	9.47E+01	9.44E+01	9.42E+01	9.42E+01	9.43E+01	9.46E+01	9.49E+01	
1657	9.44E+01	9.42E+01	9.41E+01	9.41E+01	9.42E+01	9.44E+01	9.46E+01	
1658	9.49E+01	9.48E+01	9.49E+01	9.49E+01	9.49E+01	9.49E+01	9.48E+01	
1659	9.46E+01	9.46E+01	9.46E+01	9.46E+01	9.46E+01	9.46E+01	9.46E+01	
Biased Statistics								
Average Biased	9.46E+01	9.47E+01	9.46E+01	9.44E+01	9.28E+01	9.39E+01	9.43E+01	
Std Dev Biased	7.13E-01	7.15E-01	6.93E-01	7.02E-01	1.03E+00	7.97E-01	6.76E-01	
Ps90%/90% (+KTL) Biased	9.66E+01	9.67E+01	9.65E+01	9.63E+01	9.57E+01	9.61E+01	9.62E+01	
Ps90%/90% (-KTL) Biased	9.27E+01	9.27E+01	9.27E+01	9.25E+01	9.00E+01	9.17E+01	9.25E+01	
Un-Biased Statistics								
Average Un-Biased	9.49E+01	9.47E+01	9.46E+01	9.45E+01	9.45E+01	9.48E+01	9.50E+01	
Std Dev Un-Biased	6.06E-01	6.55E-01	5.92E-01	6.17E-01	6.66E-01	6.36E-01	5.71E-01	
Ps90%/90% (+KTL) Un-Biased	9.66E+01	9.65E+01	9.62E+01	9.62E+01	9.63E+01	9.65E+01	9.66E+01	
Ps90%/90% (-KTL) Un-Biased	9.33E+01	9.29E+01	9.29E+01	9.28E+01	9.27E+01	9.30E+01	9.34E+01	
Specification MIN	9.00E+01	9.00E+01	9.00E+01	9.00E+01	8.60E+01	8.60E+01	8.60E+01	
Status	PASS	PASS	PASS	PASS	PASS	PASS	PASS	

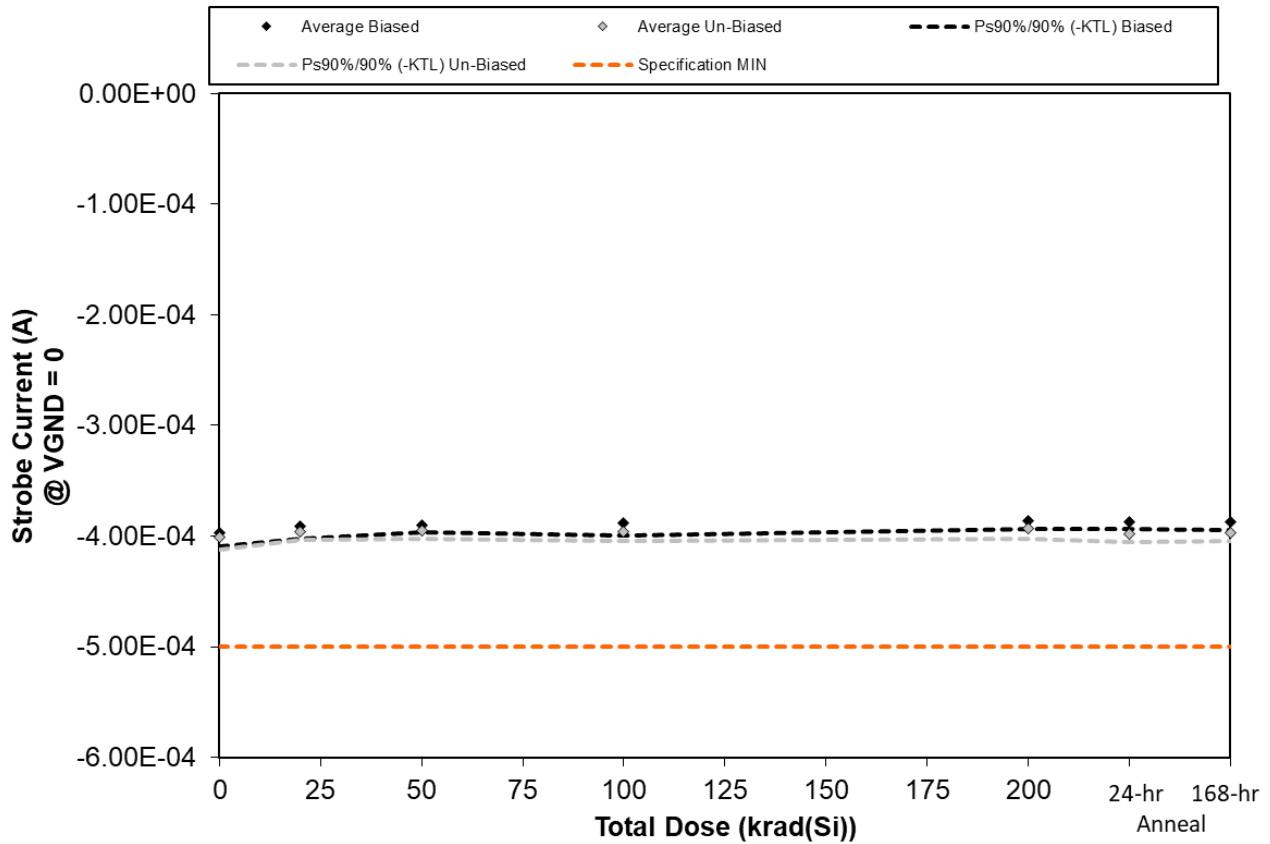


Figure 5.9. Plot of Strobe Current (A) @ VGND = 0 versus total dose. The solid diamonds are the average of the measured data points for the samples irradiated under electrical bias while the shaded diamonds are the average of the measured data points for the samples irradiated with all pins tied to ground. The black lines (solid and/or dashed) are the upper and/or lower confidence limits, as determined by KTL statistics, on the samples irradiated under electrical bias while the gray lines (solid and/or dashed) are the upper and/or lower confidence limits, as determined by KTL statistics, on the samples irradiated in the unbiased condition. The red dotted line(s) are the pre- and/or post-irradiation minimum and/or maximum specification value as defined in the datasheet and/or test plan.

Table 5.9. Raw data for Strobe Current (A) @ VGND = 0 versus total dose, including the statistical analysis, specification and the status of the testing (pass/fail).

Strobe Current (A) @ VGND = 0	Total Dose (krad(Si))					24-hr Anneal	168-hr Anneal
Device	0	20	50	100	200		
1648	-3.95E-04	-3.88E-04	-3.88E-04	-3.87E-04	-3.84E-04	-3.86E-04	-3.85E-04
1649	-4.05E-04	-3.98E-04	-3.93E-04	-3.94E-04	-3.90E-04	-3.91E-04	-3.90E-04
1650	-3.95E-04	-3.88E-04	-3.88E-04	-3.84E-04	-3.84E-04	-3.86E-04	-3.85E-04
1651	-3.95E-04	-3.88E-04	-3.88E-04	-3.84E-04	-3.84E-04	-3.86E-04	-3.85E-04
1652	-4.00E-04	-3.93E-04	-3.93E-04	-3.90E-04	-3.89E-04	-3.88E-04	-3.90E-04
1653	-4.05E-04	-3.98E-04	-3.98E-04	-3.99E-04	-3.99E-04	-4.01E-04	-4.00E-04
1654	-3.99E-04	-3.93E-04	-3.93E-04	-3.94E-04	-3.93E-04	-3.96E-04	-3.95E-04
1655	-3.95E-04	-3.93E-04	-3.93E-04	-3.94E-04	-3.89E-04	-3.96E-04	-3.95E-04
1656	-4.05E-04	-3.98E-04	-3.98E-04	-3.99E-04	-3.94E-04	-4.01E-04	-4.00E-04
1657	-4.00E-04	-3.98E-04	-3.97E-04	-3.94E-04	-3.94E-04	-3.96E-04	-3.95E-04
1658	-4.05E-04	-4.03E-04	-4.08E-04	-4.04E-04	-4.04E-04	-4.06E-04	-4.05E-04
1659	-4.05E-04	-4.03E-04	-4.03E-04	-4.04E-04	-4.04E-04	-4.06E-04	-4.05E-04
Biased Statistics							
Average Biased	-3.98E-04	-3.91E-04	-3.90E-04	-3.88E-04	-3.86E-04	-3.87E-04	-3.87E-04
Std Dev Biased	4.48E-06	4.35E-06	2.52E-06	4.12E-06	2.81E-06	2.28E-06	2.68E-06
Ps90%/90% (+KTL) Biased	-3.85E-04	-3.79E-04	-3.83E-04	-3.77E-04	-3.79E-04	-3.81E-04	-3.80E-04
Ps90%/90% (-KTL) Biased	-4.10E-04	-4.03E-04	-3.97E-04	-3.99E-04	-3.94E-04	-3.94E-04	-3.95E-04
Un-Biased Statistics							
Average Un-Biased	-4.00E-04	-3.96E-04	-3.95E-04	-3.96E-04	-3.94E-04	-3.98E-04	-3.97E-04
Std Dev Un-Biased	4.19E-06	2.85E-06	2.67E-06	2.85E-06	3.35E-06	2.68E-06	2.79E-06
Ps90%/90% (+KTL) Un-Biased	-3.89E-04	-3.88E-04	-3.88E-04	-3.88E-04	-3.84E-04	-3.90E-04	-3.89E-04
Ps90%/90% (-KTL) Un-Biased	-4.12E-04	-4.04E-04	-4.03E-04	-4.04E-04	-4.03E-04	-4.05E-04	-4.04E-04
Specification MIN	-5.00E-04	-5.00E-04	-5.00E-04	-5.00E-04	-5.00E-04	-5.00E-04	-5.00E-04
Status	PASS	PASS	PASS	PASS	PASS	PASS	PASS

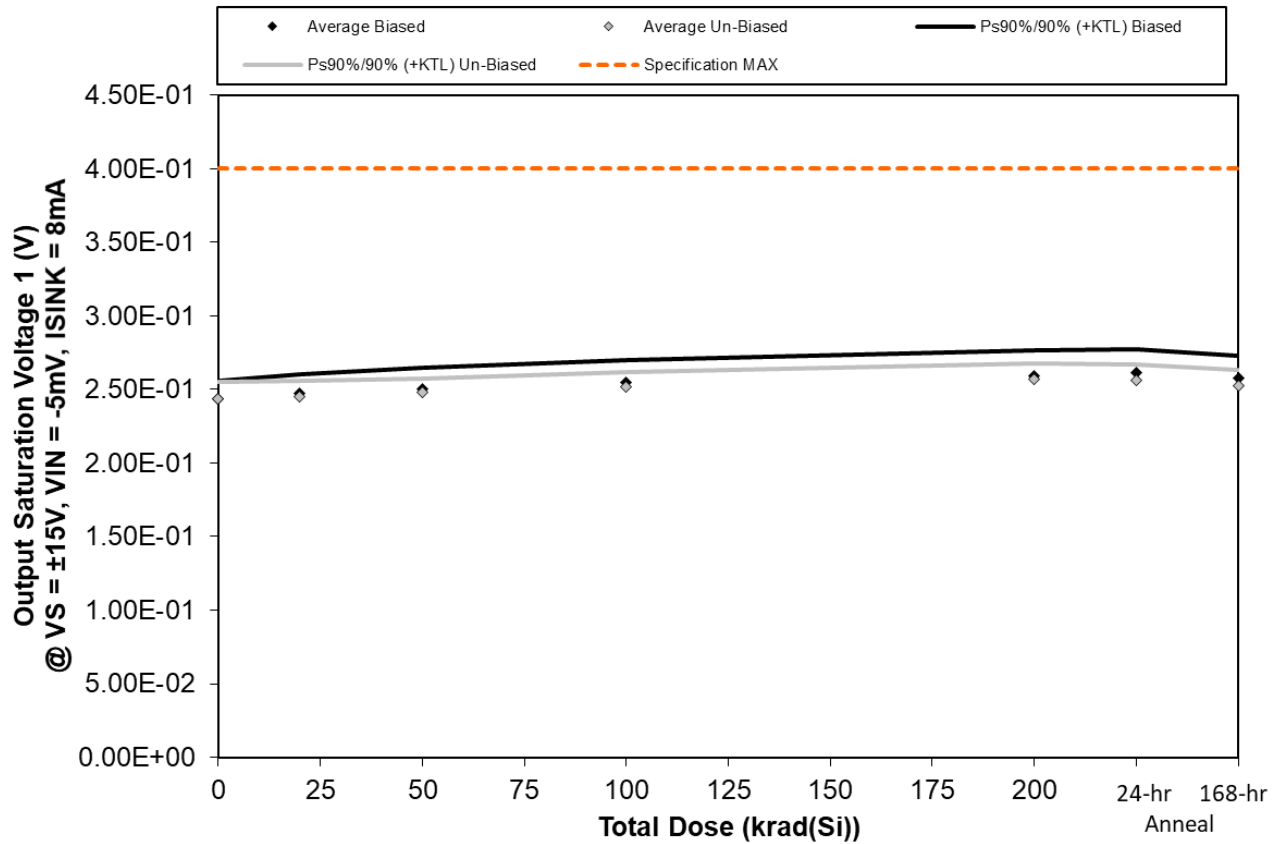


Figure 5.10. Plot of Output Saturation Voltage 1 (V) @ $V_S = \pm 15V$, $V_{IN} = -5mV$, $I_{SINK} = 8mA$ versus total dose. The solid diamonds are the average of the measured data points for the samples irradiated under electrical bias while the shaded diamonds are the average of the measured data points for the samples irradiated with all pins tied to ground. The black lines (solid and/or dashed) are the upper and/or lower confidence limits, as determined by KTL statistics, on the samples irradiated under electrical bias while the gray lines (solid and/or dashed) are the upper and/or lower confidence limits, as determined by KTL statistics, on the samples irradiated in the unbiased condition. The red dotted line(s) are the pre- and/or post-irradiation minimum and/or maximum specification value as defined in the datasheet and/or test plan.

Table 5.10. Raw data for Output Saturation Voltage 1 (V) @ VS = ±15V, VIN = -5mV, ISINK = 8mA versus total dose, including the statistical analysis, specification and the status of the testing (pass/fail).

Output Saturation Voltage 1 (V) @ VS = ±15V, VIN = -5mV, ISINK = 8mA	Total Dose (krad(Si))					24-hr Anneal	168-hr Anneal
	0	20	50	100	200		
Device							
1648	2.43E-01	2.46E-01	2.50E-01	2.53E-01	2.58E-01	2.59E-01	2.56E-01
1649	2.51E-01	2.55E-01	2.59E-01	2.64E-01	2.70E-01	2.71E-01	2.67E-01
1650	2.43E-01	2.46E-01	2.49E-01	2.53E-01	2.58E-01	2.60E-01	2.57E-01
1651	2.43E-01	2.46E-01	2.50E-01	2.53E-01	2.57E-01	2.60E-01	2.56E-01
1652	2.39E-01	2.42E-01	2.45E-01	2.49E-01	2.54E-01	2.55E-01	2.52E-01
1653	2.42E-01	2.43E-01	2.46E-01	2.50E-01	2.55E-01	2.54E-01	2.50E-01
1654	2.42E-01	2.44E-01	2.46E-01	2.49E-01	2.55E-01	2.54E-01	2.50E-01
1655	2.43E-01	2.45E-01	2.47E-01	2.51E-01	2.56E-01	2.56E-01	2.52E-01
1656	2.41E-01	2.43E-01	2.46E-01	2.49E-01	2.55E-01	2.55E-01	2.50E-01
1657	2.51E-01	2.52E-01	2.54E-01	2.58E-01	2.64E-01	2.63E-01	2.59E-01
1658	2.42E-01	2.43E-01	2.43E-01	2.42E-01	2.42E-01	2.42E-01	2.42E-01
1659	2.44E-01	2.45E-01	2.44E-01	2.44E-01	2.44E-01	2.44E-01	2.44E-01
Biased Statistics							
Average Biased	2.44E-01	2.47E-01	2.51E-01	2.54E-01	2.59E-01	2.61E-01	2.58E-01
Std Dev Biased	4.38E-03	4.80E-03	5.13E-03	5.64E-03	6.15E-03	5.96E-03	5.59E-03
Ps90%/90% (+KTL) Biased	2.56E-01	2.60E-01	2.65E-01	2.70E-01	2.76E-01	2.77E-01	2.73E-01
Ps90%/90% (-KTL) Biased	2.32E-01	2.34E-01	2.37E-01	2.39E-01	2.43E-01	2.45E-01	2.42E-01
Un-Biased Statistics							
Average Un-Biased	2.44E-01	2.45E-01	2.48E-01	2.51E-01	2.57E-01	2.56E-01	2.52E-01
Std Dev Un-Biased	4.09E-03	3.78E-03	3.49E-03	3.78E-03	3.94E-03	3.78E-03	3.90E-03
Ps90%/90% (+KTL) Un-Biased	2.55E-01	2.56E-01	2.57E-01	2.62E-01	2.68E-01	2.67E-01	2.63E-01
Ps90%/90% (-KTL) Un-Biased	2.33E-01	2.35E-01	2.38E-01	2.41E-01	2.46E-01	2.46E-01	2.42E-01
Specification MAX	4.00E-01	4.00E-01	4.00E-01	4.00E-01	4.00E-01	4.00E-01	4.00E-01
Status	PASS	PASS	PASS	PASS	PASS	PASS	PASS

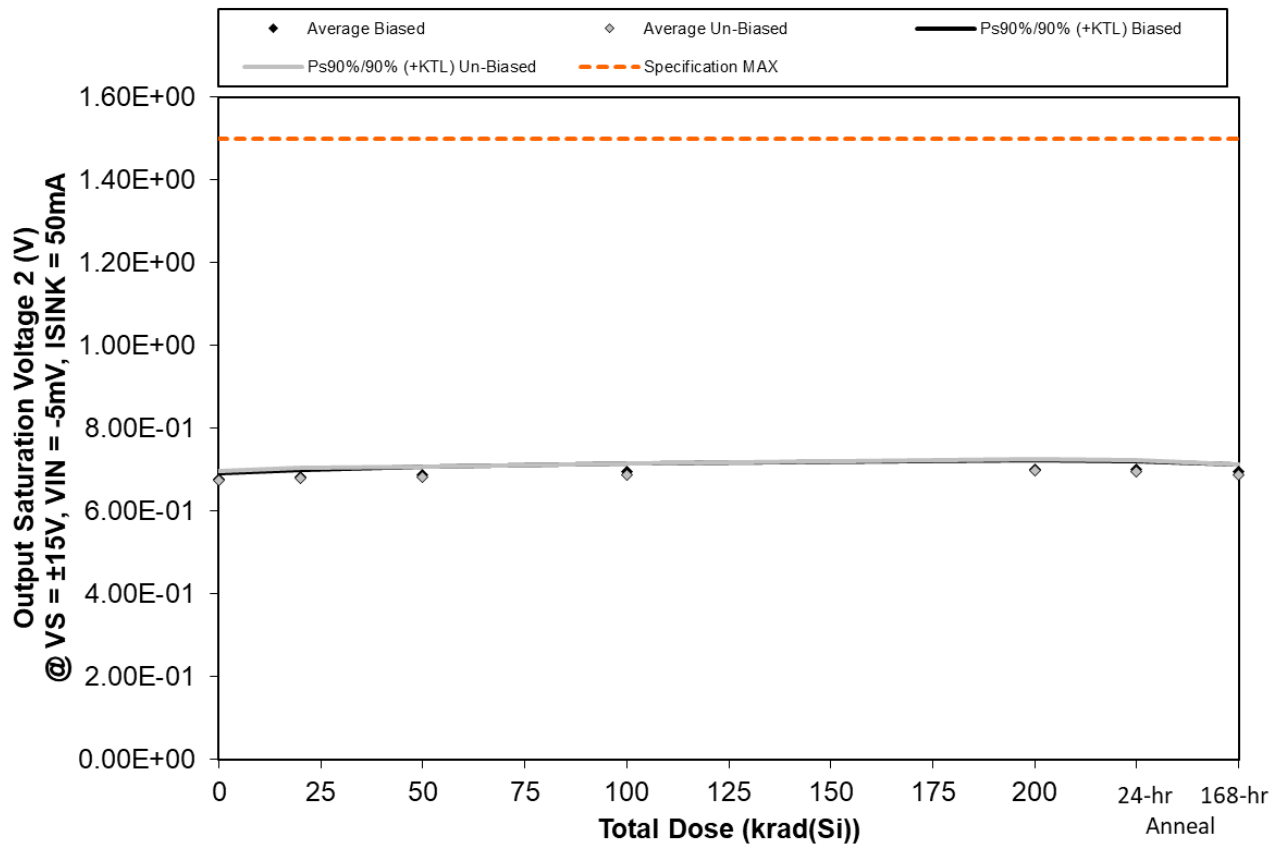


Figure 5.11. Plot of Output Saturation Voltage 2 (V) @ $V_S = \pm 15V$, $V_{IN} = -5mV$, $I_{SINK} = 50mA$ versus total dose. The solid diamonds are the average of the measured data points for the samples irradiated under electrical bias while the shaded diamonds are the average of the measured data points for the samples irradiated with all pins tied to ground. The black lines (solid and/or dashed) are the upper and/or lower confidence limits, as determined by KTL statistics, on the samples irradiated under electrical bias while the gray lines (solid and/or dashed) are the upper and/or lower confidence limits, as determined by KTL statistics, on the samples irradiated in the unbiased condition. The red dotted line(s) are the pre- and/or post-irradiation minimum and/or maximum specification value as defined in the datasheet and/or test plan.

Table 5.11. Raw data for Output Saturation Voltage 2 (V) @ VS = ±15V, VIN = -5mV, ISINK = 50mA versus total dose, including the statistical analysis, specification and the status of the testing (pass/fail).

Output Saturation Voltage 2 (V) @ VS = ±15V, VIN = -5mV, ISINK = 50mA	Total Dose (krad(Si))					24-hr Anneal	168-hr Anneal
	0	20	50	100	200		
Device							
1648	6.77E-01	6.85E-01	6.90E-01	6.96E-01	7.04E-01	7.03E-01	6.96E-01
1649	6.83E-01	6.91E-01	6.98E-01	7.05E-01	7.14E-01	7.12E-01	7.05E-01
1650	6.74E-01	6.80E-01	6.86E-01	6.91E-01	7.00E-01	6.99E-01	6.93E-01
1651	6.75E-01	6.81E-01	6.86E-01	6.93E-01	6.98E-01	6.99E-01	6.92E-01
1652	6.68E-01	6.74E-01	6.80E-01	6.85E-01	6.92E-01	6.92E-01	6.86E-01
1653	6.68E-01	6.74E-01	6.78E-01	6.83E-01	6.94E-01	6.90E-01	6.83E-01
1654	6.70E-01	6.74E-01	6.78E-01	6.83E-01	6.91E-01	6.91E-01	6.84E-01
1655	6.73E-01	6.78E-01	6.82E-01	6.88E-01	6.96E-01	6.95E-01	6.87E-01
1656	6.69E-01	6.73E-01	6.78E-01	6.83E-01	6.93E-01	6.91E-01	6.82E-01
1657	6.89E-01	6.95E-01	6.99E-01	7.05E-01	7.15E-01	7.13E-01	7.04E-01
1658	6.73E-01	6.75E-01	6.73E-01	6.70E-01	6.71E-01	6.72E-01	6.71E-01
1659	6.73E-01	6.75E-01	6.74E-01	6.74E-01	6.73E-01	6.74E-01	6.73E-01
Biased Statistics							
Average Biased	6.75E-01	6.82E-01	6.88E-01	6.94E-01	7.02E-01	7.01E-01	6.94E-01
Std Dev Biased	5.41E-03	6.30E-03	6.63E-03	7.35E-03	8.17E-03	7.31E-03	6.95E-03
Ps90%/90% (+KTL) Biased	6.90E-01	6.99E-01	7.06E-01	7.14E-01	7.24E-01	7.21E-01	7.13E-01
Ps90%/90% (-KTL) Biased	6.61E-01	6.65E-01	6.70E-01	6.74E-01	6.79E-01	6.81E-01	6.75E-01
Un-Biased Statistics							
Average Un-Biased	6.74E-01	6.79E-01	6.83E-01	6.88E-01	6.98E-01	6.96E-01	6.88E-01
Std Dev Un-Biased	8.70E-03	9.26E-03	9.11E-03	9.53E-03	9.78E-03	9.70E-03	9.14E-03
Ps90%/90% (+KTL) Un-Biased	6.98E-01	7.04E-01	7.08E-01	7.15E-01	7.25E-01	7.23E-01	7.13E-01
Ps90%/90% (-KTL) Un-Biased	6.50E-01	6.53E-01	6.58E-01	6.62E-01	6.71E-01	6.69E-01	6.63E-01
Specification MAX	1.50E+00	1.50E+00	1.50E+00	1.50E+00	1.50E+00	1.50E+00	1.50E+00
Status	PASS	PASS	PASS	PASS	PASS	PASS	PASS

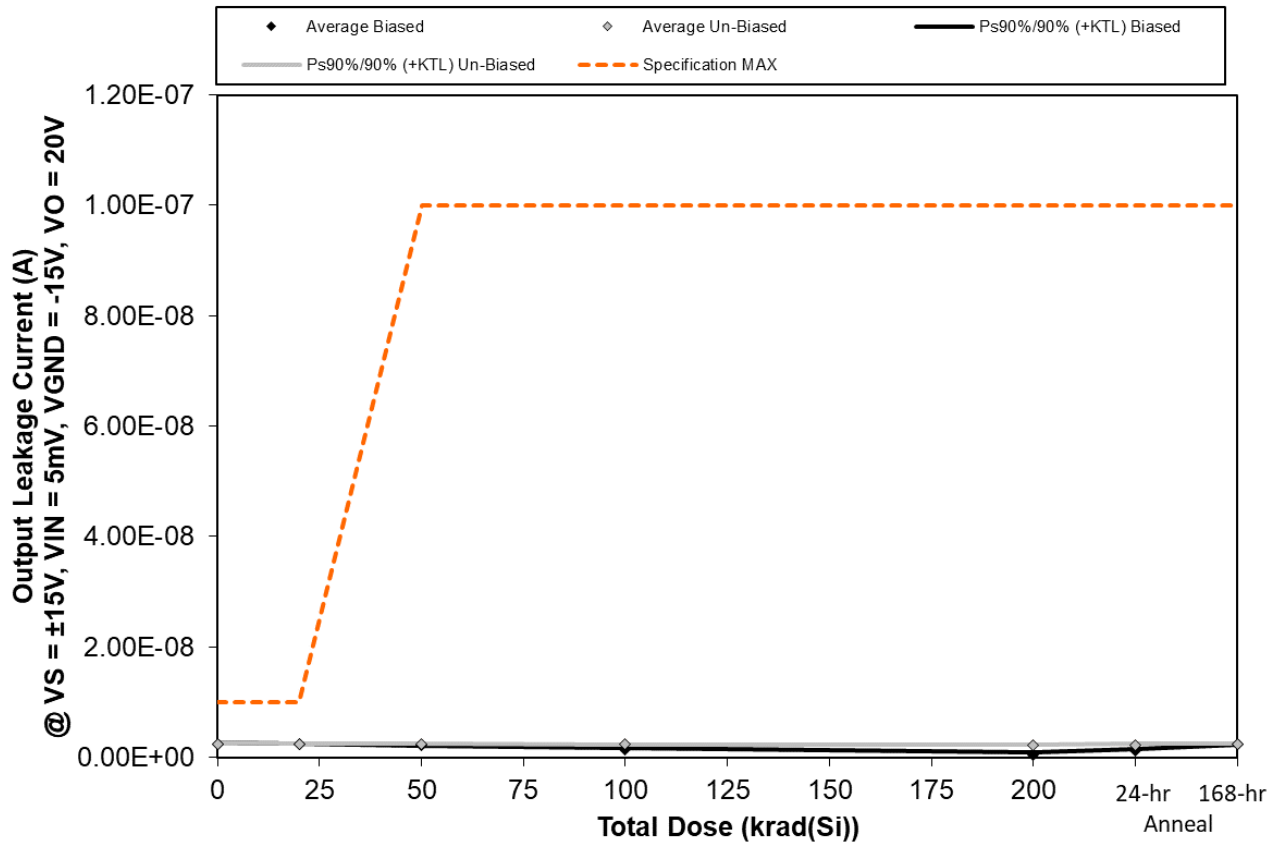


Figure 5.12. Plot of Output Leakage Current (A) @ VS = ±15V, VIN = 5mV, VGND = -15V, VO = 20V versus total dose. The solid diamonds are the average of the measured data points for the samples irradiated under electrical bias while the shaded diamonds are the average of the measured data points for the samples irradiated with all pins tied to ground. The black lines (solid and/or dashed) are the upper and/or lower confidence limits, as determined by KTL statistics, on the samples irradiated under electrical bias while the gray lines (solid and/or dashed) are the upper and/or lower confidence limits, as determined by KTL statistics, on the samples irradiated in the unbiased condition. The red dotted line(s) are the pre- and/or post-irradiation minimum and/or maximum specification value as defined in the datasheet and/or test plan.

Table 5.12. Raw data for Output Leakage Current (A) @ VS = ±15V, VIN = 5mV, VGND = -15V, VO = 20V versus total dose, including the statistical analysis, specification and the status of the testing (pass/fail).

Output Leakage Current (A) @ VS = ±15V, VIN = 5mV, VGND = -15V, VO = 20V	Total Dose (krad(Si))					24-hr Anneal	168-hr Anneal
Device	0	20	50	100	200		
1648	2.40E-09	2.40E-09	2.10E-09	1.40E-09	0.00E+00	1.20E-09	2.30E-09
1649	2.40E-09	2.40E-09	2.10E-09	1.60E-09	5.00E-10	1.40E-09	2.30E-09
1650	2.50E-09	2.40E-09	2.10E-09	1.50E-09	4.00E-10	1.30E-09	2.30E-09
1651	2.50E-09	2.40E-09	2.10E-09	1.40E-09	4.00E-10	1.20E-09	2.30E-09
1652	2.50E-09	2.40E-09	2.10E-09	1.40E-09	4.00E-10	1.30E-09	2.30E-09
1653	2.40E-09	2.40E-09	2.40E-09	2.30E-09	2.20E-09	2.30E-09	2.40E-09
1654	2.40E-09	2.40E-09	2.40E-09	2.30E-09	2.20E-09	2.20E-09	2.30E-09
1655	2.50E-09	2.40E-09	2.40E-09	2.30E-09	2.20E-09	2.30E-09	2.40E-09
1656	2.40E-09	2.40E-09	2.40E-09	2.30E-09	2.20E-09	2.20E-09	2.40E-09
1657	2.50E-09	2.40E-09	2.40E-09	2.30E-09	2.10E-09	2.20E-09	2.30E-09
1658	2.50E-09	2.50E-09	2.50E-09	2.50E-09	2.40E-09	2.50E-09	2.50E-09
1659	2.50E-09	2.40E-09	2.50E-09	2.50E-09	2.50E-09	2.50E-09	2.50E-09
Biased Statistics							
Average Biased	2.46E-09	2.40E-09	2.10E-09	1.46E-09	3.40E-10	1.28E-09	2.30E-09
Std Dev Biased	5.48E-11	0.00E+00	0.00E+00	8.94E-11	1.95E-10	8.37E-11	0.00E+00
Ps90%/90% (+KTL) Biased	2.61E-09	2.40E-09	2.10E-09	1.71E-09	8.75E-10	1.51E-09	2.30E-09
Ps90%/90% (-KTL) Biased	2.31E-09	2.40E-09	2.10E-09	1.21E-09	-1.95E-10	1.05E-09	2.30E-09
Un-Biased Statistics							
Average Un-Biased	2.44E-09	2.40E-09	2.40E-09	2.30E-09	2.18E-09	2.24E-09	2.36E-09
Std Dev Un-Biased	5.48E-11	0.00E+00	0.00E+00	0.00E+00	4.47E-11	5.48E-11	5.48E-11
Ps90%/90% (+KTL) Un-Biased	2.59E-09	2.40E-09	2.40E-09	2.30E-09	2.30E-09	2.39E-09	2.51E-09
Ps90%/90% (-KTL) Un-Biased	2.29E-09	2.40E-09	2.40E-09	2.30E-09	2.06E-09	2.09E-09	2.21E-09
Specification MAX	1.00E-08	1.00E-08	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07
Status	PASS	PASS	PASS	PASS	PASS	PASS	PASS

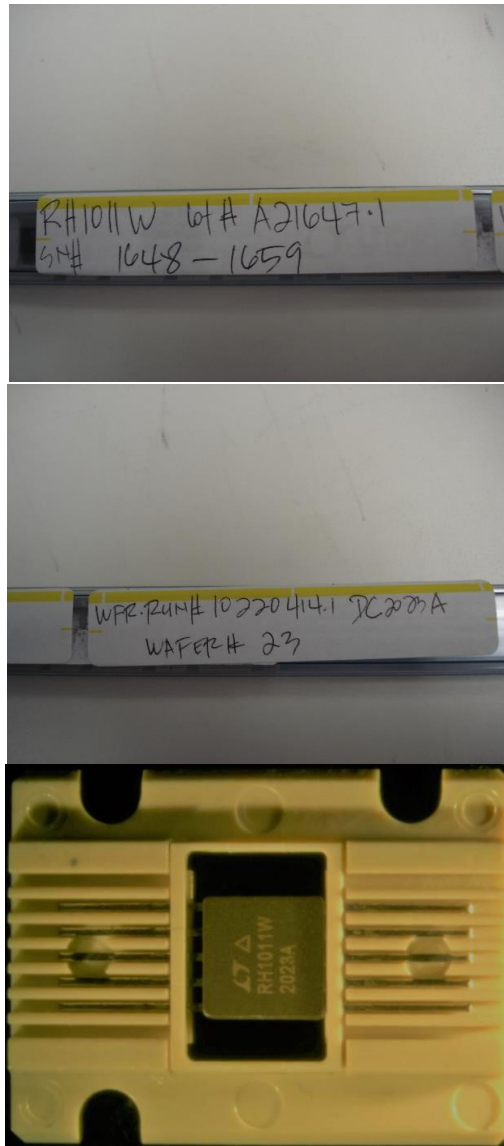
6.0. Summary / Conclusions

The total ionizing dose testing described in this final report was performed using the facilities at Radiation Test Solutions' Longmire Laboratories in Colorado Springs, CO. The high dose rate total ionizing dose (TID) source is a JLSA 81-24 irradiator modified to provide a panoramic exposure. The Co-60 rods are held in the base of the irradiator heavily shielded by lead, during the radiation exposures the rod is raised by an electronic timer/controller and the exposure is performed in air. The dose rate for this irradiator in this configuration ranges from $<1\text{rad(Si)/s}$ to a maximum of approximately 300rad(Si)/s , determined by the distance from the source.

The parametric data was obtained as "read and record" and all the raw data plus an attributes summary are contained in this report as well as in a separate Excel file. The attributes data contains the average, standard deviation and the average with the KTL values applied. The KTL value used in this work is 2.742 per MIL-HDBK-814 using one sided tolerance limits of 90/90 and a 5-piece sample size. The 90/90 KTL values were selected to match the statistical levels specified in the MIL-PRF-38535 sampling plan for the qualification of a radiation hardness assured (RHA) component. Note that the following criteria must be met for a device to pass the total ionizing dose test: following the radiation exposure each of the 5 pieces irradiated under electrical bias shall pass the specification value. The units irradiated without electrical bias and the KTL statistics are included in this report for reference only. If any of the 5 pieces irradiated under electrical bias exceed the device post radiation data sheet specification limits, then the lot could be logged as a failure.

Based on this criterion the RH1011W Voltage Comparator (from the lot traceability information provided on the first page of this test report) PASSED the high dose rate total ionizing dose test to the maximum tested dose level of 200krad(Si) with all parameters remaining within their datasheet specifications.

Appendix A: Photograph of Packing Label and a Sample Unit-Under-Test to Show Part Traceability



Appendix B: Radiation Bias Connections and Absolute Maximum Ratings

TID Radiation Biased Conditions: Extracted from Analog Devices RH1011 Datasheet Revision F.

Pin	Function	Connection / Bias
1	GND	To GND
2	+INPUT	To +12V via 5.1k Ω Resistor
3	-INPUT	To GND
4	NC	NC
5	V-	To -12V via 12 Ω Resistor
6	BALANCE	NC
7	BALANCE/STROBE	NC
8	NC	NC
9	OUTPUT	To +12V via 5.1k Ω Resistor
10	V+	To +12V via 12 Ω Resistor

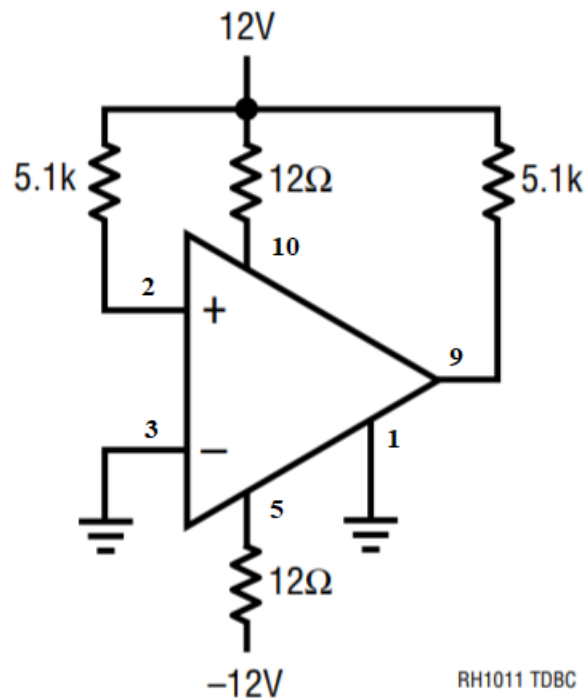


Figure B.1. Irradiation bias circuit. This figure was extracted from Analog Devices RH1011 Datasheet Revision F.

TID Radiation Unbiased Conditions:

Pin	Function	Connection / Bias
1	GND	GND
2	+INPUT	GND
3	-INPUT	GND
4	NC	GND
5	V-	GND
6	BALANCE	GND
7	BALANCE/STROBE	GND
8	NC	GND
9	OUTPUT	GND
10	V+	GND

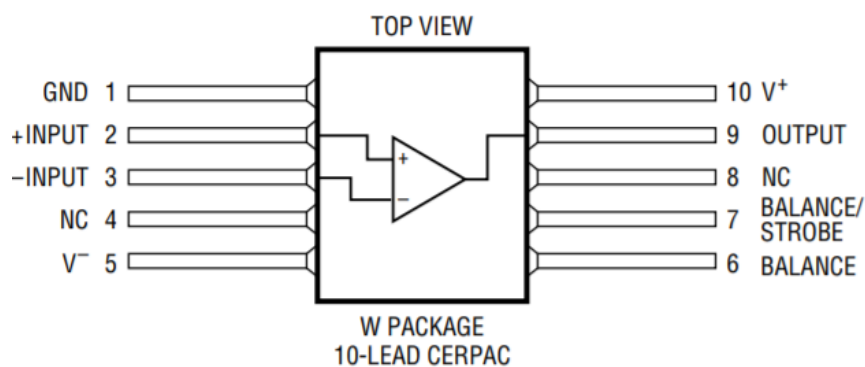


Figure B.2. Package Drawing (for reference only).

Absolute Maximum Ratings:

Parameter	Max Rating
Supply Voltage	36V
Output to Negative Supply	35V
Ground to Negative Supply	30V
Differential Input Voltage	±35V
Voltage at STROBE Pin	5V
Input Voltage	Equal to Supplies
Output Short-Circuit Duration	10 sec

Appendix C: Electrical Test Parameters and Conditions

The expected ranges of values as well as the measurement conditions are taken from Analog Devices RH1011 Datasheet Revision F. All electrical tests for this device are performed on one of Radiation Test Solutions' LTS2020 Test Systems. The LTS2020 Test System is a programmable parametric tester that provides parameter measurements for a variety of digital, analog and mixed signal products including voltage regulators, voltage comparators, D to A and A to D converters. The LTS2020 Test System achieves accuracy and sensitivity through the use of software self-calibration and an internal relay matrix with separate family boards and custom personality adapter boards. The tester uses this relay matrix to connect the required test circuits, select the appropriate voltage / current sources and establish the needed measurement loops for all the tests performed. The measured parameters and test conditions are shown in Table C.1.

A listing of the measurement precision/resolution for each parameter is shown in Table C.2. The precision/resolution values were obtained from test data or from the DAC resolution of the LTS-2020 for the particular test shown, whichever is greater. To generate the precision/resolution shown in Table C.2, one of the units-under-test was tested repetitively (a total of 10-times with re-insertion between tests) to obtain the average test value and standard deviation. Using this test data MIL-HDBK-814 90/90 KTL statistics were applied to the measured standard deviation to generate the final measurement range. This value encompasses the precision/resolution of all aspects of the test system, including the LTS2020 mainframe, family board, socket assembly and DUT board as well as insertion error. In some cases, the measurement resolution is limited by the internal DACs, which results in a measured standard deviation of zero. In these instances the precision/resolution will be reported back as the LSB of the DAC.

Note that the testing and statistics used in this document are based on an “analysis of variables” technique, which relies on small sample sizes to qualify much larger lot sizes (see MIL-HDBK-814, p. 91 for a discussion of statistical treatments). Not all measured parameters are well suited to this approach due to inherent large variations. If necessary, larger samples sizes could be used to qualify these parameters using an “attributes” approach.

Table C.1. Measured parameters and test conditions for the RH1011W Voltage Comparator.

Parameter	Symbol	Test Conditions
Pos Supply Current (A)	+ICC	VS = ±15V
Neg Supply Current (A)	-ICC	VS = ±15V
Input Offset Voltage (V)	VOS	VS = ±15V, VO = 0, ISINK = 1.5mA
Input Offset Current (A)	IOS	VS = ±15V, VO = 0, ISINK = 1.5mA
Pos Input Bias Current (A)	+IB	VS = ±15V, VO = 0, ISINK = 1.5mA
Neg Input Bias Current (A)	-IB	VS = ±15V, VO = 0, ISINK = 1.5mA
Large Signal Voltage Gain (V/mV)	AOL	VS = ±15V, RL= 1kW, -10V < VO < 14.5V
Common Mode Rejection Ratio (dB)	CMRR	VCM = -14.5V to 13V
Strobe Current (A)	ISTB	VGND = 0
Output Saturation Voltage 1 (V)	VOL 1	VS = ±15V, VIN = -5mV, ISINK = 8mA
Output Saturation Voltage 2 (V)	VOL 2	VS = ±15V, VIN = -5mV, ISINK = 50mA
Output Leakage Current (A)	ICEX	VS = ±15V, VIN = 5mV, VGND = -15V, VO = 20V

Table C.2. Measured parameters, pre-irradiation specifications and measurement precision for the RH1011W Voltage Comparator.

Parameter	Pre-Irradiation Specification		Measurement Precision/Resolution
	MIN	MAX	
Pos Supply Current (A)		4.00E-03	±2.04E-05
Neg Supply Current (A)	-2.50E-03		±1.32E-05
Input Offset Voltage (V)	-1.50E-03	1.50E-03	±3.40E-06
Input Offset Current (A)	-4.00E-09	4.00E-09	±1.00E-10
Pos Input Bias Current (A)	-5.00E-08	5.00E-08	±9.97E-11
Neg Input Bias Current (A)	-5.00E-08	5.00E-08	±1.90E-10
Large Signal Voltage Gain (V/mV)	2.00E+02		±2.81E+01
Common Mode Rejection Ratio (dB)	9.00E+01		±1.22E-01
Strobe Current (A)	-5.00E-04		±1.00E-07
Output Saturation Voltage 1 (V)		4.00E-01	±1.00E-03
Output Saturation Voltage 2 (V)		1.50E+00	±2.47E-03
Output Leakage Current (A)		1.00E-08	±8.71E-11

Appendix D: List of Figures Used in the Results Section (Section 5)

- 5.1. Pos Supply Current (A) @ $V_S = \pm 15V$
- 5.2. Neg Supply Current (A) @ $V_S = \pm 15V$
- 5.3. Input Offset Voltage (V) @ $V_S = \pm 15V$, $V_O = 0$, $I_{SINK} = 1.5mA$
- 5.4. Input Offset Current (A) @ $V_S = \pm 15V$, $V_O = 0$, $I_{SINK} = 1.5mA$
- 5.5. Pos Input Bias Current (A) @ $V_S = \pm 15V$, $V_O = 0$, $I_{SINK} = 1.5mA$
- 5.6. Neg Input Bias Current (A) @ $V_S = \pm 15V$, $V_O = 0$, $I_{SINK} = 1.5mA$
- 5.7. Large Signal Voltage Gain (V/mV) @ $V_S = \pm 15V$, $R_L = 1kW$, $-10V < V_O < 14.5V$
- 5.8. Common Mode Rejection Ratio (dB) @ $V_{CM} = -14.5V$ to $13V$
- 5.9. Strobe Current (A) @ $V_{GND} = 0$
- 5.10. Output Saturation Voltage 1 (V) @ $V_S = \pm 15V$, $V_{IN} = -5mV$, $I_{SINK} = 8mA$
- 5.11. Output Saturation Voltage 2 (V) @ $V_S = \pm 15V$, $V_{IN} = -5mV$, $I_{SINK} = 50mA$
- 5.12. Output Leakage Current (A) @ $V_S = \pm 15V$, $V_{IN} = 5mV$, $V_{GND} = -15V$, $V_O = 20V$