Radiation Lot Acceptance Test (RLAT) of the RH119W High Performance Dual Comparator for Linear Technology

Customer: Linear Technology, PO 50963L

RAD Job Number: 08-279

Part Type Tested: Linear Technology RH119W High Performance Dual Comparator

Commercial Part Number: RH119W

Traceability Information: FAB #F0258.1, Wafer 18, Lot #472013.1

Quantity of Units: 11 units total, 5 units for biased irradiation, 5 units for unbiased irradiation and 1 control unit.

External Traveler: None required

Pre-Irradiation Burn-In: Burn-In performed by Linear Technology prior to receipt by RAD, Inc.

TID Dose Rate and Maximum Total Dose: 50 to 300rad(Si)/s to 200krad(Si) total ionizing dose

TID Test Increments: Pre-Irradiation, 20krad(Si), 50krad(Si) 100krad(Si) and 200krad(Si)

TID Overtest and Post-Irradiation Anneal: No overtest. No anneal.

TID Test Standard: MIL-STD-883G, Method 1019.7, Condition A

TID Electrical Test Conditions: Pre-irradiation, and within one hour following each radiation exposure.

Test Hardware and Software: LTS2020 tester, TS-04 Calibration Date: 11-03-08, Calibration Due: 05-03-09. Test program: RH119JH.SRC

TID Bias Conditions: Serial numbers 694, 695, 698, 699 and 700, were biased during irradiation, serial numbers 701, 702, 704, 705 and 706 were unbiased during irradiation and serial number 1280 was used as the control.

Facility and Radiation Source: Radiation Assured Devices Longmire Laboratories, Colorado Springs, CO using their JLSA 81-24 Co60 cell. Dosimetry performed using CaF TLDs traceable to NIST. RAD's dosimetry has been audited by DSCC and RAD has been awarded Laboratory Suitability for MIL-STD-750 TM 1019.5

Irradiation and Test Temperature: Ambient, room temperature

RLAT Result: Units passed with only minor degradation to the input offset and input bias parameters and no significant degradation to any other measured parameter.

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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 TM1019.7 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 TM1019.7 Condition A.

2.0. Radiation Test Apparatus

The total ionizing dose testing described in this final report was performed using the facilities at Radiation Assured Devices' Longmire Laboratories in Colorado Springs, CO. The high dose rate total ionizing dose (TID) source is a JLSA 84-21 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 120rad(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 Assured Devices Longmire Laboratories using thermoluminescent dosimeters (TLDs)) traceable to the National Institute of Standards and Technology (NIST). Figure 2.1 shows a photograph of the JLSA 81-24 Co-60 irradiator at RAD's Longmire Laboratory facility.

RAD is currently certified by the Defense Supply Center Columbus (DSCC) for Laboratory Suitability under MIL STD 750. Additional details regarding Radiation Assured Devices dosimetry for TM1019 Condition A testing are available in RAD's report to DSCC entitled: "Dose Rate Mapping of the J.L. Shepherd and Associates Model 81 Irradiator Installed by Radiation Assured Devices"

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Figure 2.1. Radiation Assured Devices' 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 120rad(Si)/s close to the rods down to 1rad(Si)/s at a distance of approximately 2-feet.

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3.0. Radiation Test Conditions

The RH119W dual comparators described in this final report were irradiated using a split 15V supply and with all pins tied to ground, that is biased and unbiased. See the TID Bias Table in Appendix A for the full bias circuits and electrical connections during the radiation exposure. These bias circuits satisfy the requirements of MIL-STD-883G TM1019.7 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 readings at 20, 50, 100 and 200krad(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-883G TM1019.7 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 lead-aluminum enclosure was determined based on TLD dosimetry measurements (see previous section). The final dose rate for this work was 64rad(Si)/s with a precision of ±5%.

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4.0. Tested Parameters

During the radiation lot acceptance testing the pre- and post-irradiation electrical parameters measured were:

1. Input Offset Voltage, V_{OS1} and V_{OS2}
2. Common Mode Rejection Ratio, CMRR1 and CMRR2
3. Input Offset Current, I_{OS1} and I_{OS2}
4. Input Bias Current, Non-Inverting Input, $+I_{B1}$ and $+I_{B2}$
5. Input Bias Current, Inverting Input, $-I_{B1}$ and $-I_{B2}$
6. Large Signal Voltage Gain, AVOL1, AVOL2
7. Saturation Voltage, V_{SAT1} and V_{SAT2}
8. Saturation Voltage, V_{SAT3} and V_{SAT4}
9. Output Leakage Current, I_{CEX1} and I_{CEX2}
10. Positive Supply Current, $+I_S$
11. Negative Supply Current, $-I_S$

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 values used is 2.742 per MIL HDBK 814 using one sided tolerance limits of 90/90 and a 5-piece sample size. This survival probability/level of confidence is consistent with a 22-piece sample size and zero failures analyzed using a lot tolerance percent defective (LTPD) approach. Note that the following criteria must be met for a device to pass the TID testing: following the radiation exposure the units shall pass the specification value and the average value for the each device must pass the specification value when the KTL limits are applied. If either of these conditions is not satisfied following the radiation exposure, then the lot could be logged as an RLAT failure.

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5.0. Total Ionizing Dose Test Results

The units passed the radiation lot acceptance test with only minor degradation to the input offset and input bias parameters and no significant degradation to any other measured parameter.

Figures 5.1 and 5.22 show plots of all the measured parameters versus total ionizing dose while Tables 5.1 – 5.22 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 samples 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 average of the data points after application of the KTL statistics on the sample irradiated in the biased condition while the shaded lines (solid or dashed) are the average of the data points after application of the 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.

As seen clearly in these figures and tables, the pre-irradiation data is well within the specification and the control sample remains stable during the course of the measurements. Therefore, we can conclude that any of the observed degradation was due to the radiation exposure.

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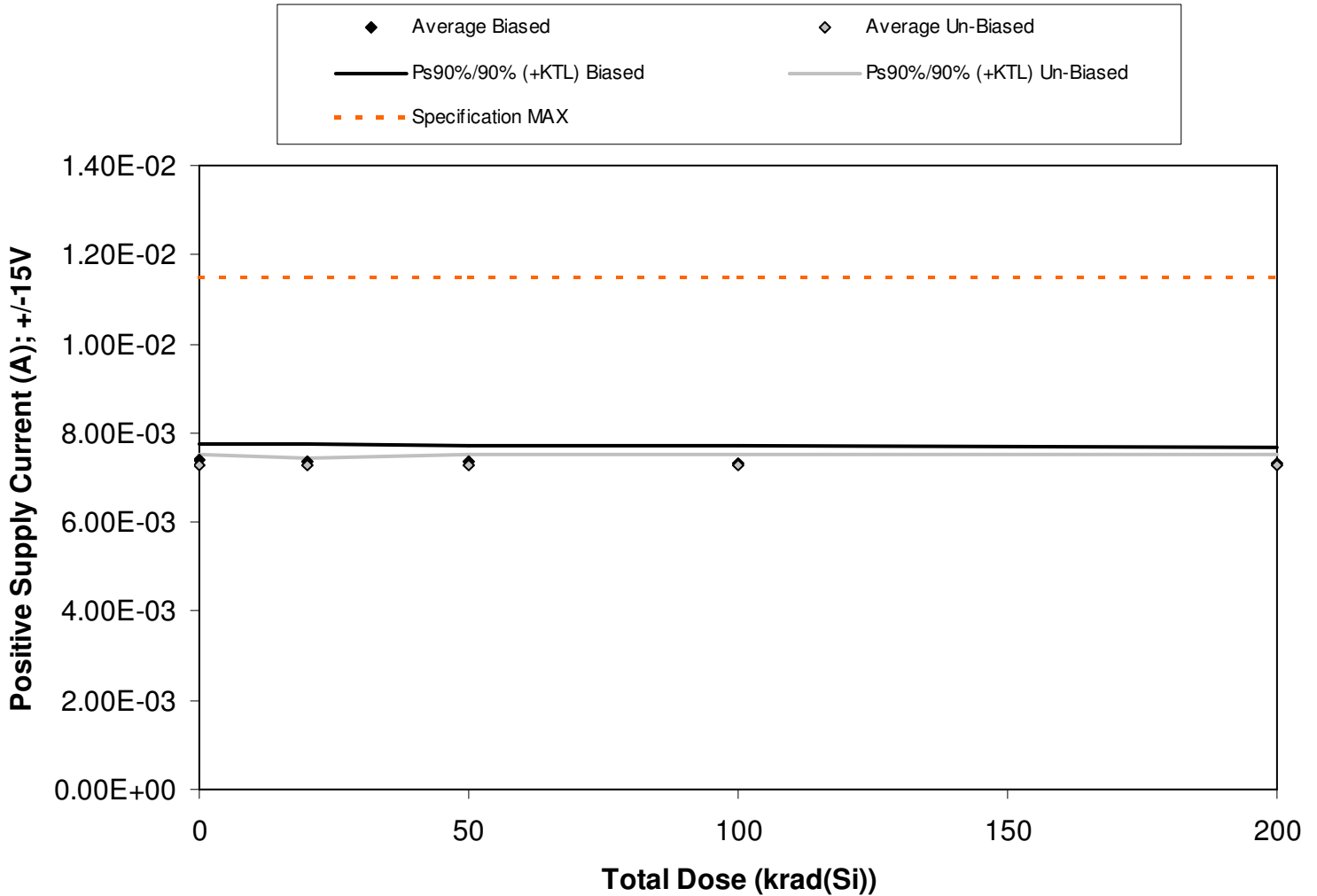**Colorado Springs, CO 80919**
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Figure 5.1. Plot of positive supply current versus total dose. The data show no significant degradation with total dose. The solid diamonds are the average of the measured data points for the sample irradiated under electrical 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 average of the data points after application of the KTL statistics on the sample irradiated in the biased condition while the shaded lines (solid or dashed) are the average of the data points after application of the 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.

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Table 5.1. Raw data of the positive supply current versus total dose, including the statistical analysis, the specification and the status of the testing (pass/fail).

Positive Supply Current (A); +/-15V	Total Dose (krad(Si))				
Device	0	20	50	100	200
694	7.28E-03	7.28E-03	7.28E-03	7.25E-03	7.26E-03
695	7.28E-03	7.27E-03	7.25E-03	7.24E-03	7.23E-03
698	7.58E-03	7.58E-03	7.57E-03	7.54E-03	7.53E-03
699	7.45E-03	7.44E-03	7.42E-03	7.41E-03	7.39E-03
700	7.31E-03	7.30E-03	7.28E-03	7.25E-03	7.25E-03
701	7.36E-03	7.32E-03	7.36E-03	7.36E-03	7.36E-03
702	7.37E-03	7.34E-03	7.36E-03	7.36E-03	7.37E-03
704	7.20E-03	7.19E-03	7.19E-03	7.19E-03	7.18E-03
705	7.21E-03	7.19E-03	7.21E-03	7.20E-03	7.21E-03
706	7.28E-03	7.27E-03	7.28E-03	7.25E-03	7.28E-03
1280	7.25E-03	7.24E-03	7.24E-03	7.24E-03	7.26E-03
Biased Statistics					
Average Biased	7.38E-03	7.37E-03	7.36E-03	7.34E-03	7.33E-03
Std Dev Biased	1.32E-04	1.34E-04	1.35E-04	1.33E-04	1.27E-04
Ps90%/90% (+KTL) Biased	7.74E-03	7.74E-03	7.73E-03	7.70E-03	7.68E-03
Ps90%/90% (-KTL) Biased	7.02E-03	7.01E-03	6.99E-03	6.97E-03	6.98E-03
Un-Biased Statistics					
Average Un-Biased	7.28E-03	7.26E-03	7.28E-03	7.27E-03	7.28E-03
Std Dev Un-Biased	8.02E-05	7.05E-05	8.03E-05	8.35E-05	8.57E-05
Ps90%/90% (+KTL) Un-Biased	7.50E-03	7.46E-03	7.50E-03	7.50E-03	7.52E-03
Ps90%/90% (-KTL) Un-Biased	7.06E-03	7.07E-03	7.06E-03	7.04E-03	7.04E-03
Specification MAX	1.15E-02	1.15E-02	1.15E-02	1.15E-02	1.15E-02
Status	PASS	PASS	PASS	PASS	PASS

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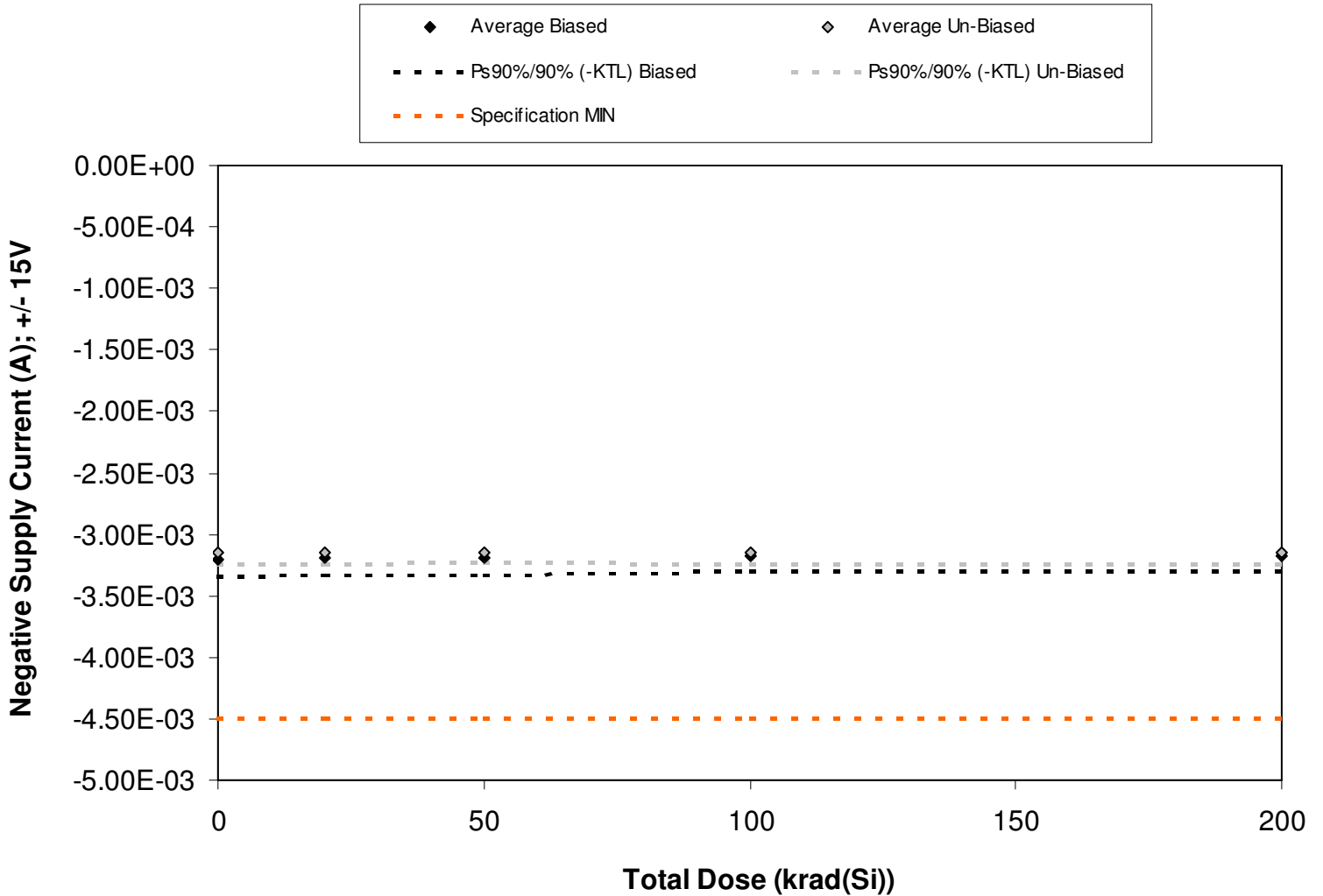**Colorado Springs, CO 80919**
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Figure 5.2. Plot of negative supply current versus total dose. The data show no significant degradation with total dose. The solid diamonds are the average of the measured data points for the sample irradiated under electrical 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 average of the data points after application of the KTL statistics on the sample irradiated in the biased condition while the shaded lines (solid or dashed) are the average of the data points after application of the 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.

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Table 5.2. Raw data for the negative supply current versus total dose, including the statistical analysis, the specification and the status of the testing (pass/fail).

Negative Supply Current (A); +/- 15V	Total Dose (krad(Si))				
Device	0	20	50	100	200
694	-3.17E-03	-3.16E-03	-3.16E-03	-3.15E-03	-3.15E-03
695	-3.15E-03	-3.14E-03	-3.14E-03	-3.14E-03	-3.14E-03
698	-3.28E-03	-3.27E-03	-3.27E-03	-3.25E-03	-3.25E-03
699	-3.23E-03	-3.22E-03	-3.22E-03	-3.21E-03	-3.21E-03
700	-3.17E-03	-3.16E-03	-3.15E-03	-3.15E-03	-3.15E-03
701	-3.17E-03	-3.17E-03	-3.17E-03	-3.17E-03	-3.17E-03
702	-3.19E-03	-3.19E-03	-3.19E-03	-3.19E-03	-3.19E-03
704	-3.11E-03	-3.10E-03	-3.11E-03	-3.11E-03	-3.10E-03
705	-3.12E-03	-3.11E-03	-3.12E-03	-3.12E-03	-3.12E-03
706	-3.16E-03	-3.16E-03	-3.15E-03	-3.16E-03	-3.16E-03
1280	-3.15E-03	-3.15E-03	-3.16E-03	-3.15E-03	-3.16E-03
Biased Statistics					
Average Biased	-3.20E-03	-3.19E-03	-3.19E-03	-3.18E-03	-3.18E-03
Std Dev Biased	5.39E-05	5.39E-05	5.54E-05	4.80E-05	4.80E-05
Ps90%/90% (+KTL) Biased	-3.05E-03	-3.04E-03	-3.04E-03	-3.05E-03	-3.05E-03
Ps90%/90% (-KTL) Biased	-3.35E-03	-3.34E-03	-3.34E-03	-3.31E-03	-3.31E-03
Un-Biased Statistics					
Average Un-Biased	-3.15E-03	-3.15E-03	-3.15E-03	-3.15E-03	-3.15E-03
Std Dev Un-Biased	3.39E-05	3.91E-05	3.35E-05	3.39E-05	3.70E-05
Ps90%/90% (+KTL) Un-Biased	-3.06E-03	-3.04E-03	-3.06E-03	-3.06E-03	-3.05E-03
Ps90%/90% (-KTL) Un-Biased	-3.24E-03	-3.25E-03	-3.24E-03	-3.24E-03	-3.25E-03
Specification MIN	-4.50E-03	-4.50E-03	-4.50E-03	-4.50E-03	-4.50E-03
Status	PASS	PASS	PASS	PASS	PASS

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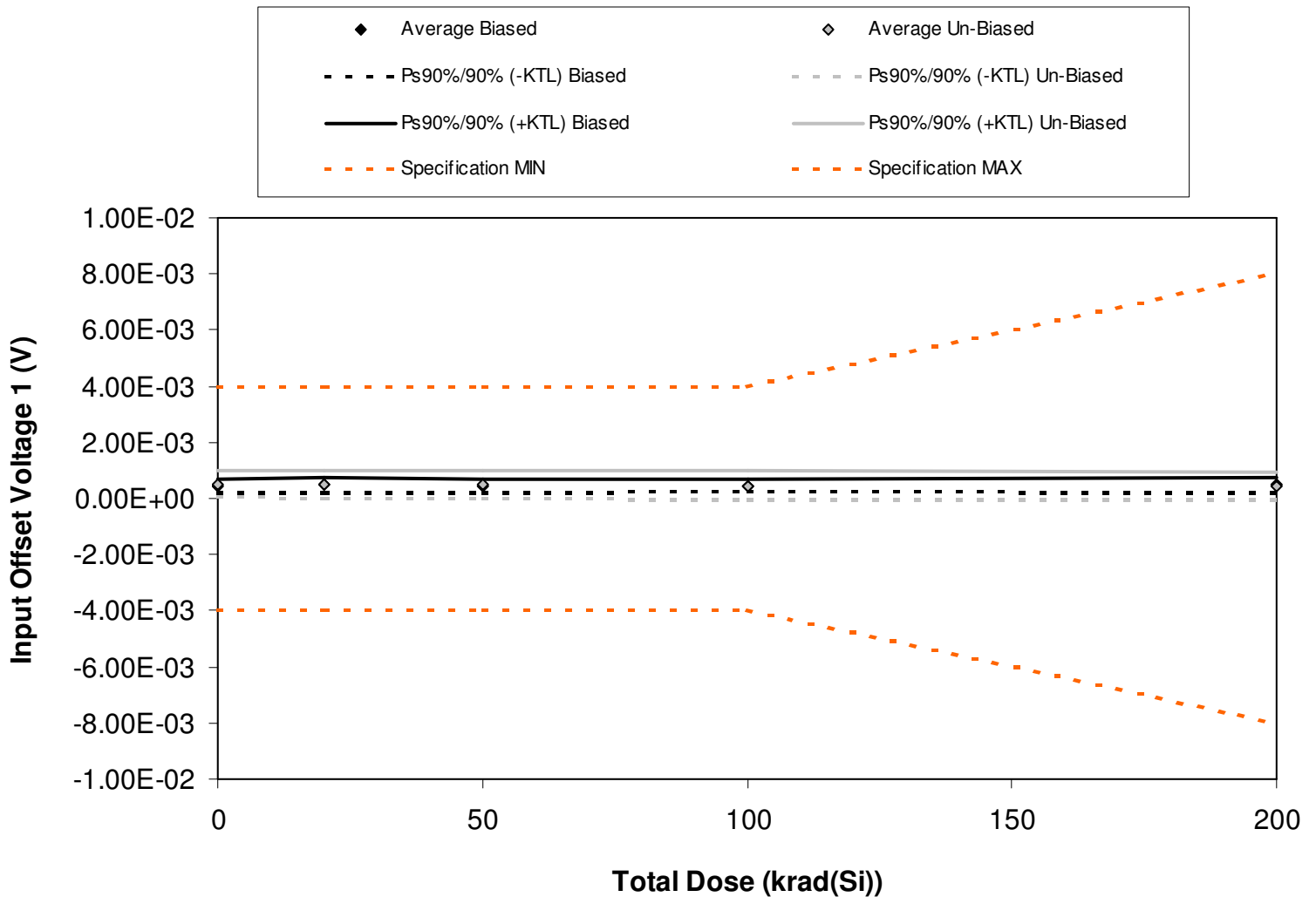**Colorado Springs, CO 80919**
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Figure 5.3. Plot of input offset voltage (comparator 1) versus total dose. The data show no significant degradation with total dose. The solid diamonds are the average of the measured data points for the sample irradiated 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 average of the data points after application of the KTL statistics on the sample irradiated in the biased condition while the shaded lines (solid or dashed) are the average of the data points after application of the 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.

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Table 5.3. Raw data of input offset voltage (comparator 1) versus total dose, including the statistical analysis, the specification and the status of the testing (pass/fail).

Input Offset Voltage 1 (V)	Total Dose (krad(Si))				
Device	0	20	50	100	200
694	4.10E-04	4.50E-04	4.60E-04	4.40E-04	4.50E-04
695	3.00E-04	3.20E-04	3.20E-04	3.30E-04	3.10E-04
698	5.20E-04	5.40E-04	5.30E-04	5.20E-04	5.40E-04
699	5.10E-04	5.40E-04	5.50E-04	4.90E-04	5.30E-04
700	5.00E-04	5.20E-04	4.50E-04	5.00E-04	5.20E-04
701	3.40E-04	3.30E-04	3.30E-04	2.80E-04	2.50E-04
702	5.00E-04	4.60E-04	4.70E-04	4.40E-04	4.40E-04
704	3.90E-04	3.60E-04	3.40E-04	3.10E-04	3.00E-04
705	5.50E-04	5.50E-04	5.40E-04	5.20E-04	5.00E-04
706	7.80E-04	7.80E-04	7.70E-04	7.60E-04	7.20E-04
1280	6.90E-04	7.10E-04	6.90E-04	7.00E-04	7.00E-04
Biased Statistics					
Average Biased	4.48E-04	4.74E-04	4.62E-04	4.56E-04	4.70E-04
Std Dev Biased	9.36E-05	9.37E-05	9.04E-05	7.64E-05	9.62E-05
Ps90%/90% (+KTL) Biased	7.05E-04	7.31E-04	7.10E-04	6.65E-04	7.34E-04
Ps90%/90% (-KTL) Biased	1.91E-04	2.17E-04	2.14E-04	2.47E-04	2.06E-04
Un-Biased Statistics					
Average Un-Biased	5.12E-04	4.96E-04	4.90E-04	4.62E-04	4.42E-04
Std Dev Un-Biased	1.72E-04	1.81E-04	1.80E-04	1.93E-04	1.86E-04
Ps90%/90% (+KTL) Un-Biased	9.83E-04	9.92E-04	9.83E-04	9.91E-04	9.51E-04
Ps90%/90% (-KTL) Un-Biased	4.13E-05	-6.71E-08	-3.18E-06	-6.70E-05	-6.67E-05
Specification MIN	-4.00E-03	-4.00E-03	-4.00E-03	-4.00E-03	-8.00E-03
Status	PASS	PASS	PASS	PASS	PASS
Specification MAX	4.00E-03	4.00E-03	4.00E-03	4.00E-03	8.00E-03
Status	PASS	PASS	PASS	PASS	PASS

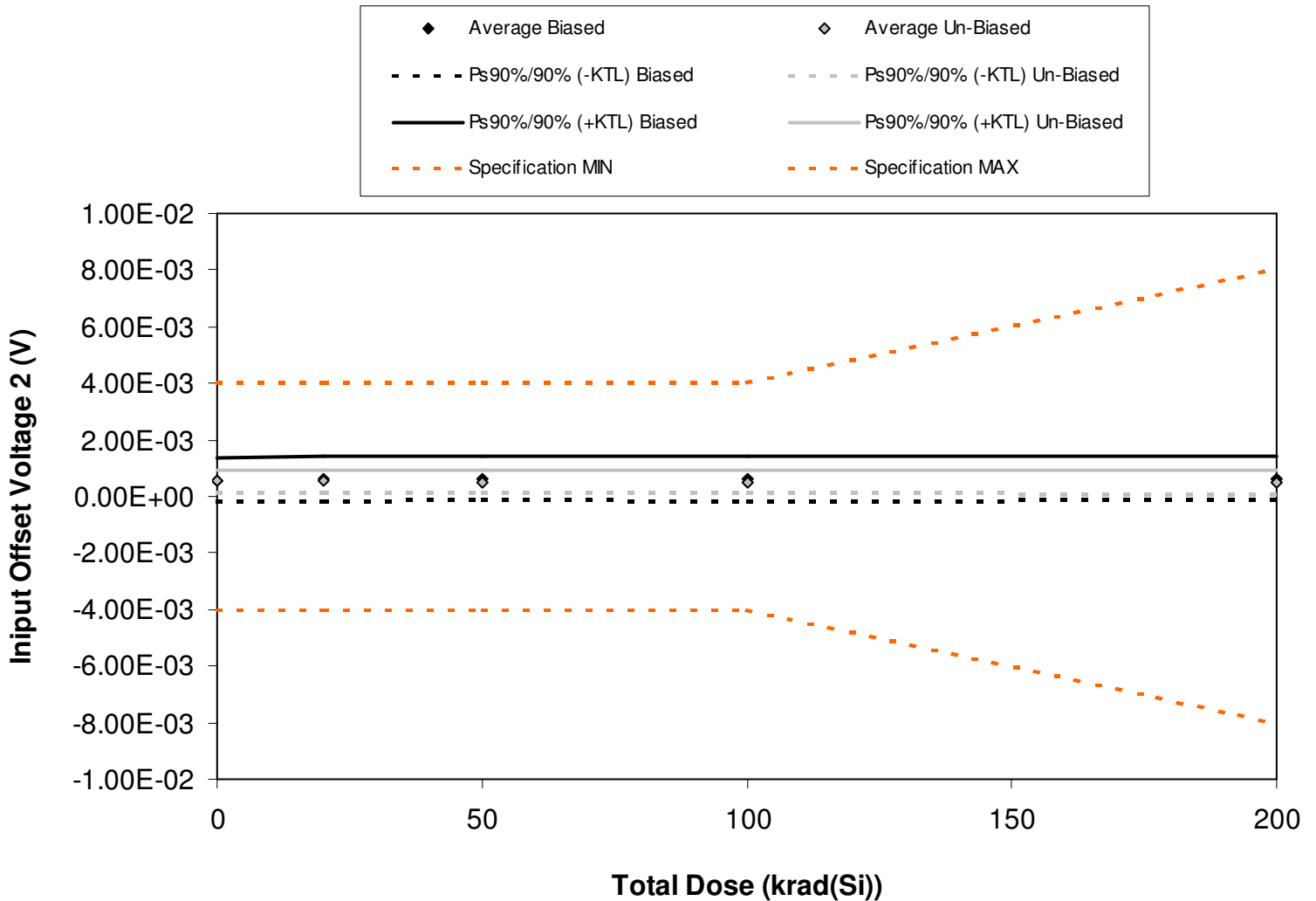**An ISO 9001:2000 Certified Company**

Figure 5.4.   Plot of input offset voltage (comparator 2) versus total dose.   The data show no significant degradation with total dose. 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 average of the data points after application of the KTL statistics on the sample irradiated in the biased condition while the shaded lines (solid or dashed) are the average of the data points after application of the 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.

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Table 5.4. Raw data of input offset voltage (comparator 2) versus total dose, including the statistical analysis, the specification and the status of the testing (pass/fail).

Iniput Offset Voltage 2 (V)	Total Dose (krad(Si))				
Device	0	20	50	100	200
694	4.40E-04	4.90E-04	5.00E-04	5.10E-04	5.10E-04
695	9.10E-04	9.60E-04	9.70E-04	9.90E-04	9.70E-04
698	4.30E-04	4.30E-04	4.30E-04	4.60E-04	4.70E-04
699	2.90E-04	3.30E-04	3.50E-04	3.30E-04	3.60E-04
700	8.50E-04	8.80E-04	9.00E-04	9.10E-04	9.10E-04
701	6.10E-04	6.00E-04	5.90E-04	5.90E-04	5.70E-04
702	3.80E-04	3.80E-04	3.80E-04	3.60E-04	3.50E-04
704	6.00E-04	6.00E-04	5.90E-04	5.80E-04	5.70E-04
705	3.60E-04	3.60E-04	3.50E-04	3.40E-04	3.30E-04
706	6.80E-04	6.90E-04	6.80E-04	6.80E-04	6.60E-04
1280	5.80E-04	5.90E-04	6.00E-04	5.90E-04	5.90E-04
Biased Statistics					
Average Biased	5.84E-04	6.18E-04	6.30E-04	6.40E-04	6.44E-04
Std Dev Biased	2.77E-04	2.83E-04	2.85E-04	2.92E-04	2.77E-04
Ps90%/90% (+KTL) Biased	1.34E-03	1.39E-03	1.41E-03	1.44E-03	1.40E-03
Ps90%/90% (-KTL) Biased	-1.77E-04	-1.58E-04	-1.50E-04	-1.60E-04	-1.14E-04
Un-Biased Statistics					
Average Un-Biased	5.26E-04	5.26E-04	5.18E-04	5.10E-04	4.96E-04
Std Dev Un-Biased	1.46E-04	1.47E-04	1.45E-04	1.51E-04	1.47E-04
Ps90%/90% (+KTL) Un-Biased	9.26E-04	9.30E-04	9.15E-04	9.25E-04	9.00E-04
Ps90%/90% (-KTL) Un-Biased	1.26E-04	1.22E-04	1.21E-04	9.51E-05	9.23E-05
Specification MIN	-4.00E-03	-4.00E-03	-4.00E-03	-4.00E-03	-8.00E-03
Status	PASS	PASS	PASS	PASS	PASS
Specification MAX	4.00E-03	4.00E-03	4.00E-03	4.00E-03	8.00E-03
Status	PASS	PASS	PASS	PASS	PASS

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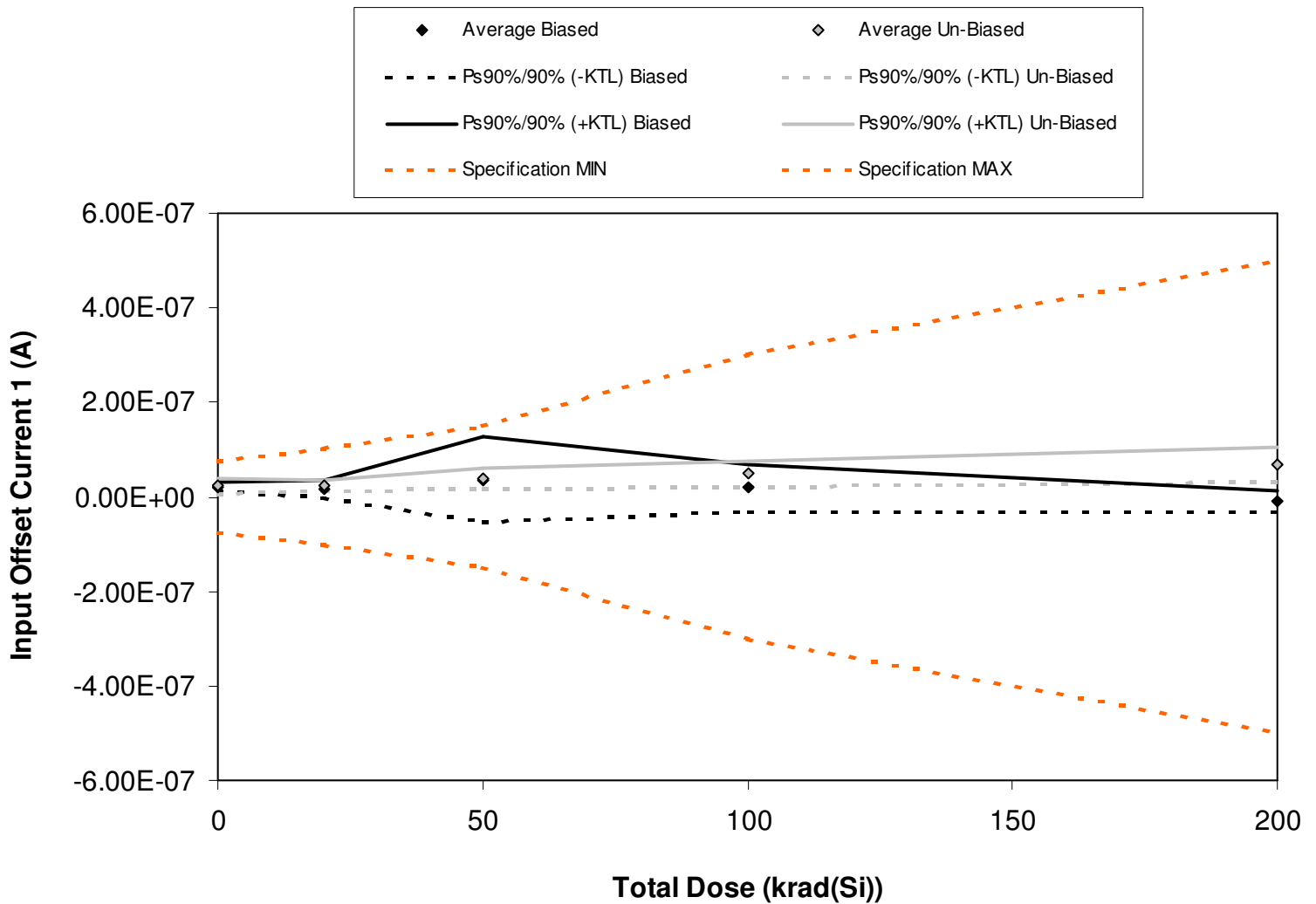**Colorado Springs, CO 80919**
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Figure 5.5. Plot of input offset current (comparator 1) versus total dose. The data show a modest degradation with total dose, however it stays within specification to the maximum total dose tested. The solid diamonds 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 average of the data points after application of the KTL statistics on the sample irradiated in the biased condition while the shaded lines (solid or dashed) are the average of the data points after application of the 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.

Table 5.5. Raw data of input offset current (comparator 1) versus total dose, including the statistical analysis, the specification and the status of the testing (pass/fail).

Input Offset Current 1 (A)	Total Dose (krad(Si))				
Device	0	20	50	100	200
694	1.92E-08	1.46E-08	2.43E-08	1.97E-08	-1.39E-08
695	1.76E-08	8.75E-09	3.91E-09	-2.00E-11	3.79E-09
698	2.20E-08	2.39E-08	4.06E-08	6.08E-09	-1.74E-08
699	2.66E-08	2.33E-08	2.18E-08	4.75E-08	-1.42E-08
700	2.16E-08	1.09E-08	9.16E-08	2.39E-08	-5.85E-09
701	2.78E-08	2.51E-08	3.81E-08	4.72E-08	6.35E-08
702	2.85E-08	3.21E-08	4.97E-08	6.48E-08	8.55E-08
704	2.39E-08	2.57E-08	3.79E-08	4.82E-08	6.80E-08
705	1.31E-08	2.12E-08	2.84E-08	3.70E-08	4.78E-08
706	1.85E-08	2.37E-08	3.28E-08	5.00E-08	7.48E-08
1280	-6.61E-09	-3.80E-09	-7.14E-09	-7.82E-09	-7.22E-09
Biased Statistics					
Average Biased	2.14E-08	1.63E-08	3.64E-08	1.94E-08	-9.51E-09
Std Dev Biased	3.43E-09	6.99E-09	3.35E-08	1.85E-08	8.57E-09
Ps90%/90% (+KTL) Biased	3.08E-08	3.55E-08	1.28E-07	7.01E-08	1.40E-08
Ps90%/90% (-KTL) Biased	1.20E-08	-2.89E-09	-5.53E-08	-3.12E-08	-3.30E-08
Un-Biased Statistics					
Average Un-Biased	2.24E-08	2.56E-08	3.74E-08	4.94E-08	6.79E-08
Std Dev Un-Biased	6.54E-09	4.04E-09	7.97E-09	9.96E-09	1.40E-08
Ps90%/90% (+KTL) Un-Biased	4.03E-08	3.66E-08	5.92E-08	7.67E-08	1.06E-07
Ps90%/90% (-KTL) Un-Biased	4.42E-09	1.45E-08	1.55E-08	2.21E-08	2.96E-08
Specification MIN	-7.50E-08	-1.00E-07	-1.50E-07	-3.00E-07	-5.00E-07
Status	PASS	PASS	PASS	PASS	PASS
Specification MAX	7.50E-08	1.00E-07	1.50E-07	3.00E-07	5.00E-07
Status	PASS	PASS	PASS	PASS	PASS

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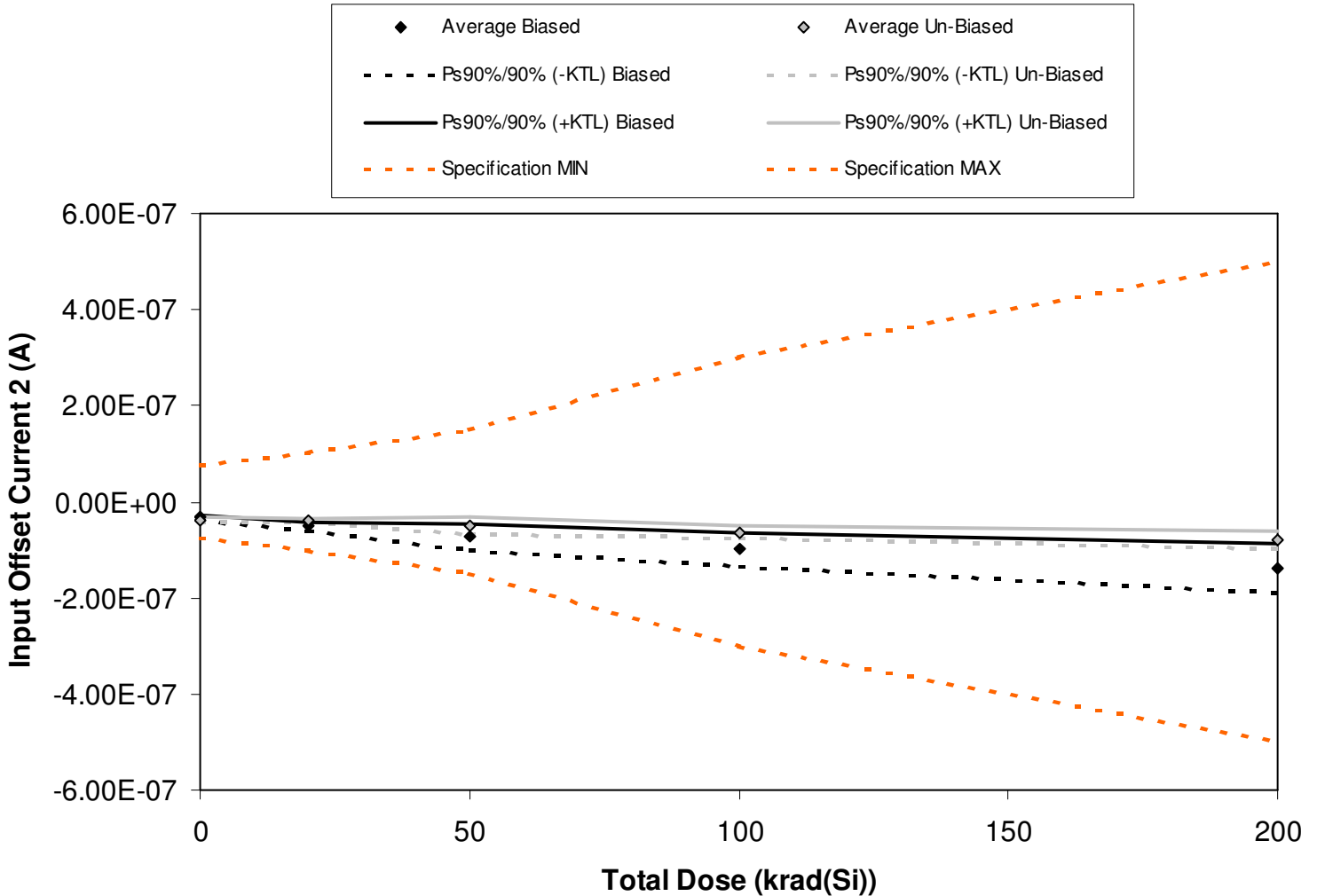**Colorado Springs, CO 80919**
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Figure 5.6. Plot of input offset current (comparator 2) versus total dose. The data show a modest degradation with total dose, however it stays within specification to the maximum total dose tested. The solid diamonds 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 average of the data points after application of the KTL statistics on the sample irradiated in the biased condition while the shaded lines (solid or dashed) are the average of the data points after application of the 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.

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Table 5.6. Raw data of input offset current (comparator 2) versus total dose, including the statistical analysis, the specification and the status of the testing (pass/fail).

Input Offset Current 2 (A)	Total Dose (krad(Si))				
Device	0	20	50	100	200
694	-2.93E-08	-4.84E-08	-5.83E-08	-7.85E-08	-1.39E-07
695	-3.18E-08	-5.29E-08	-7.04E-08	-9.93E-08	-1.09E-07
698	-3.57E-08	-5.22E-08	-8.66E-08	-9.75E-08	-1.36E-07
699	-3.27E-08	-4.81E-08	-7.31E-08	-1.12E-07	-1.52E-07
700	-3.31E-08	-5.54E-08	-7.56E-08	-1.06E-07	-1.55E-07
701	-4.01E-08	-3.92E-08	-4.75E-08	-6.14E-08	-7.68E-08
702	-3.37E-08	-3.76E-08	-4.89E-08	-6.26E-08	-7.56E-08
704	-3.81E-08	-3.96E-08	-5.95E-08	-6.78E-08	-8.11E-08
705	-3.61E-08	-3.66E-08	-4.27E-08	-5.75E-08	-7.26E-08
706	-3.81E-08	-4.02E-08	-5.40E-08	-6.84E-08	-8.97E-08
1280	-1.08E-08	-1.23E-08	-1.12E-08	-1.19E-08	-1.18E-08
Biased Statistics					
Average Biased	-3.25E-08	-5.14E-08	-7.28E-08	-9.88E-08	-1.38E-07
Std Dev Biased	2.31E-09	3.12E-09	1.02E-08	1.27E-08	1.86E-08
Ps90%/90% (+KTL) Biased	-2.62E-08	-4.28E-08	-4.50E-08	-6.38E-08	-8.71E-08
Ps90%/90% (-KTL) Biased	-3.89E-08	-5.99E-08	-1.01E-07	-1.34E-07	-1.89E-07
Un-Biased Statistics					
Average Un-Biased	-3.72E-08	-3.86E-08	-5.05E-08	-6.35E-08	-7.92E-08
Std Dev Un-Biased	2.44E-09	1.47E-09	6.44E-09	4.55E-09	6.63E-09
Ps90%/90% (+KTL) Un-Biased	-3.05E-08	-3.46E-08	-3.28E-08	-5.10E-08	-6.10E-08
Ps90%/90% (-KTL) Un-Biased	-4.39E-08	-4.27E-08	-6.82E-08	-7.60E-08	-9.73E-08
Specification MIN	-7.50E-08	-1.00E-07	-1.50E-07	-3.00E-07	-5.00E-07
Status	PASS	PASS	PASS	PASS	PASS
Specification MAX	7.50E-08	1.00E-07	1.50E-07	3.00E-07	5.00E-07
Status	PASS	PASS	PASS	PASS	PASS

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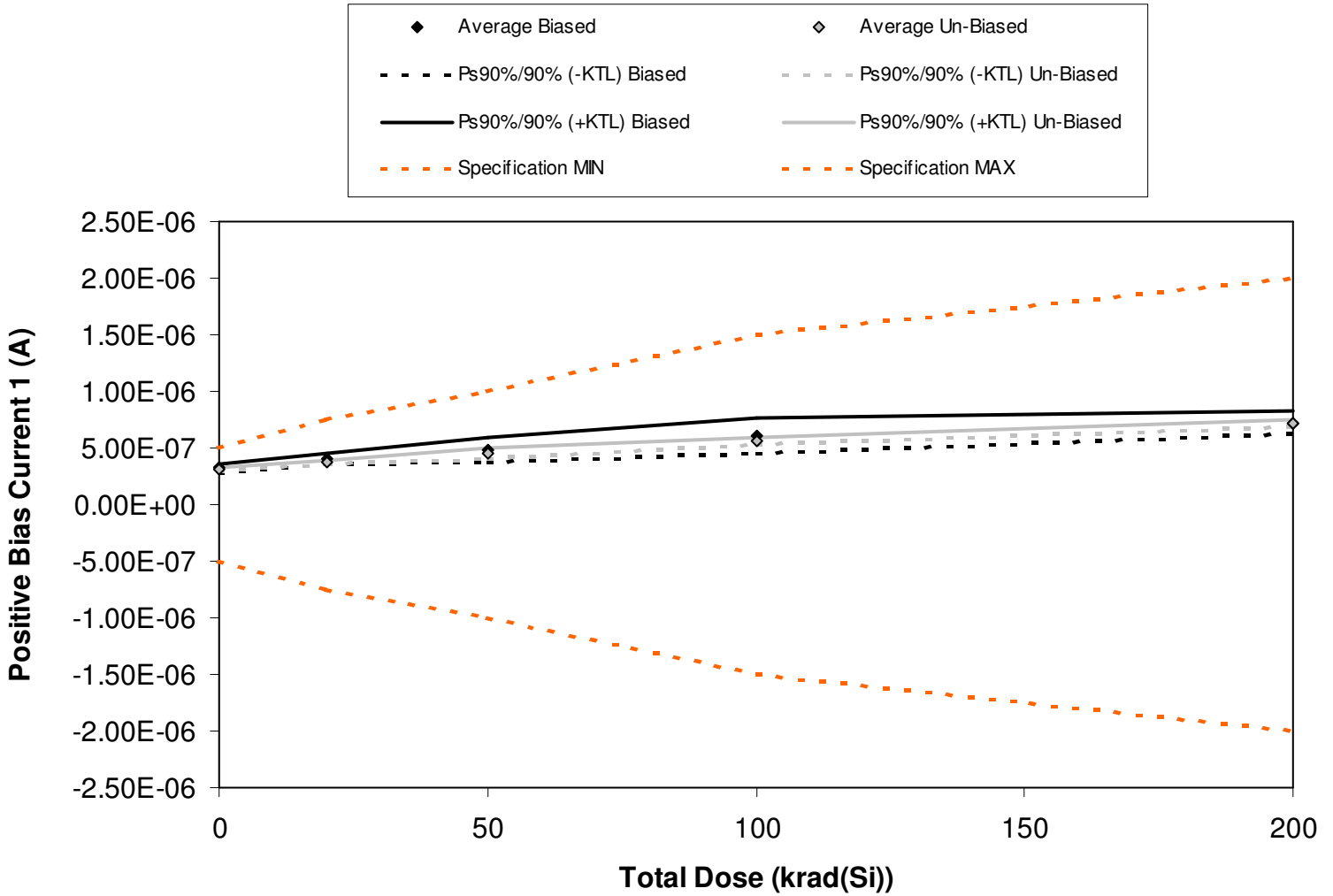**Colorado Springs, CO 80919**
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Figure 5.7. Plot of input bias current, non-inverting input (comparator 1) versus total dose. The data show a modest degradation with total dose, however it stays within specification to the maximum total dose tested. The solid diamonds are the average of measured data points from the biased sample (devices irradiated with an electrical bias) while the shaded diamonds are the average from the un-biased sample. The black lines show the effects on the data after application of the biased KTL statistics (solid and dashed lines) while the gray lines show the effects on the data after application of the unbiased KTL statistics (solid and dashed lines). The red dashed lines are the minimum and maximum specification values as defined in the datasheet and/or test plan.

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Table 5.5. Raw data of input bias current, non-inverting input (comparator 1) versus total dose, including the statistical analysis, the specification and the status of the testing (pass/fail).

Positive Bias Current 1 (A)	Total Dose (krad(Si))				
Device	0	20	50	100	200
694	3.18E-07	4.01E-07	4.52E-07	5.75E-07	7.26E-07
695	2.99E-07	3.84E-07	4.66E-07	5.64E-07	6.67E-07
698	3.27E-07	4.23E-07	5.32E-07	6.05E-07	7.44E-07
699	3.36E-07	4.16E-07	5.16E-07	7.04E-07	7.58E-07
700	3.27E-07	4.15E-07	4.53E-07	5.90E-07	7.32E-07
701	3.14E-07	3.84E-07	4.65E-07	5.67E-07	7.09E-07
702	3.11E-07	3.80E-07	4.51E-07	5.63E-07	7.06E-07
704	3.11E-07	3.83E-07	4.64E-07	5.70E-07	7.05E-07
705	3.21E-07	3.89E-07	4.43E-07	5.80E-07	7.18E-07
706	3.09E-07	3.73E-07	4.21E-07	5.47E-07	7.31E-07
1280	3.27E-07	3.29E-07	3.32E-07	3.30E-07	3.32E-07
Biased Statistics					
Average Biased	3.21E-07	4.08E-07	4.84E-07	6.08E-07	7.26E-07
Std Dev Biased	1.41E-08	1.53E-08	3.77E-08	5.58E-08	3.48E-08
Ps90%/90% (+KTL) Biased	3.60E-07	4.50E-07	5.87E-07	7.60E-07	8.21E-07
Ps90%/90% (-KTL) Biased	2.83E-07	3.66E-07	3.80E-07	4.55E-07	6.30E-07
Un-Biased Statistics					
Average Un-Biased	3.13E-07	3.82E-07	4.49E-07	5.65E-07	7.14E-07
Std Dev Un-Biased	4.76E-09	5.84E-09	1.82E-08	1.19E-08	1.08E-08
Ps90%/90% (+KTL) Un-Biased	3.26E-07	3.98E-07	4.99E-07	5.98E-07	7.43E-07
Ps90%/90% (-KTL) Un-Biased	3.00E-07	3.66E-07	3.99E-07	5.33E-07	6.84E-07
Specification MIN	-5.00E-07	-7.50E-07	-1.00E-06	-1.50E-06	-2.00E-06
Status	PASS	PASS	PASS	PASS	PASS
Specification MAX	5.00E-07	7.50E-07	1.00E-06	1.50E-06	2.00E-06
Status	PASS	PASS	PASS	PASS	PASS

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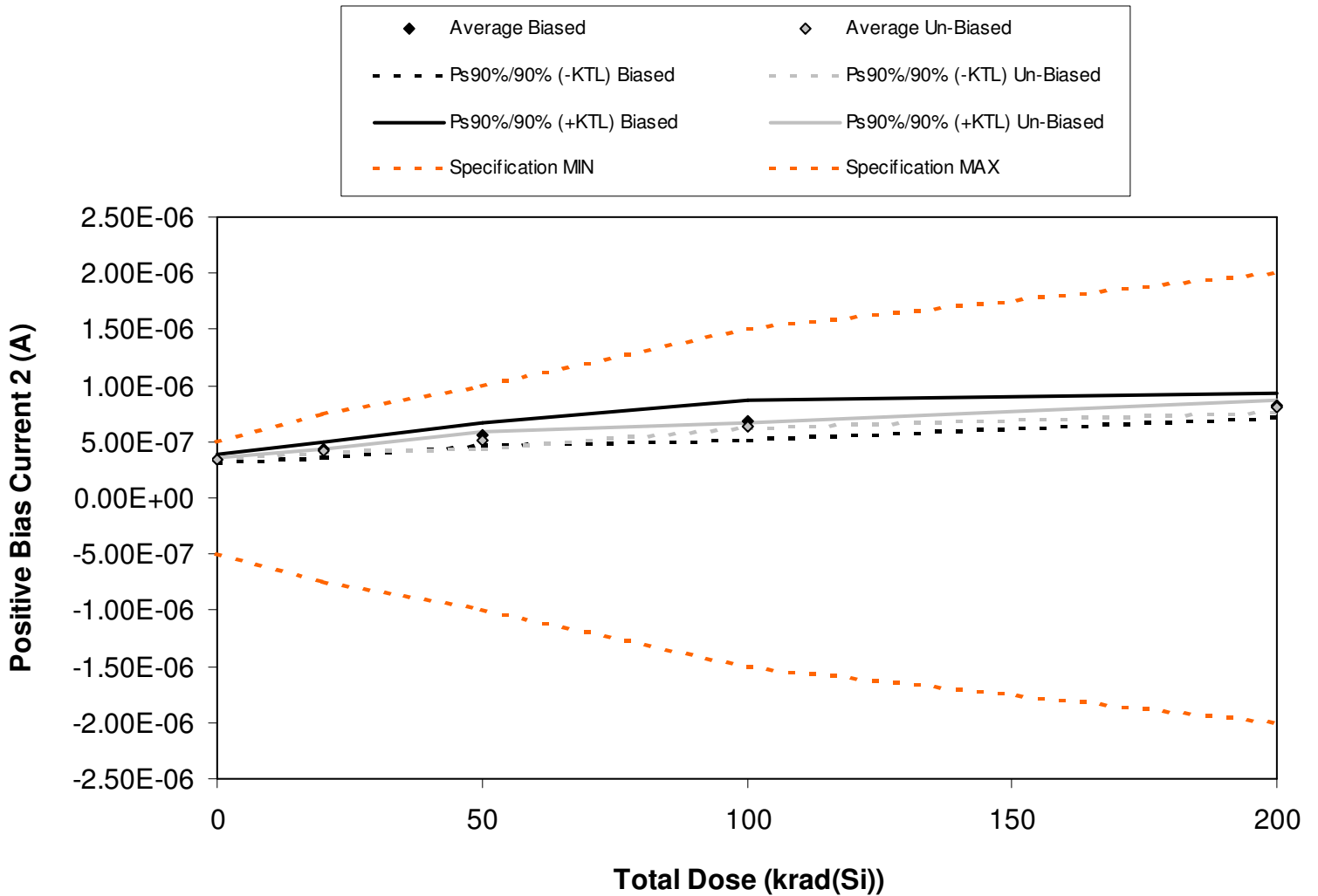**Colorado Springs, CO 80919**
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Figure 5.8. Plot of input bias current, non-inverting input (comparator 2) versus total dose. The data show a modest degradation with total dose, however it stays within specification to the maximum total dose tested. The solid diamonds are the average of measured data points from the biased sample (devices irradiated with an electrical bias) while the shaded diamonds are the average from the un-biased sample. The black lines show the effects on the data after application of the biased KTL statistics (solid and dashed lines) while the gray lines show the effects on the data after application of the unbiased KTL statistics (solid and dashed lines). The red dashed lines are the minimum and maximum specification values as defined in the datasheet and/or test plan.

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Table 5.6. Raw data of input bias current, non-inverting input (comparator 2) versus total dose, including the statistical analysis, the specification and the status of the testing (pass/fail).

Positive Bias Current 2 (A)	Total Dose (krad(Si))				
Device	0	20	50	100	200
694	3.47E-07	4.42E-07	5.40E-07	6.51E-07	8.29E-07
695	3.24E-07	4.02E-07	5.20E-07	6.34E-07	7.53E-07
698	3.57E-07	4.55E-07	6.18E-07	6.82E-07	8.29E-07
699	3.62E-07	4.58E-07	5.73E-07	8.04E-07	8.61E-07
700	3.56E-07	4.09E-07	5.62E-07	6.81E-07	8.46E-07
701	3.47E-07	4.21E-07	5.20E-07	6.34E-07	7.96E-07
702	3.43E-07	4.16E-07	5.19E-07	6.44E-07	8.13E-07
704	3.45E-07	4.22E-07	5.43E-07	6.51E-07	8.15E-07
705	3.44E-07	4.18E-07	4.63E-07	6.35E-07	7.93E-07
706	3.38E-07	4.11E-07	5.11E-07	6.28E-07	8.47E-07
1280	3.36E-07	3.36E-07	3.35E-07	3.36E-07	3.36E-07
Biased Statistics					
Average Biased	3.49E-07	4.33E-07	5.63E-07	6.90E-07	8.24E-07
Std Dev Biased	1.53E-08	2.60E-08	3.69E-08	6.67E-08	4.15E-08
Ps90%/90% (+KTL) Biased	3.91E-07	5.04E-07	6.64E-07	8.73E-07	9.37E-07
Ps90%/90% (-KTL) Biased	3.07E-07	3.62E-07	4.61E-07	5.08E-07	7.10E-07
Un-Biased Statistics					
Average Un-Biased	3.43E-07	4.18E-07	5.11E-07	6.39E-07	8.13E-07
Std Dev Un-Biased	3.24E-09	4.46E-09	2.93E-08	9.18E-09	2.14E-08
Ps90%/90% (+KTL) Un-Biased	3.52E-07	4.30E-07	5.91E-07	6.64E-07	8.72E-07
Ps90%/90% (-KTL) Un-Biased	3.34E-07	4.05E-07	4.31E-07	6.13E-07	7.54E-07
Specification MIN	-5.00E-07	-7.50E-07	-1.00E-06	-1.50E-06	-2.00E-06
Status	PASS	PASS	PASS	PASS	PASS
Specification MAX	5.00E-07	7.50E-07	1.00E-06	1.50E-06	2.00E-06
Status	PASS	PASS	PASS	PASS	PASS

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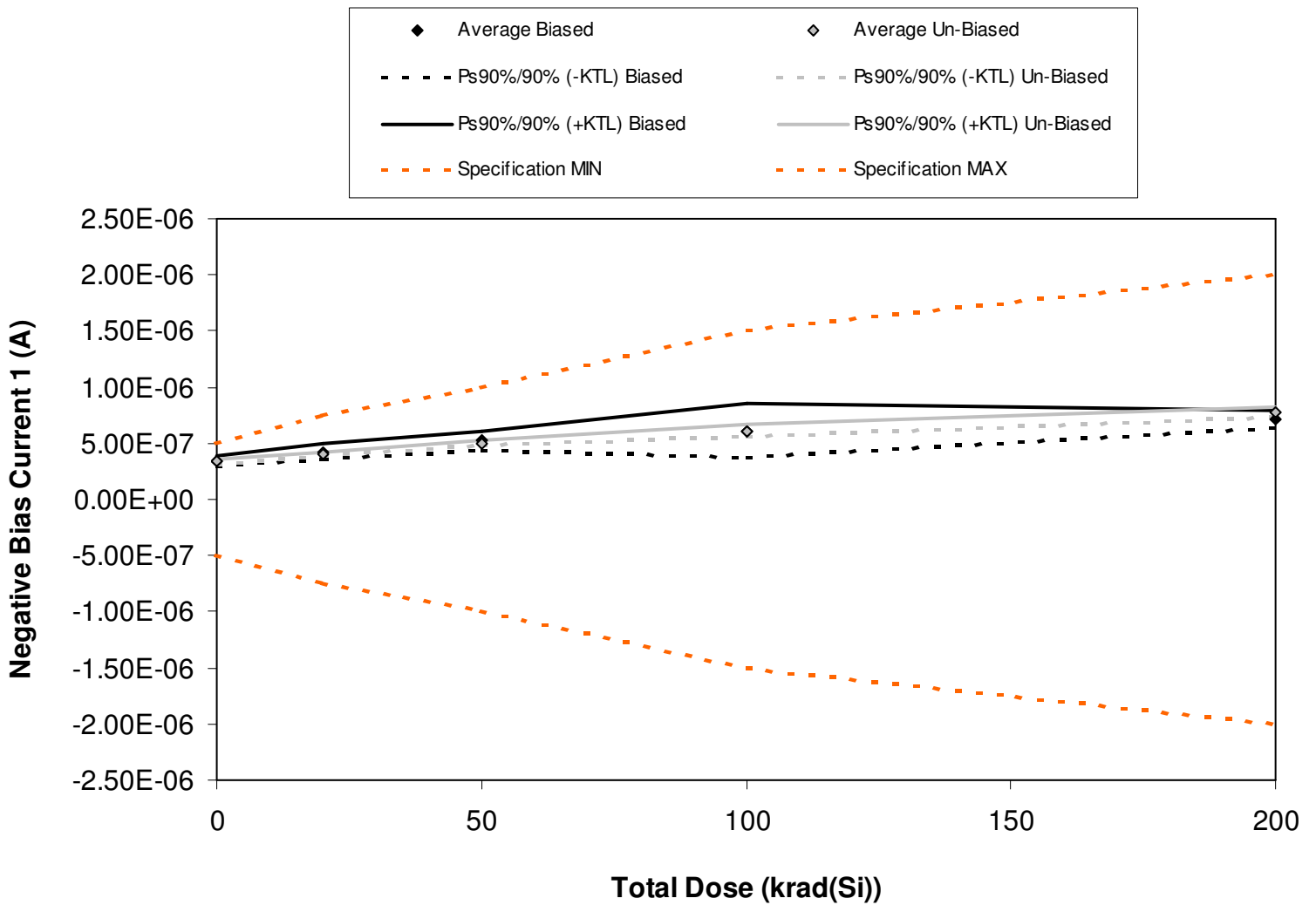**Colorado Springs, CO 80919**
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Figure 5.9. Plot of input bias current, inverting input (comparator 1) versus total dose. The data show a modest degradation with total dose, however it stays within specification to the maximum total dose tested. The solid diamonds are the average of measured data points from the biased sample (devices irradiated with an electrical bias) while the shaded diamonds are the average from the un-biased sample. The black lines show the effects on the data after application of the biased KTL statistics (solid and dashed lines) while the gray lines show the effects on the data after application of the unbiased KTL statistics (solid and dashed lines). The red dashed lines are the minimum and maximum specification values as defined in the datasheet and/or test plan.

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Table 5.7. Raw data for the input bias current, inverting input (comparator 1) versus total dose, including the statistical analysis, the specification and the status of the testing (pass/fail).

Negative Bias Current 1 (A)	Total Dose (krad(Si))				
Device	0	20	50	100	200
694	3.37E-07	4.15E-07	5.07E-07	5.41E-07	7.13E-07
695	3.15E-07	3.90E-07	4.75E-07	5.31E-07	6.75E-07
698	3.46E-07	4.50E-07	5.51E-07	6.14E-07	7.22E-07
699	3.61E-07	4.43E-07	5.35E-07	7.52E-07	7.47E-07
700	3.44E-07	4.24E-07	5.43E-07	6.15E-07	7.28E-07
701	3.42E-07	4.10E-07	5.06E-07	6.15E-07	7.70E-07
702	3.40E-07	4.12E-07	5.08E-07	6.27E-07	7.94E-07
704	3.38E-07	4.09E-07	5.03E-07	6.17E-07	7.77E-07
705	3.35E-07	4.05E-07	5.01E-07	6.13E-07	7.64E-07
706	3.23E-07	3.96E-07	4.88E-07	5.73E-07	8.04E-07
1280	3.21E-07	3.22E-07	3.20E-07	3.20E-07	3.22E-07
Biased Statistics					
Average Biased	3.40E-07	4.25E-07	5.22E-07	6.11E-07	7.17E-07
Std Dev Biased	1.68E-08	2.38E-08	3.13E-08	8.82E-08	2.66E-08
Ps90%/90% (+KTL) Biased	3.86E-07	4.90E-07	6.08E-07	8.52E-07	7.90E-07
Ps90%/90% (-KTL) Biased	2.94E-07	3.59E-07	4.36E-07	3.69E-07	6.44E-07
Un-Biased Statistics					
Average Un-Biased	3.36E-07	4.06E-07	5.01E-07	6.09E-07	7.82E-07
Std Dev Un-Biased	7.51E-09	6.55E-09	7.88E-09	2.08E-08	1.68E-08
Ps90%/90% (+KTL) Un-Biased	3.56E-07	4.24E-07	5.23E-07	6.66E-07	8.28E-07
Ps90%/90% (-KTL) Un-Biased	3.15E-07	3.88E-07	4.80E-07	5.52E-07	7.36E-07
Specification MIN	-5.00E-07	-7.50E-07	-1.00E-06	-1.50E-06	-2.00E-06
Status	PASS	PASS	PASS	PASS	PASS
Specification MAX	5.00E-07	7.50E-07	1.00E-06	1.50E-06	2.00E-06
Status	PASS	PASS	PASS	PASS	PASS

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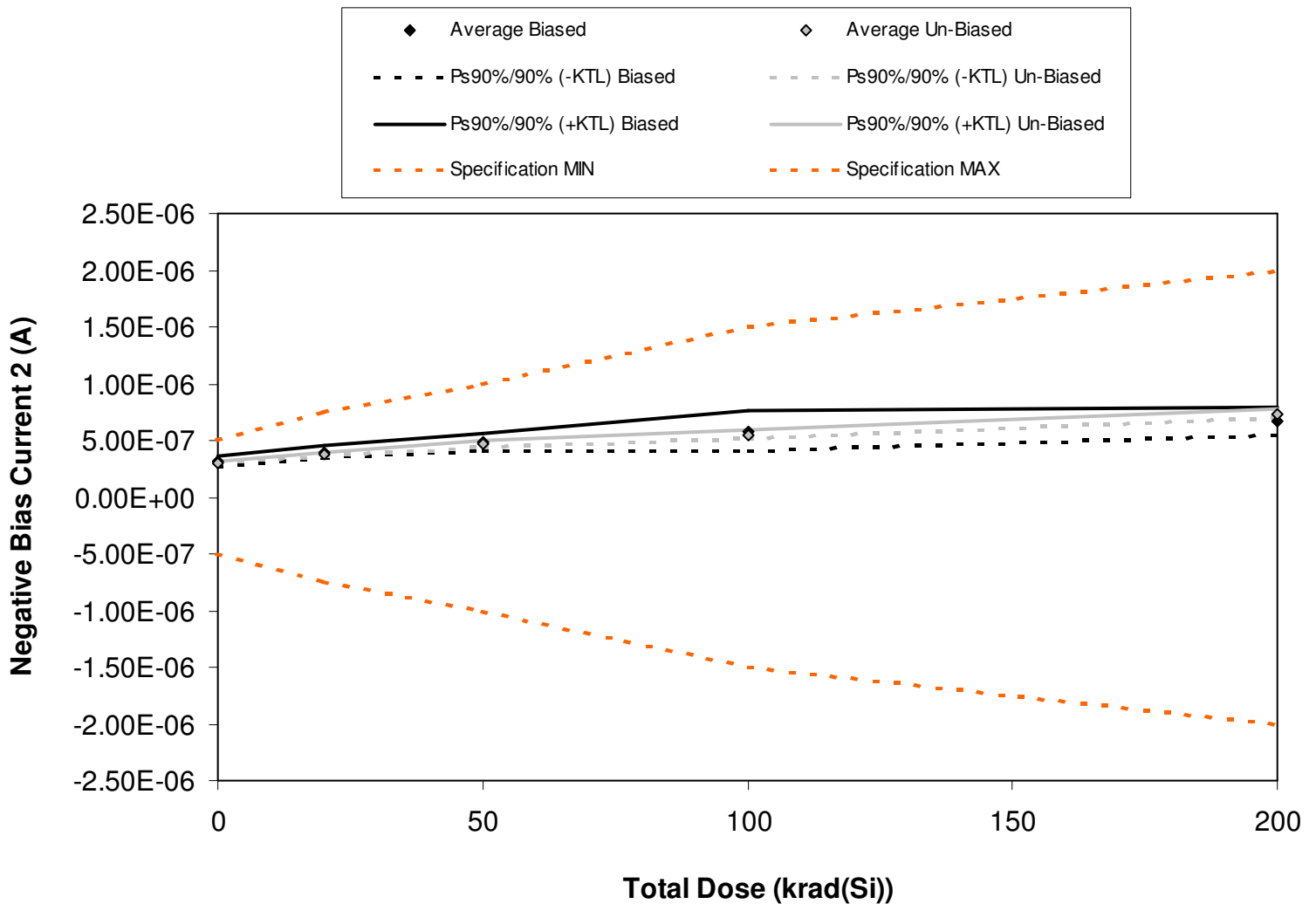**Colorado Springs, CO 80919**
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Figure 5.10. Plot of input bias current, inverting input (comparator 2) versus total dose. The data show a modest degradation with total dose, however it stays within specification to the maximum total dose tested. The solid diamonds are the average of measured data points from the biased sample (devices irradiated with an electrical bias) while the shaded diamonds are the average from the un-biased sample. The black lines show the effects on the data after application of the biased KTL statistics (solid and dashed lines) while the gray lines show the effects on the data after application of the unbiased KTL statistics (solid and dashed lines). The red dashed lines are the minimum and maximum specification values as defined in the datasheet and/or test plan.

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Table 5.10. Raw data for the input bias current, inverting input (comparator 2) versus total dose, including the statistical analysis, the specification and the status of the testing (pass/fail).

Negative Bias Current 2 (A)	Total Dose (krad(Si))				
Device	0	20	50	100	200
694	3.18E-07	3.94E-07	4.80E-07	5.49E-07	6.90E-07
695	2.90E-07	3.66E-07	4.49E-07	5.34E-07	5.95E-07
698	3.22E-07	4.21E-07	5.30E-07	5.44E-07	6.94E-07
699	3.27E-07	4.09E-07	4.99E-07	6.90E-07	7.05E-07
700	3.22E-07	4.02E-07	4.85E-07	5.74E-07	6.90E-07
701	3.07E-07	3.79E-07	4.69E-07	5.57E-07	7.17E-07
702	3.09E-07	3.78E-07	4.70E-07	5.34E-07	7.37E-07
704	3.04E-07	3.81E-07	4.81E-07	5.55E-07	7.33E-07
705	3.05E-07	3.79E-07	4.68E-07	5.31E-07	7.20E-07
706	3.00E-07	3.71E-07	4.56E-07	5.60E-07	7.53E-07
1280	3.22E-07	3.21E-07	3.22E-07	3.21E-07	3.23E-07
Biased Statistics					
Average Biased	3.16E-07	3.98E-07	4.89E-07	5.78E-07	6.75E-07
Std Dev Biased	1.49E-08	2.07E-08	2.93E-08	6.44E-08	4.51E-08
Ps90%/90% (+KTL) Biased	3.57E-07	4.55E-07	5.69E-07	7.55E-07	7.98E-07
Ps90%/90% (-KTL) Biased	2.75E-07	3.42E-07	4.08E-07	4.02E-07	5.51E-07
Un-Biased Statistics					
Average Un-Biased	3.05E-07	3.77E-07	4.68E-07	5.48E-07	7.32E-07
Std Dev Un-Biased	3.51E-09	3.96E-09	8.84E-09	1.38E-08	1.42E-08
Ps90%/90% (+KTL) Un-Biased	3.15E-07	3.88E-07	4.93E-07	5.85E-07	7.71E-07
Ps90%/90% (-KTL) Un-Biased	2.95E-07	3.66E-07	4.44E-07	5.10E-07	6.93E-07
Specification MIN	-5.00E-07	-7.50E-07	-1.00E-06	-1.50E-06	-2.00E-06
Status	PASS	PASS	PASS	PASS	PASS
Specification MAX	5.00E-07	7.50E-07	1.00E-06	1.50E-06	2.00E-06
Status	PASS	PASS	PASS	PASS	PASS

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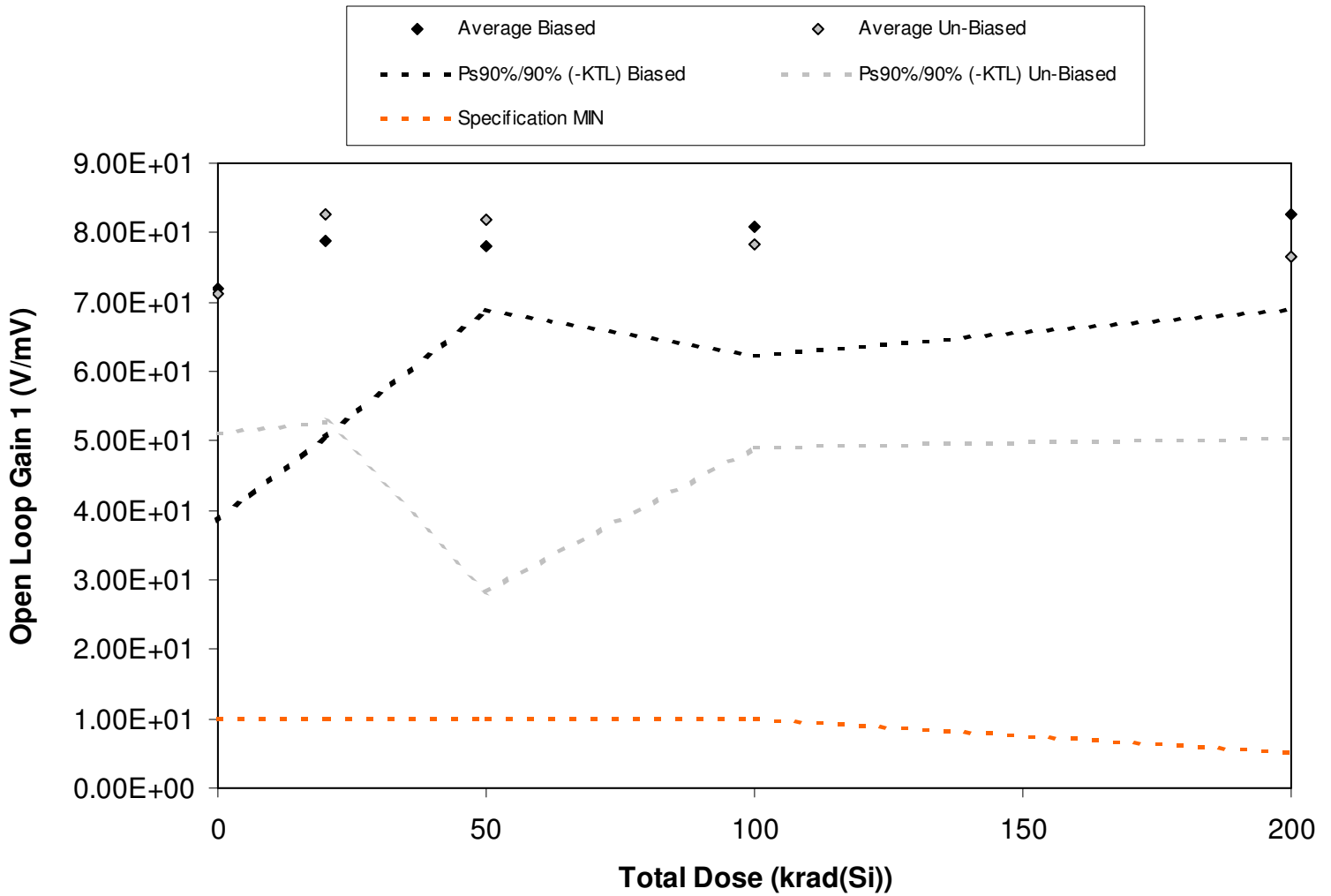**Colorado Springs, CO 80919**
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Figure 5.11. Plot of open loop gain (comparator 1) versus total dose using the datasheet units of V/mV. The data show no significant degradation with total dose, however the KTL statistics are erratic due to the sensitivity of the measurement to input conditions and the limitations of the test equipment. The solid diamonds are the average of measured data points from the biased sample (devices irradiated with an electrical bias) while the shaded diamonds are the average from the un-biased sample. The black lines show the effects on the data after application of the biased KTL statistics (solid and dashed lines) while the gray lines show the effects on the data after application of the unbiased KTL statistics (solid and dashed lines). The red dashed lines are the minimum and maximum specification values as defined in the datasheet and/or test plan.

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Table 5.11. Raw data for the open loop gain (comparator 1) versus total dose using the datasheet units of V/mV, including the statistical analysis, the specification and the status of the testing (pass/fail).

Open Loop Gain 1 (V/mV)	Total Dose (krad(Si))				
Device	0	20	50	100	200
694	7.86E+01	6.70E+01	7.63E+01	8.93E+01	7.69E+01
695	8.78E+01	9.16E+01	7.49E+01	7.60E+01	8.78E+01
698	5.58E+01	7.08E+01	8.05E+01	7.93E+01	8.55E+01
699	6.69E+01	7.85E+01	8.23E+01	7.33E+01	7.77E+01
700	7.03E+01	8.67E+01	7.57E+01	8.62E+01	8.54E+01
701	7.55E+01	7.57E+01	7.80E+01	9.08E+01	8.07E+01
702	5.87E+01	8.25E+01	7.86E+01	6.86E+01	7.09E+01
704	7.71E+01	6.86E+01	6.68E+01	6.66E+01	9.12E+01
705	7.31E+01	9.54E+01	7.00E+01	8.64E+01	6.99E+01
706	7.15E+01	9.14E+01	1.16E+02	7.93E+01	6.93E+01
1280	9.97E+01	7.16E+01	7.74E+01	5.53E+01	5.40E+01
Biased Statistics					
Average Biased	7.19E+01	7.89E+01	7.79E+01	8.08E+01	8.27E+01
Std Dev Biased	1.21E+01	1.04E+01	3.26E+00	6.76E+00	4.99E+00
Ps90%/90% (+KTL) Biased	1.05E+02	1.07E+02	8.69E+01	9.94E+01	9.64E+01
Ps90%/90% (-KTL) Biased	3.87E+01	5.05E+01	6.90E+01	6.23E+01	6.90E+01
Un-Biased Statistics					
Average Un-Biased	7.12E+01	8.27E+01	8.18E+01	7.83E+01	7.64E+01
Std Dev Un-Biased	7.30E+00	1.10E+01	1.95E+01	1.07E+01	9.49E+00
Ps90%/90% (+KTL) Un-Biased	9.12E+01	1.13E+02	1.35E+02	1.08E+02	1.02E+02
Ps90%/90% (-KTL) Un-Biased	5.12E+01	5.25E+01	2.82E+01	4.91E+01	5.04E+01
Specification MIN	1.00E+01	1.00E+01	1.00E+01	1.00E+01	5.00E+00
Status	PASS	PASS	PASS	PASS	PASS

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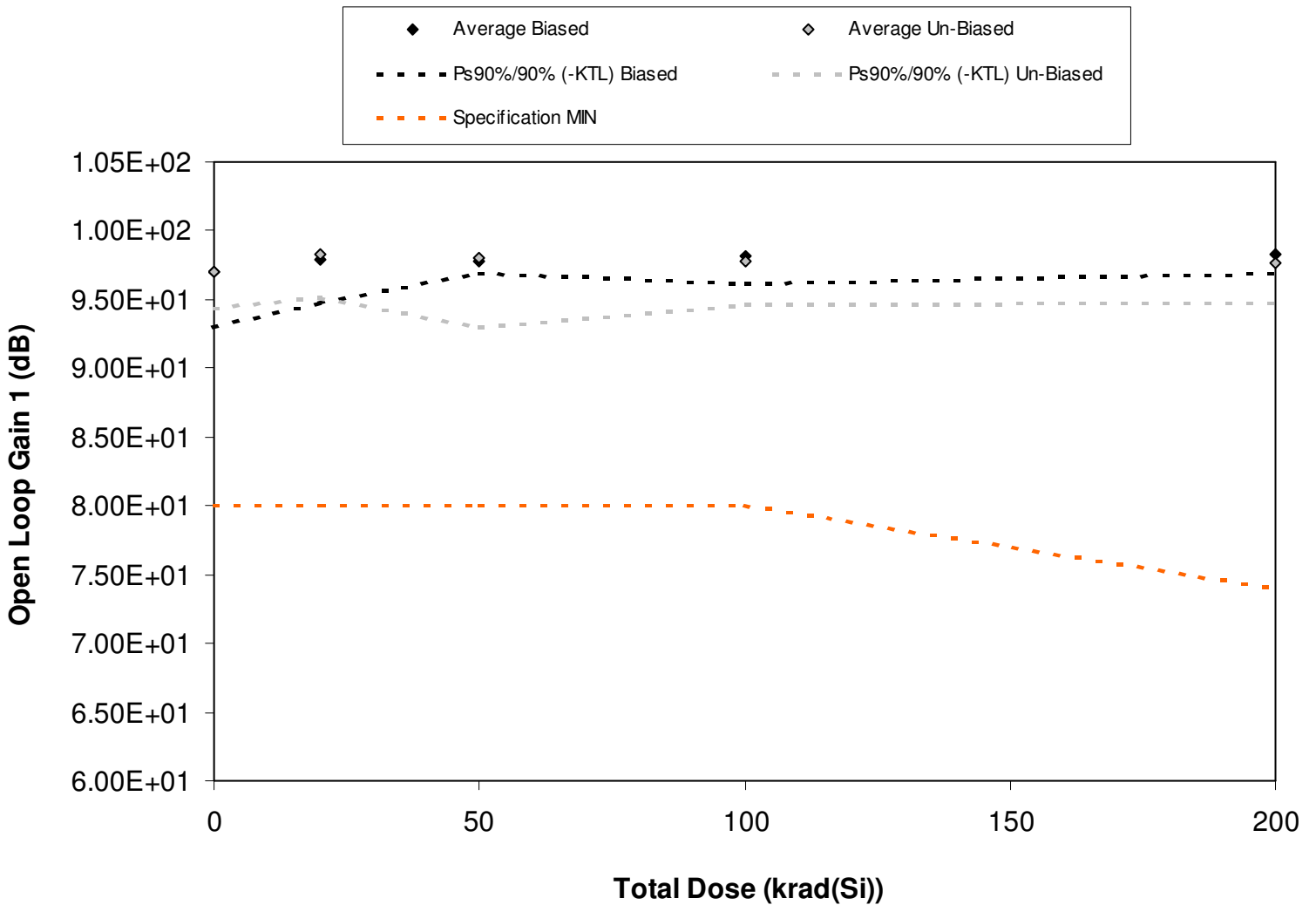**Colorado Springs, CO 80919**
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Figure 5.12. Plot of open loop gain (comparator 1) versus total dose using units of dB. The data show no significant degradation with total dose. Note that using units of dB to measure the gain (a commonly used unit for this measurement) removes the erratic behavior of the KTL statistics observed in Figure 5.11. The solid diamonds are the average of measured data points from the biased sample (devices irradiated with an electrical bias) while the shaded diamonds are the average from the un-biased sample. The black lines show the effects on the data after application of the biased KTL statistics (solid and dashed lines) while the gray lines show the effects on the data after application of the unbiased KTL statistics (solid and dashed lines). The red dashed lines are the minimum and maximum specification values as defined in the datasheet and/or test plan.

Table 5.12. Raw data for the open loop gain (comparator 1) versus total dose using units of dB, including the statistical analysis, the specification and the status of the testing (pass/fail).

Open Loop Gain 1 (dB)	Total Dose (krad(Si))				
Device	0	20	50	100	200
694	97.91	96.52	97.65	99.02	97.72
695	98.87	99.24	97.49	97.62	98.87
698	94.93	97.00	98.12	97.99	98.64
699	96.51	97.90	98.31	97.30	97.81
700	96.94	98.76	97.58	98.71	98.63
701	97.56	97.58	97.84	99.16	98.14
702	95.37	98.33	97.91	96.73	97.01
704	97.74	96.73	96.50	96.47	99.20
705	97.28	99.59	96.90	98.73	96.89
706	97.09	99.22	101.25	97.99	96.81
1280	99.97	97.10	97.77	94.85	94.65
Biased Statistics					
Average Biased	9.70E+01	9.79E+01	9.78E+01	9.81E+01	9.83E+01
Std Dev Biased	1.49E+00	1.14E+00	3.61E-01	7.23E-01	5.30E-01
Ps90%/90% (+KTL) Biased	1.01E+02	1.01E+02	9.88E+01	1.00E+02	9.98E+01
Ps90%/90% (-KTL) Biased	9.30E+01	9.47E+01	9.68E+01	9.61E+01	9.69E+01
Un-Biased Statistics					
Average Un-Biased	9.70E+01	9.83E+01	9.81E+01	9.78E+01	9.76E+01
Std Dev Un-Biased	9.48E-01	1.17E+00	1.87E+00	1.19E+00	1.04E+00
Ps90%/90% (+KTL) Un-Biased	9.96E+01	1.02E+02	1.03E+02	1.01E+02	1.00E+02
Ps90%/90% (-KTL) Un-Biased	9.44E+01	9.51E+01	9.29E+01	9.45E+01	9.48E+01
Specification MIN	8.00E+01	8.00E+01	8.00E+01	8.00E+01	7.40E+01
Status	PASS	PASS	PASS	PASS	PASS

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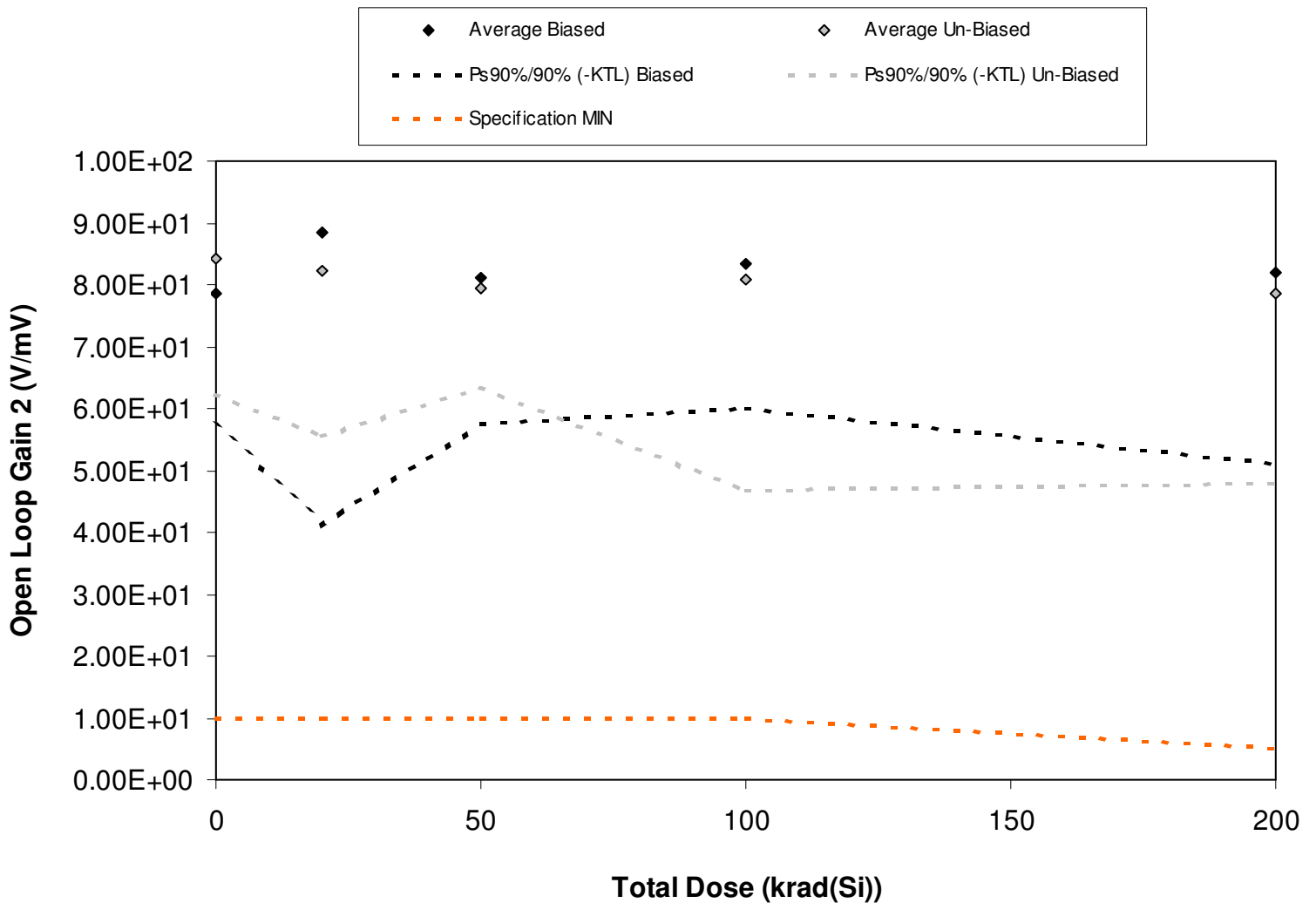**(719) 531-0800**

Figure 5.13. Plot of open loop gain (comparator 2) versus total dose using the datasheet units of V/mV. The data show no significant degradation with total dose, however the KTL statistics are erratic due to the sensitivity of the measurement to input conditions and the limitations of the test equipment.   The solid diamonds are the average of measured data points from the biased sample (devices irradiated with an electrical bias) while the shaded diamonds are the average from the un-biased sample. The black lines show the effects on the data after application of the biased KTL statistics (solid and dashed lines) while the gray lines show the effects on the data after application of the unbiased KTL statistics (solid and dashed lines). The red dashed lines are the minimum and maximum specification values as defined in the datasheet and/or test plan.

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Table 5.13. Raw data for the open loop gain (comparator 2) versus total dose using the datasheet units of V/mV, including the statistical analysis, the specification and the status of the testing (pass/fail).

Open Loop Gain 2 (V/mV)	Total Dose (krad(Si))				
Device	0	20	50	100	200
694	9.15E+01	1.08E+02	9.02E+01	9.82E+01	7.31E+01
695	7.74E+01	7.74E+01	7.65E+01	7.65E+01	8.90E+01
698	7.24E+01	6.56E+01	7.25E+01	8.29E+01	9.51E+01
699	7.92E+01	8.97E+01	9.04E+01	7.86E+01	6.77E+01
700	7.31E+01	1.01E+02	7.57E+01	8.13E+01	8.44E+01
701	7.84E+01	7.00E+01	8.44E+01	9.54E+01	8.90E+01
702	9.33E+01	9.28E+01	6.95E+01	6.88E+01	7.95E+01
704	8.55E+01	9.14E+01	8.03E+01	8.13E+01	9.02E+01
705	9.00E+01	8.07E+01	8.26E+01	9.04E+01	6.79E+01
706	7.40E+01	7.65E+01	8.03E+01	6.79E+01	6.65E+01
1280	9.40E+01	8.55E+01	9.40E+01	1.06E+02	8.78E+01
Biased Statistics					
Average Biased	7.87E+01	8.84E+01	8.11E+01	8.35E+01	8.19E+01
Std Dev Biased	7.69E+00	1.72E+01	8.57E+00	8.58E+00	1.13E+01
Ps90%/90% (+KTL) Biased	9.98E+01	1.36E+02	1.05E+02	1.07E+02	1.13E+02
Ps90%/90% (-KTL) Biased	5.76E+01	4.11E+01	5.76E+01	6.00E+01	5.09E+01
Un-Biased Statistics					
Average Un-Biased	8.42E+01	8.23E+01	7.94E+01	8.08E+01	7.86E+01
Std Dev Un-Biased	8.00E+00	9.75E+00	5.81E+00	1.24E+01	1.12E+01
Ps90%/90% (+KTL) Un-Biased	1.06E+02	1.09E+02	9.53E+01	1.15E+02	1.09E+02
Ps90%/90% (-KTL) Un-Biased	6.23E+01	5.55E+01	6.35E+01	4.67E+01	4.78E+01
Specification MIN	1.00E+01	1.00E+01	1.00E+01	1.00E+01	5.00E+00
Status	PASS	PASS	PASS	PASS	PASS

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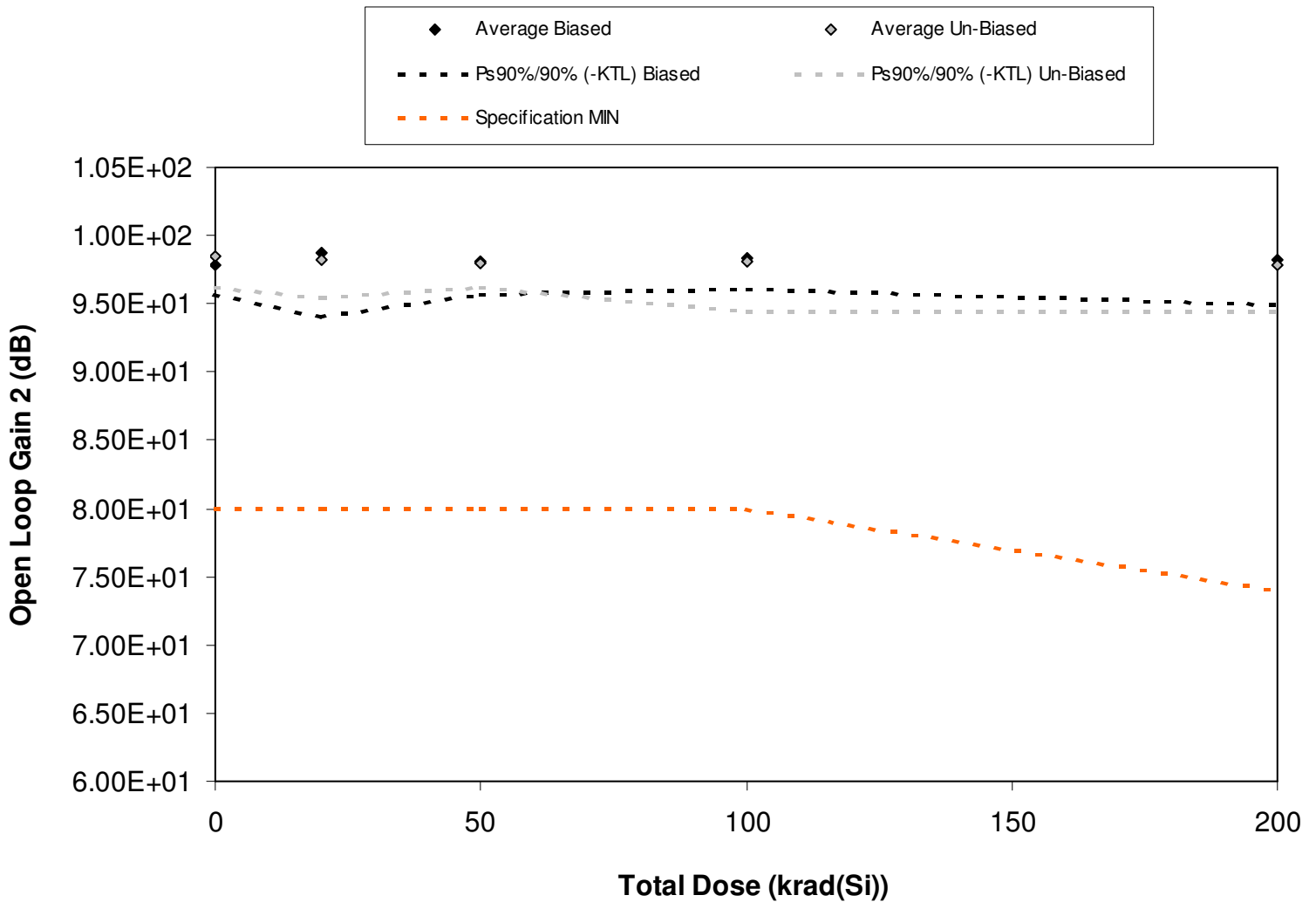**Colorado Springs, CO 80919**
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Figure 5.14. Plot of open loop gain (comparator 2) versus total dose using units of dB. The data show no significant degradation with total dose. Note that using units of dB to measure the gain (a commonly used unit for this measurement) removes the erratic behavior of the KTL statistics observed in Figure 5.13. The solid diamonds are the average of measured data points from the biased sample (devices irradiated with an electrical bias) while the shaded diamonds are the average from the un-biased sample. The black lines show the effects on the data after application of the biased KTL statistics (solid and dashed lines) while the gray lines show the effects on the data after application of the unbiased KTL statistics (solid and dashed lines). The red dashed lines are the minimum and maximum specification values as defined in the datasheet and/or test plan.

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Table 5.14. Raw data for the open loop gain (comparator 2) versus total dose using units of dB, including the statistical analysis, the specification and the status of the testing (pass/fail).

Open Loop Gain 2 (dB)	Total Dose (krad(Si))				
Device	0	20	50	100	200
694	99.23	100.66	99.10	99.84	97.28
695	97.77	97.77	97.67	97.67	98.99
698	97.19	96.34	97.21	98.37	99.56
699	97.97	99.06	99.12	97.91	96.61
700	97.28	100.11	97.58	98.20	98.53
701	97.89	96.90	98.53	99.59	98.99
702	99.40	99.35	96.84	96.75	98.01
704	98.64	99.22	98.09	98.20	99.10
705	99.08	98.14	98.34	99.12	96.64
706	97.38	97.67	98.09	96.64	96.46
1280	99.46	98.64	99.46	100.52	98.87
Biased Statistics					
Average Biased	9.79E+01	9.88E+01	9.81E+01	9.84E+01	9.82E+01
Std Dev Biased	8.17E-01	1.76E+00	9.08E-01	8.50E-01	1.22E+00
Ps90%/90% (+KTL) Biased	1.00E+02	1.04E+02	1.01E+02	1.01E+02	1.02E+02
Ps90%/90% (-KTL) Biased	9.57E+01	9.40E+01	9.56E+01	9.61E+01	9.48E+01
Un-Biased Statistics					
Average Un-Biased	9.85E+01	9.83E+01	9.80E+01	9.81E+01	9.78E+01
Std Dev Un-Biased	8.34E-01	1.04E+00	6.62E-01	1.34E+00	1.26E+00
Ps90%/90% (+KTL) Un-Biased	1.01E+02	1.01E+02	9.98E+01	1.02E+02	1.01E+02
Ps90%/90% (-KTL) Un-Biased	9.62E+01	9.54E+01	9.62E+01	9.44E+01	9.44E+01
Specification MIN	8.00E+01	8.00E+01	8.00E+01	8.00E+01	7.40E+01
Status	PASS	PASS	PASS	PASS	PASS

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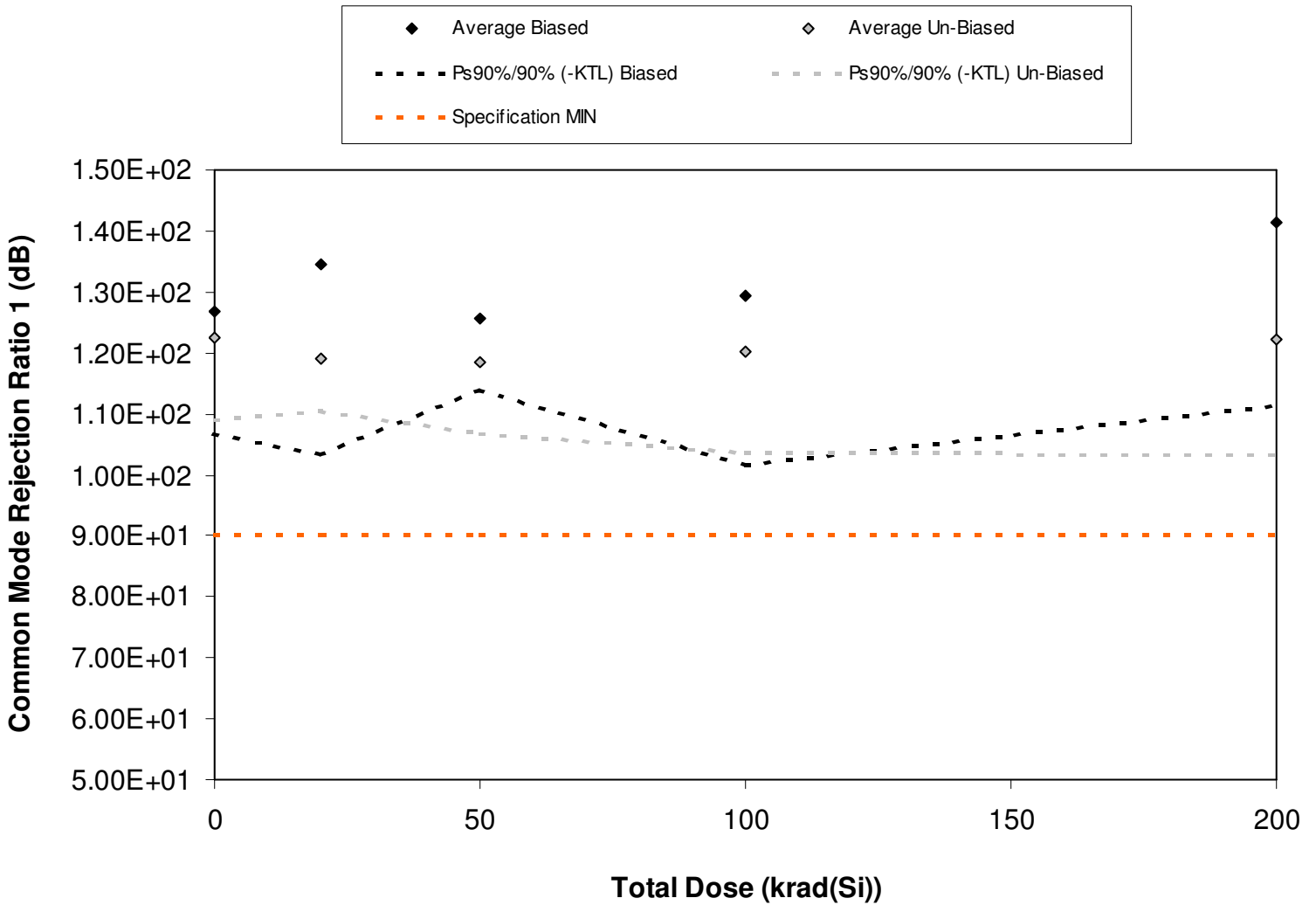**(719) 531-0800**

Figure 5.15. Plot of common mode rejection ratio (comparator 1) versus total dose. The data show no significant degradation with total dose. The solid diamonds are the average of measured data points from the biased sample (devices irradiated with an electrical bias) while the shaded diamonds are the average from the un-biased sample. The black lines show the effects on the data after application of the biased KTL statistics (solid and dashed lines) while the gray lines show the effects on the data after application of the unbiased KTL statistics (solid and dashed lines). The red dashed lines are the minimum and maximum specification values as defined in the datasheet and/or test plan.

Table 5.15. Raw data for the common mode rejection ratio (comparator 1), including the statistical analysis, the specification and the status of the testing (pass/fail).

Common Mode Rejection Ratio 1 (dB)	Total Dose (krad(Si))				
Device	0	20	50	100	200
694	1.36E+02	1.34E+02	1.24E+02	1.26E+02	1.40E+02
695	1.28E+02	1.39E+02	1.20E+02	1.19E+02	1.58E+02
698	1.18E+02	1.17E+02	1.28E+02	1.27E+02	1.39E+02
699	1.22E+02	1.48E+02	1.26E+02	1.46E+02	1.42E+02
700	1.30E+02	1.34E+02	1.31E+02	1.28E+02	1.28E+02
701	1.28E+02	1.21E+02	1.23E+02	1.21E+02	1.21E+02
702	1.15E+02	1.14E+02	1.16E+02	1.14E+02	1.16E+02
704	1.23E+02	1.21E+02	1.17E+02	1.20E+02	1.20E+02
705	1.24E+02	1.18E+02	1.13E+02	1.15E+02	1.20E+02
706	1.23E+02	1.21E+02	1.23E+02	1.29E+02	1.34E+02
1280	1.15E+02	1.13E+02	1.19E+02	1.17E+02	1.21E+02
Biased Statistics					
Average Biased	1.27E+02	1.35E+02	1.26E+02	1.29E+02	1.42E+02
Std Dev Biased	7.25E+00	1.14E+01	4.22E+00	1.01E+01	1.10E+01
Ps90%/90% (+KTL) Biased	1.47E+02	1.66E+02	1.37E+02	1.57E+02	1.72E+02
Ps90%/90% (-KTL) Biased	1.07E+02	1.03E+02	1.14E+02	1.02E+02	1.11E+02
Un-Biased Statistics					
Average Un-Biased	1.23E+02	1.19E+02	1.18E+02	1.20E+02	1.22E+02
Std Dev Un-Biased	4.95E+00	3.13E+00	4.30E+00	6.00E+00	6.97E+00
Ps90%/90% (+KTL) Un-Biased	1.36E+02	1.28E+02	1.30E+02	1.37E+02	1.41E+02
Ps90%/90% (-KTL) Un-Biased	1.09E+02	1.11E+02	1.07E+02	1.04E+02	1.03E+02
Specification MIN	9.00E+01	9.00E+01	9.00E+01	9.00E+01	9.00E+01
Status	PASS	PASS	PASS	PASS	PASS

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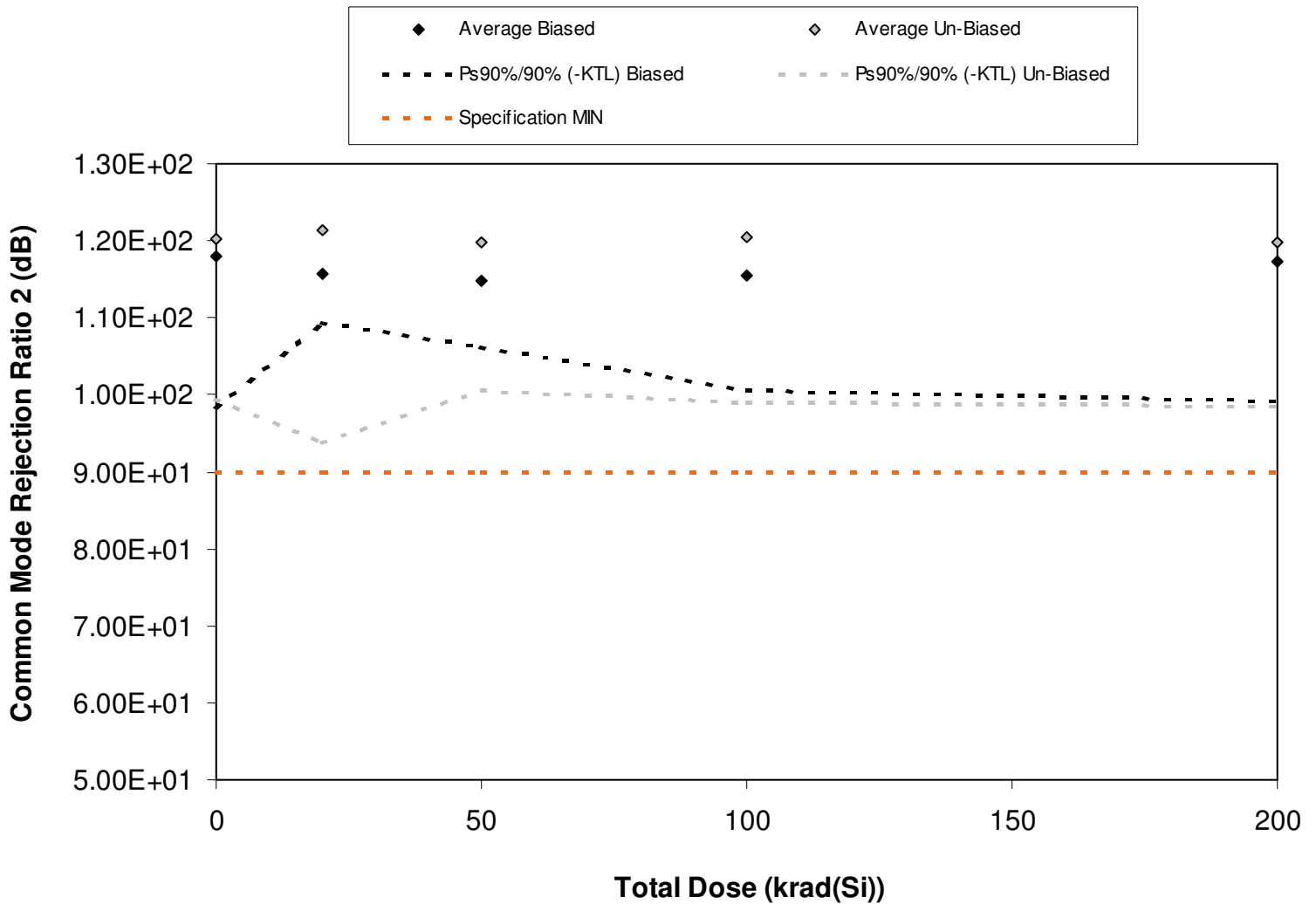**Colorado Springs, CO 80919**
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Figure 5.16. Plot of common mode rejection ratio (comparator 2) versus total dose. The data show no significant degradation with total dose. The solid diamonds are the average of measured data points from the biased sample (devices irradiated with an electrical bias) while the shaded diamonds are the average from the un-biased sample. The black lines show the effects on the data after application of the biased KTL statistics (solid and dashed lines) while the gray lines show the effects on the data after application of the unbiased KTL statistics (solid and dashed lines). The red dashed lines are the minimum and maximum specification values as defined in the datasheet and/or test plan.

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Table 5.16. Raw data for the common mode rejection ratio (comparator 2) versus total dose, including the statistical analysis, the specification and the status of the testing (pass/fail).

Common Mode Rejection Ratio 2 (dB)	Total Dose (krad(Si))				
Device	0	20	50	100	200
694	1.12E+02	1.14E+02	1.12E+02	1.13E+02	1.15E+02
695	1.30E+02	1.19E+02	1.15E+02	1.25E+02	1.28E+02
698	1.19E+02	1.18E+02	1.19E+02	1.14E+02	1.16E+02
699	1.15E+02	1.14E+02	1.12E+02	1.11E+02	1.11E+02
700	1.14E+02	1.15E+02	1.16E+02	1.15E+02	1.15E+02
701	1.32E+02	1.39E+02	1.32E+02	1.32E+02	1.32E+02
702	1.13E+02	1.13E+02	1.13E+02	1.12E+02	1.13E+02
704	1.19E+02	1.18E+02	1.20E+02	1.20E+02	1.19E+02
705	1.24E+02	1.19E+02	1.19E+02	1.23E+02	1.21E+02
706	1.14E+02	1.18E+02	1.16E+02	1.15E+02	1.14E+02
1280	1.34E+02	1.33E+02	1.39E+02	1.30E+02	1.42E+02
Biased Statistics					
Average Biased	1.18E+02	1.16E+02	1.15E+02	1.16E+02	1.17E+02
Std Dev Biased	7.29E+00	2.36E+00	3.15E+00	5.51E+00	6.59E+00
Ps90%/90% (+KTL) Biased	1.38E+02	1.22E+02	1.23E+02	1.31E+02	1.35E+02
Ps90%/90% (-KTL) Biased	9.81E+01	1.09E+02	1.06E+02	1.00E+02	9.91E+01
Un-Biased Statistics					
Average Un-Biased	1.20E+02	1.21E+02	1.20E+02	1.20E+02	1.20E+02
Std Dev Un-Biased	7.58E+00	1.01E+01	7.01E+00	7.87E+00	7.77E+00
Ps90%/90% (+KTL) Un-Biased	1.41E+02	1.49E+02	1.39E+02	1.42E+02	1.41E+02
Ps90%/90% (-KTL) Un-Biased	9.94E+01	9.37E+01	1.01E+02	9.89E+01	9.84E+01
Specification MIN	9.00E+01	9.00E+01	9.00E+01	9.00E+01	9.00E+01
Status	PASS	PASS	PASS	PASS	PASS

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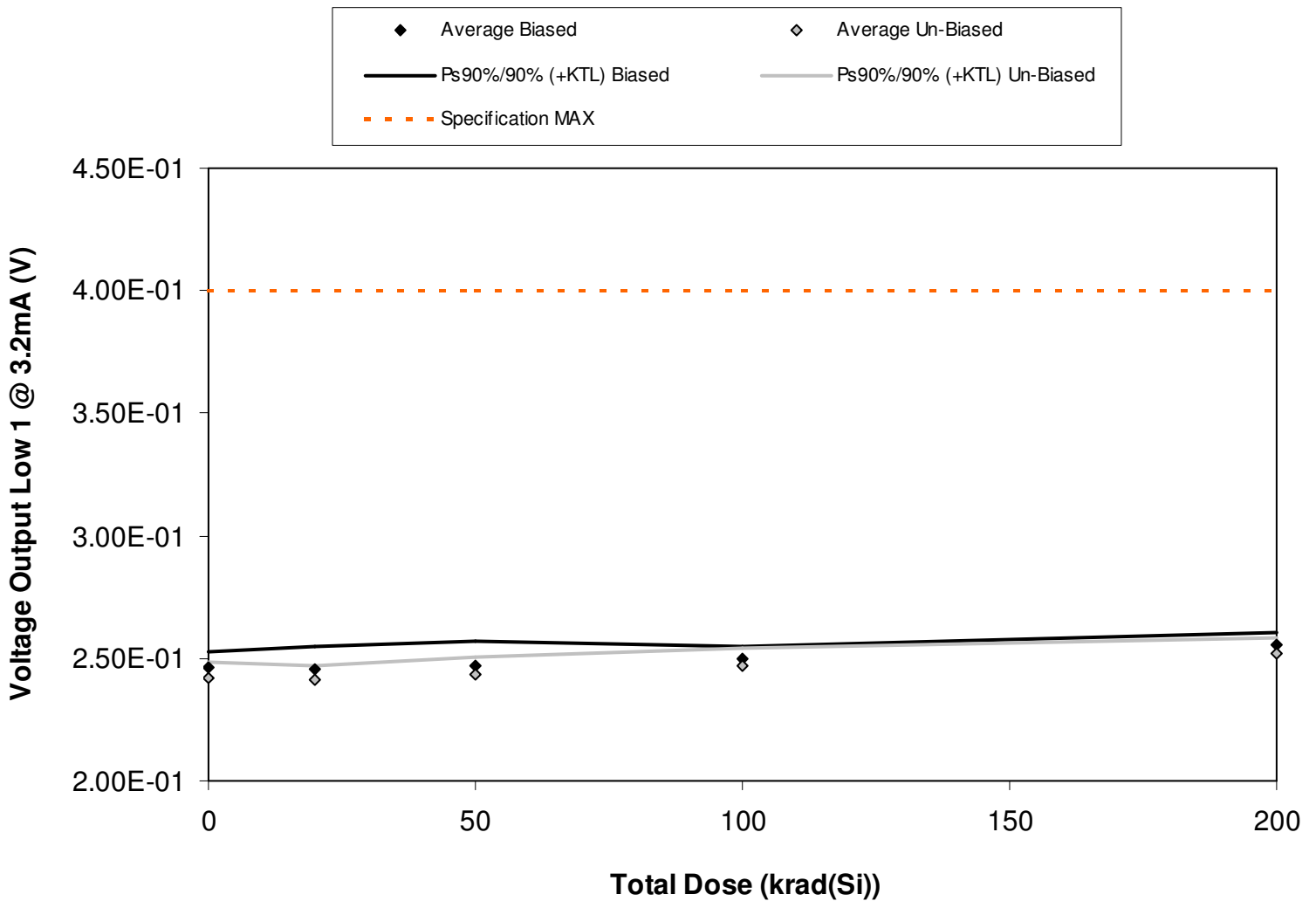**Colorado Springs, CO 80919**
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Figure 5.17. Plot of the saturation voltage (V_{SAT}) at 3.2mA for comparator 1 versus total dose. The data show no significant degradation with total dose. The solid diamonds are the average of measured data points from the biased sample (devices irradiated with an electrical bias) while the shaded diamonds are the average from the un-biased sample. The black lines show the effects on the data after application of the biased KTL statistics (solid and dashed lines) while the gray lines show the effects on the data after application of the unbiased KTL statistics (solid and dashed lines). The red dashed lines are the minimum and maximum specification values as defined in the datasheet and/or test plan.

Table 5.17. Raw data for the saturation voltage (V_{SAT}) at 3.2mA for comparator 1 versus total dose, including the statistical analysis, the specification and the status of the testing (pass/fail).

Voltage Output Low 1 @ 3.2mA (V)	Total Dose (krad(Si))				
Device	0	20	50	100	200
694	2.48E-01	2.47E-01	2.48E-01	2.51E-01	2.56E-01
695	2.44E-01	2.44E-01	2.44E-01	2.48E-01	2.53E-01
698	2.44E-01	2.41E-01	2.43E-01	2.49E-01	2.53E-01
699	2.48E-01	2.49E-01	2.51E-01	2.51E-01	2.57E-01
700	2.48E-01	2.48E-01	2.50E-01	2.52E-01	2.57E-01
701	2.46E-01	2.45E-01	2.48E-01	2.51E-01	2.56E-01
702	2.42E-01	2.41E-01	2.43E-01	2.47E-01	2.52E-01
704	2.41E-01	2.41E-01	2.43E-01	2.46E-01	2.51E-01
705	2.40E-01	2.40E-01	2.42E-01	2.46E-01	2.50E-01
706	2.41E-01	2.40E-01	2.42E-01	2.44E-01	2.51E-01
1280	2.51E-01	2.52E-01	2.52E-01	2.52E-01	2.52E-01
Biased Statistics					
Average Biased	2.46E-01	2.46E-01	2.47E-01	2.50E-01	2.55E-01
Std Dev Biased	2.19E-03	3.27E-03	3.56E-03	1.64E-03	2.05E-03
Ps90%/90% (+KTL) Biased	2.52E-01	2.55E-01	2.57E-01	2.55E-01	2.61E-01
Ps90%/90% (-KTL) Biased	2.40E-01	2.37E-01	2.37E-01	2.46E-01	2.50E-01
Un-Biased Statistics					
Average Un-Biased	2.42E-01	2.41E-01	2.44E-01	2.47E-01	2.52E-01
Std Dev Un-Biased	2.35E-03	2.07E-03	2.51E-03	2.59E-03	2.35E-03
Ps90%/90% (+KTL) Un-Biased	2.48E-01	2.47E-01	2.50E-01	2.54E-01	2.58E-01
Ps90%/90% (-KTL) Un-Biased	2.36E-01	2.36E-01	2.37E-01	2.40E-01	2.46E-01
Specification MAX	4.00E-01	4.00E-01	4.00E-01	4.00E-01	4.00E-01
Status	PASS	PASS	PASS	PASS	PASS

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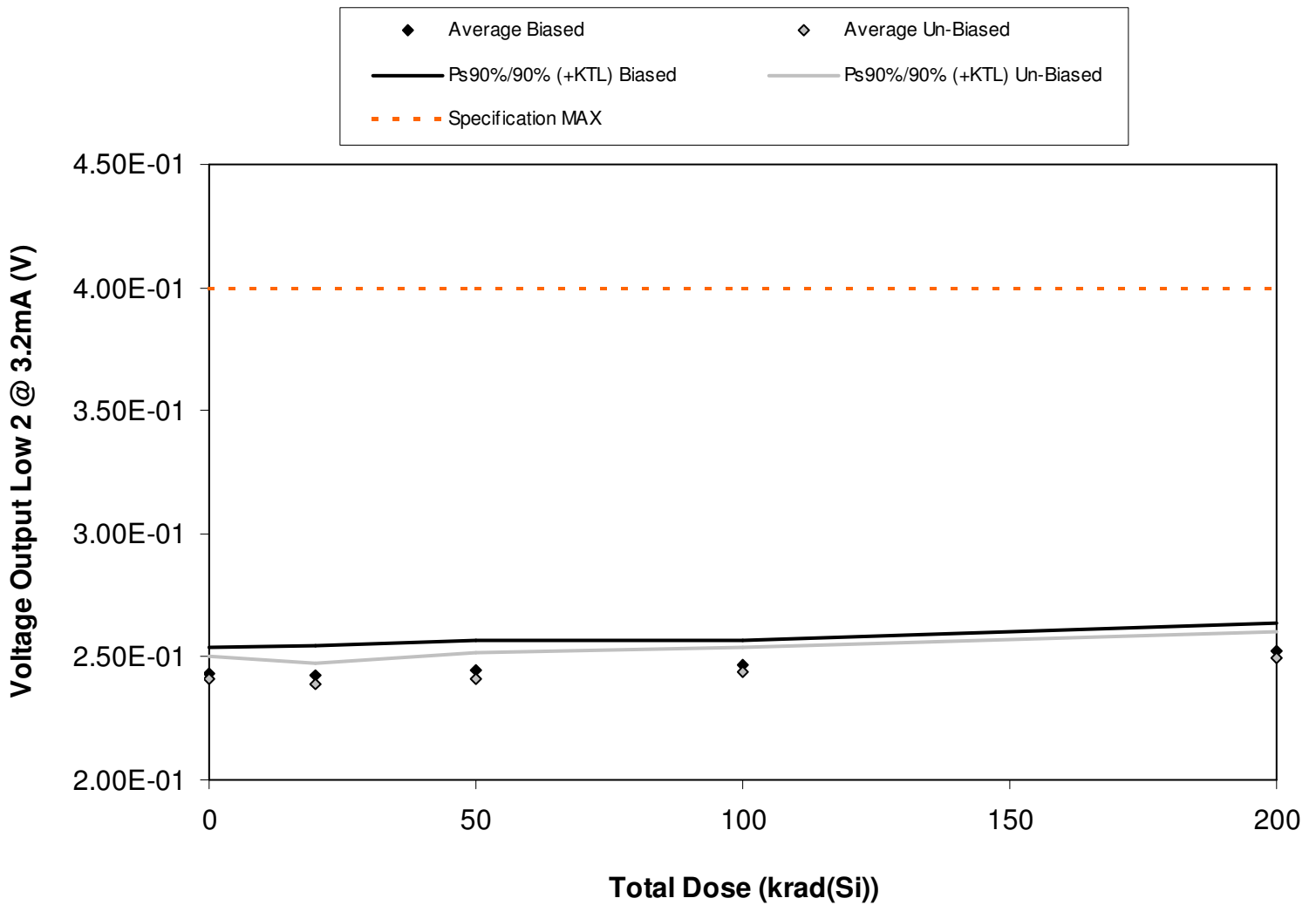**Colorado Springs, CO 80919**
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Figure 5.18. Plot of the saturation voltage (V_{SAT}) at 3.2mA for comparator 2 versus total dose. The data show no significant degradation with total dose. The solid diamonds are the average of measured data points from the biased sample (devices irradiated with an electrical bias) while the shaded diamonds are the average from the un-biased sample. The black lines show the effects on the data after application of the biased KTL statistics (solid and dashed lines) while the gray lines show the effects on the data after application of the unbiased KTL statistics (solid and dashed lines). The red dashed lines are the minimum and maximum specification values as defined in the datasheet and/or test plan.

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Table 5.18. Raw data for the saturation voltage (V_{SAT}) at 3.2mA for comparator 2 versus total dose, including the statistical analysis, the specification and the status of the testing (pass/fail).

Voltage Output Low 2 @ 3.2mA (V)	Total Dose (krad(Si))				
Device	0	20	50	100	200
694	2.45E-01	2.43E-01	2.46E-01	2.48E-01	2.54E-01
695	2.38E-01	2.38E-01	2.39E-01	2.41E-01	2.47E-01
698	2.41E-01	2.39E-01	2.41E-01	2.45E-01	2.49E-01
699	2.48E-01	2.48E-01	2.50E-01	2.50E-01	2.57E-01
700	2.45E-01	2.46E-01	2.47E-01	2.49E-01	2.54E-01
701	2.46E-01	2.43E-01	2.46E-01	2.49E-01	2.55E-01
702	2.43E-01	2.41E-01	2.44E-01	2.46E-01	2.52E-01
704	2.38E-01	2.36E-01	2.37E-01	2.41E-01	2.45E-01
705	2.40E-01	2.38E-01	2.41E-01	2.43E-01	2.49E-01
706	2.38E-01	2.36E-01	2.39E-01	2.40E-01	2.48E-01
1280	2.51E-01	2.51E-01	2.52E-01	2.52E-01	2.52E-01
Biased Statistics					
Average Biased	2.43E-01	2.43E-01	2.45E-01	2.47E-01	2.52E-01
Std Dev Biased	3.91E-03	4.32E-03	4.51E-03	3.65E-03	4.09E-03
Ps90%/90% (+KTL) Biased	2.54E-01	2.55E-01	2.57E-01	2.57E-01	2.63E-01
Ps90%/90% (-KTL) Biased	2.33E-01	2.31E-01	2.32E-01	2.37E-01	2.41E-01
Un-Biased Statistics					
Average Un-Biased	2.41E-01	2.39E-01	2.41E-01	2.44E-01	2.50E-01
Std Dev Un-Biased	3.46E-03	3.11E-03	3.65E-03	3.70E-03	3.83E-03
Ps90%/90% (+KTL) Un-Biased	2.50E-01	2.47E-01	2.51E-01	2.54E-01	2.60E-01
Ps90%/90% (-KTL) Un-Biased	2.32E-01	2.30E-01	2.31E-01	2.34E-01	2.39E-01
Specification MAX	4.00E-01	4.00E-01	4.00E-01	4.00E-01	4.00E-01
Status	PASS	PASS	PASS	PASS	PASS

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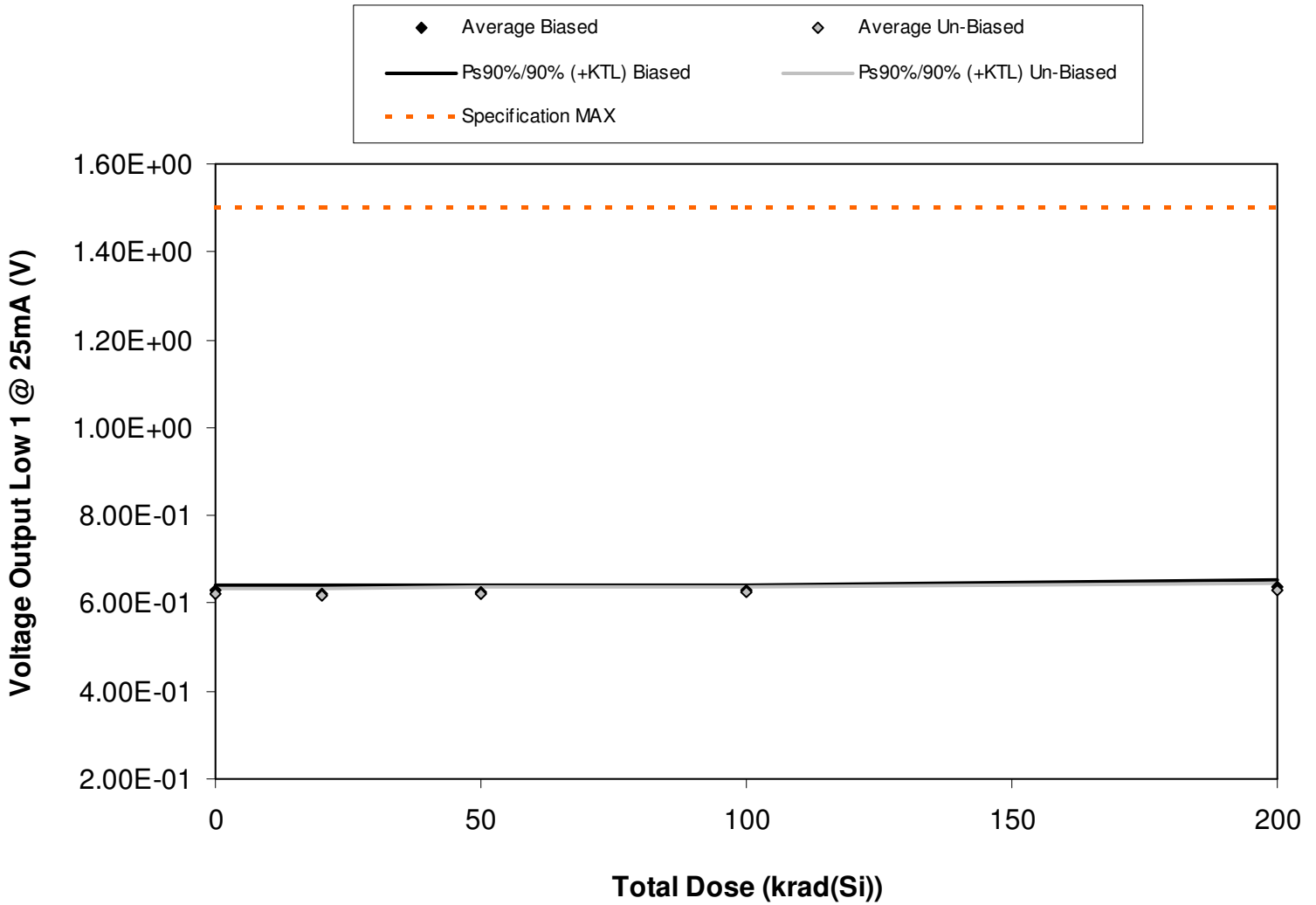**Colorado Springs, CO 80919**
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Figure 5.19. Plot of the saturation voltage (V_{SAT}) at 25mA for comparator 1 versus total dose. The data show no significant degradation with total dose. The solid diamonds are the average of measured data points from the biased sample (devices irradiated with an electrical bias) while the shaded diamonds are the average from the un-biased sample. The black lines show the effects on the data after application of the biased KTL statistics (solid and dashed lines) while the gray lines show the effects on the data after application of the unbiased KTL statistics (solid and dashed lines). The red dashed lines are the minimum and maximum specification values as defined in the datasheet and/or test plan.

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Table 5.19. Raw data for the saturation voltage (V_{SAT}) at 25mA for comparator 1 versus total dose versus total dose, including the statistical analysis, the specification and the status of the testing (pass/fail).

Voltage Output Low 1 @ 25mA (V)	Total Dose (krad(Si))				
Device	0	20	50	100	200
694	6.33E-01	6.26E-01	6.28E-01	6.33E-01	6.39E-01
695	6.27E-01	6.22E-01	6.25E-01	6.30E-01	6.36E-01
698	6.22E-01	6.12E-01	6.17E-01	6.25E-01	6.31E-01
699	6.29E-01	6.24E-01	6.27E-01	6.31E-01	6.40E-01
700	6.34E-01	6.29E-01	6.32E-01	6.37E-01	6.45E-01
701	6.29E-01	6.28E-01	6.27E-01	6.31E-01	6.37E-01
702	6.17E-01	6.15E-01	6.15E-01	6.18E-01	6.26E-01
704	6.21E-01	6.17E-01	6.18E-01	6.22E-01	6.30E-01
705	6.24E-01	6.23E-01	6.26E-01	6.29E-01	6.35E-01
706	6.19E-01	6.15E-01	6.17E-01	6.22E-01	6.26E-01
1280	6.43E-01	6.42E-01	6.42E-01	6.41E-01	6.40E-01
Biased Statistics					
Average Biased	6.29E-01	6.23E-01	6.26E-01	6.31E-01	6.38E-01
Std Dev Biased	4.85E-03	6.47E-03	5.54E-03	4.38E-03	5.17E-03
Ps90%/90% (+KTL) Biased	6.42E-01	6.40E-01	6.41E-01	6.43E-01	6.52E-01
Ps90%/90% (-KTL) Biased	6.16E-01	6.05E-01	6.11E-01	6.19E-01	6.24E-01
Un-Biased Statistics					
Average Un-Biased	6.22E-01	6.20E-01	6.21E-01	6.24E-01	6.31E-01
Std Dev Un-Biased	4.69E-03	5.73E-03	5.50E-03	5.41E-03	5.07E-03
Ps90%/90% (+KTL) Un-Biased	6.35E-01	6.35E-01	6.36E-01	6.39E-01	6.45E-01
Ps90%/90% (-KTL) Un-Biased	6.09E-01	6.04E-01	6.06E-01	6.10E-01	6.17E-01
Specification MAX	1.50E+00	1.50E+00	1.50E+00	1.50E+00	1.50E+00
Status	PASS	PASS	PASS	PASS	PASS

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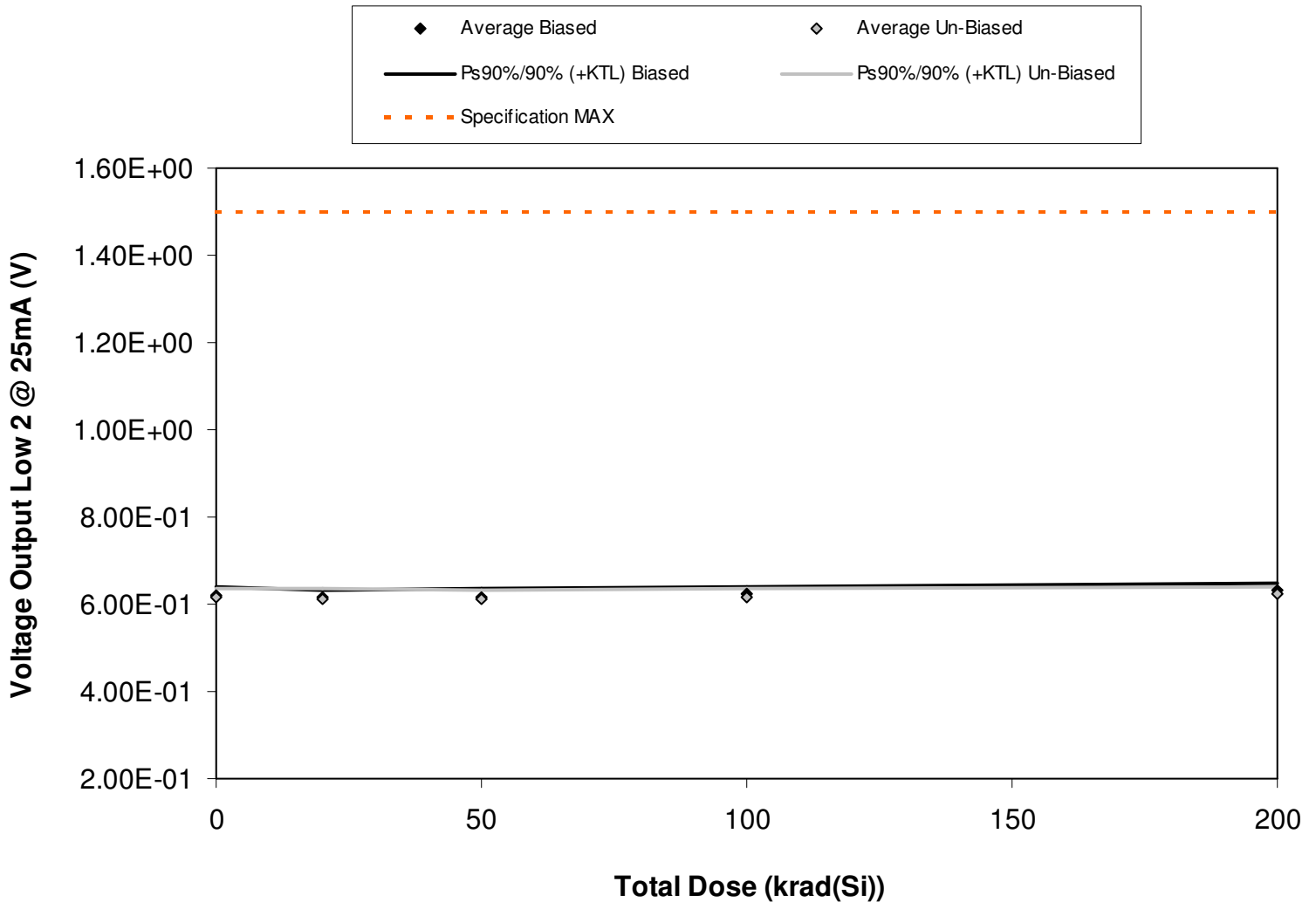**Colorado Springs, CO 80919**
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Figure 5.20. Plot of the saturation voltage (V_{SAT}) at 25mA for comparator 2 versus total dose. The data show no significant degradation with total dose. The solid diamonds are the average of measured data points from the biased sample (devices irradiated with an electrical bias) while the shaded diamonds are the average from the un-biased sample. The black lines show the effects on the data after application of the biased KTL statistics (solid and dashed lines) while the gray lines show the effects on the data after application of the unbiased KTL statistics (solid and dashed lines). The red dashed lines are the minimum and maximum specification values as defined in the datasheet and/or test plan.

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Table 5.20. Raw data of the saturation voltage (V_{SAT}) at 25mA for comparator 2 versus total dose, including the statistical analysis, the specification and the status of the testing (pass/fail).

Voltage Output Low 2 @ 25mA (V)	Total Dose (krad(Si))				
Device	0	20	50	100	200
694	6.24E-01	6.18E-01	6.20E-01	6.26E-01	6.32E-01
695	6.13E-01	6.08E-01	6.12E-01	6.16E-01	6.22E-01
698	6.17E-01	6.10E-01	6.12E-01	6.20E-01	6.27E-01
699	6.30E-01	6.25E-01	6.28E-01	6.31E-01	6.40E-01
700	6.19E-01	6.15E-01	6.17E-01	6.22E-01	6.31E-01
701	6.26E-01	6.25E-01	6.23E-01	6.27E-01	6.32E-01
702	6.13E-01	6.09E-01	6.10E-01	6.14E-01	6.21E-01
704	6.12E-01	6.09E-01	6.10E-01	6.14E-01	6.21E-01
705	6.20E-01	6.17E-01	6.18E-01	6.22E-01	6.28E-01
706	6.09E-01	6.05E-01	6.06E-01	6.12E-01	6.15E-01
1280	6.34E-01	6.32E-01	6.32E-01	6.32E-01	6.31E-01
Biased Statistics					
Average Biased	6.21E-01	6.15E-01	6.18E-01	6.23E-01	6.30E-01
Std Dev Biased	6.58E-03	6.76E-03	6.65E-03	5.74E-03	6.66E-03
Ps90%/90% (+KTL) Biased	6.39E-01	6.34E-01	6.36E-01	6.39E-01	6.49E-01
Ps90%/90% (-KTL) Biased	6.03E-01	5.97E-01	6.00E-01	6.07E-01	6.12E-01
Un-Biased Statistics					
Average Un-Biased	6.16E-01	6.13E-01	6.13E-01	6.18E-01	6.23E-01
Std Dev Un-Biased	6.89E-03	8.00E-03	6.91E-03	6.42E-03	6.66E-03
Ps90%/90% (+KTL) Un-Biased	6.35E-01	6.35E-01	6.32E-01	6.35E-01	6.42E-01
Ps90%/90% (-KTL) Un-Biased	5.97E-01	5.91E-01	5.94E-01	6.00E-01	6.05E-01
Specification MAX	1.50E+00	1.50E+00	1.50E+00	1.50E+00	1.50E+00
Status	PASS	PASS	PASS	PASS	PASS

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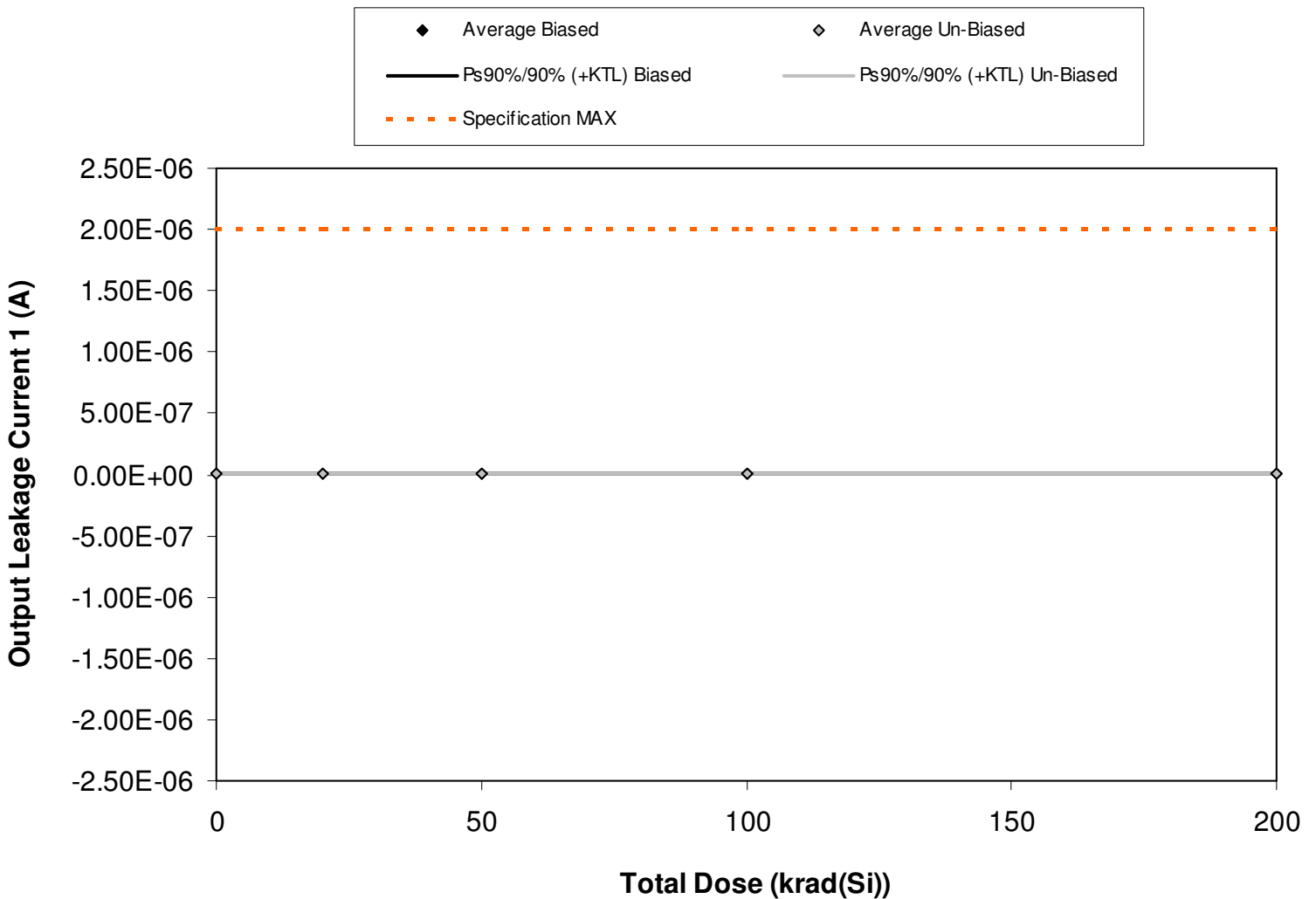|			
◆ Average Biased		◇ Average Un-Biased	
▬▬ Ps90%/90% (+KTL) Biased		▬▬ Ps90%/90% (+KTL) Un-Biased	
▬ ▬ ▬ Specification MAX			

Figure 5.21. Plot of output leakage current (comparator 1) versus total dose. The data show no significant degradation with total dose. The solid diamonds are the average of measured data points from the biased sample (devices irradiated with an electrical bias) while the shaded diamonds are the average from the un-biased sample. The black lines show the effects on the data after application of the biased KTL statistics (solid and dashed lines) while the gray lines show the effects on the data after application of the unbiased KTL statistics (solid and dashed lines). The red dashed lines are the minimum and maximum specification values as defined in the datasheet and/or test plan.

Table 5.21. Raw data of the output leakage current (comparator 1) versus total dose, including the statistical analysis, the specification and the status of the testing (pass/fail).

Output Leakage Current 1 (A)	Total Dose (krad(Si))				
Device	0	20	50	100	200
694	4.00E-09	2.00E-09	2.00E-09	2.00E-09	4.00E-09
695	3.00E-09	2.00E-09	3.00E-09	3.00E-09	2.00E-09
698	0.00E+00	1.00E-09	2.00E-09	4.00E-09	1.00E-09
699	2.00E-09	0.00E+00	0.00E+00	0.00E+00	4.00E-09
700	2.00E-09	0.00E+00	0.00E+00	2.00E-09	0.00E+00
701	0.00E+00	1.00E-09	2.00E-09	4.00E-09	3.00E-09
702	3.00E-09	1.00E-09	1.00E-09	3.00E-09	3.00E-09
704	0.00E+00	1.00E-09	2.00E-09	3.00E-09	4.00E-09
705	2.00E-09	3.00E-09	2.00E-09	0.00E+00	4.00E-09
706	2.00E-09	5.00E-09	2.00E-09	3.00E-09	2.00E-09
1280	1.00E-09	0.00E+00	1.00E-09	1.00E-09	1.00E-09
Biased Statistics					
Average Biased	2.20E-09	1.00E-09	1.40E-09	2.20E-09	2.20E-09
Std Dev Biased	1.48E-09	1.00E-09	1.34E-09	1.48E-09	1.79E-09
Ps90%/90% (+KTL) Biased	6.27E-09	3.74E-09	5.08E-09	6.27E-09	7.11E-09
Ps90%/90% (-KTL) Biased	-1.87E-09	-1.74E-09	-2.28E-09	-1.87E-09	-2.71E-09
Un-Biased Statistics					
Average Un-Biased	1.40E-09	2.20E-09	1.80E-09	2.60E-09	3.20E-09
Std Dev Un-Biased	1.34E-09	1.79E-09	4.47E-10	1.52E-09	8.37E-10
Ps90%/90% (+KTL) Un-Biased	5.08E-09	7.11E-09	3.03E-09	6.76E-09	5.49E-09
Ps90%/90% (-KTL) Un-Biased	-2.28E-09	-2.71E-09	5.74E-10	-1.56E-09	9.06E-10
Specification MAX	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06
Status	PASS	PASS	PASS	PASS	PASS

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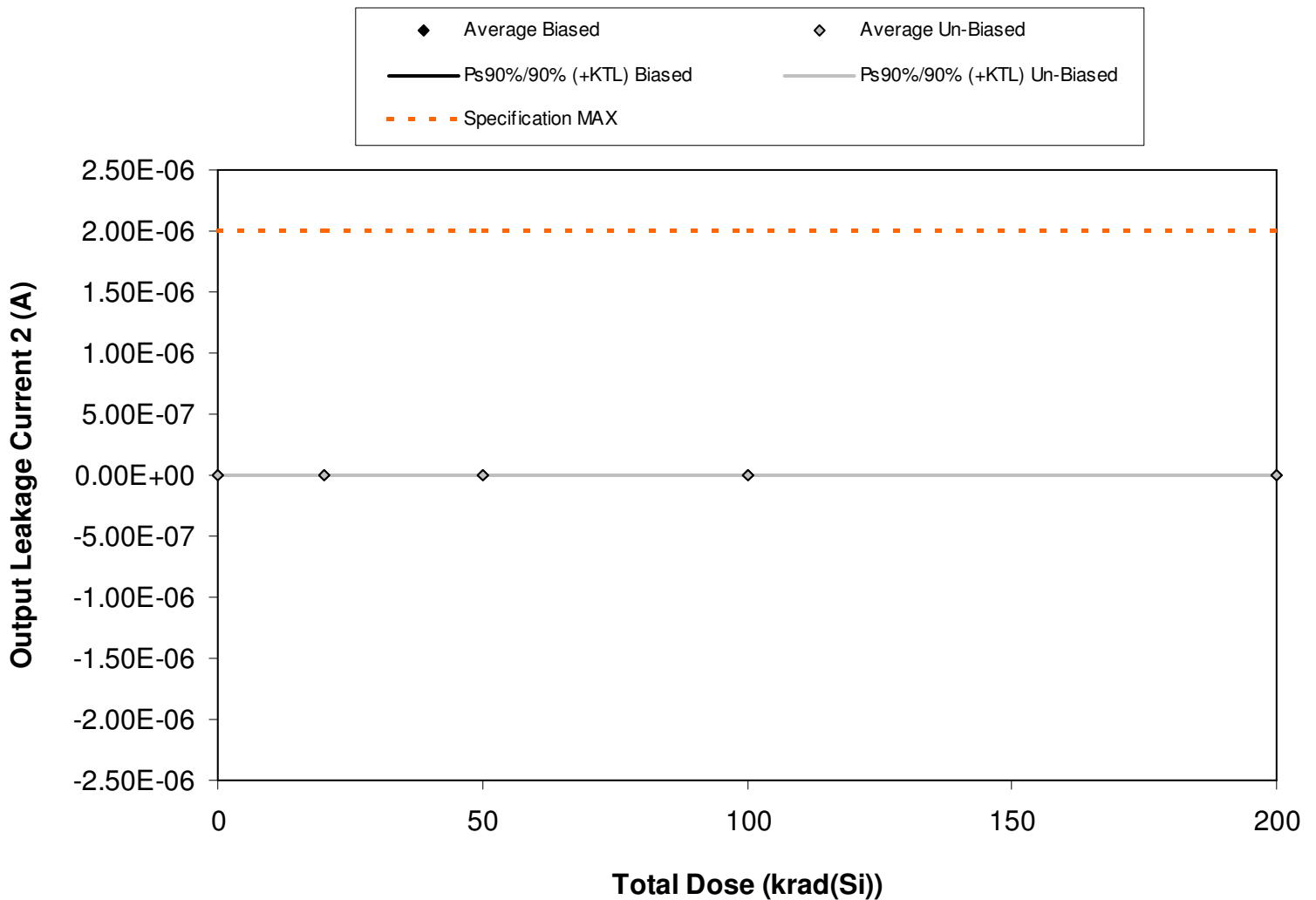**(719) 531-0800**

Figure 5.22. Plot of output leakage current (comparator 2) versus total dose. The data show no significant degradation with total dose. The solid diamonds are the average of measured data points from the biased sample (devices irradiated with an electrical bias) while the shaded diamonds are the average from the un-biased sample. The black lines show the effects on the data after application of the biased KTL statistics (solid and dashed lines) while the gray lines show the effects on the data after application of the unbiased KTL statistics (solid and dashed lines). The red dashed lines are the minimum and maximum specification values as defined in the datasheet and/or test plan.

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Table 5.22. Raw data for the output leakage current (comparator 2) versus total dose, including the statistical analysis, the specification and the status of the testing (pass/fail).

Output Leakage Current 2 (A)	Total Dose (krad(Si))				
Device	0	20	50	100	200
694	0.00E+00	3.00E-09	2.00E-09	2.00E-09	0.00E+00
695	1.00E-09	2.00E-09	3.00E-09	2.00E-09	2.00E-09
698	1.00E-09	0.00E+00	0.00E+00	0.00E+00	2.00E-09
699	0.00E+00	2.00E-09	2.00E-09	0.00E+00	2.00E-09
700	1.00E-09	0.00E+00	3.00E-09	2.00E-09	2.00E-09
701	1.00E-09	2.00E-09	2.00E-09	0.00E+00	1.00E-09
702	3.00E-09	1.00E-09	1.00E-09	3.00E-09	3.00E-09
704	1.00E-09	2.00E-09	1.00E-09	4.00E-09	4.00E-09
705	3.00E-09	2.00E-09	1.00E-09	2.00E-09	2.00E-09
706	0.00E+00	1.00E-09	0.00E+00	1.00E-09	1.00E-09
1280	0.00E+00	0.00E+00	2.00E-09	2.00E-09	0.00E+00
Biased Statistics					
Average Biased	6.00E-10	1.40E-09	2.00E-09	1.20E-09	1.60E-09
Std Dev Biased	5.48E-10	1.34E-09	1.22E-09	1.10E-09	8.94E-10
Ps90%/90% (+KTL) Biased	2.10E-09	5.08E-09	5.36E-09	4.20E-09	4.05E-09
Ps90%/90% (-KTL) Biased	-9.02E-10	-2.28E-09	-1.36E-09	-1.80E-09	-8.53E-10
Un-Biased Statistics					
Average Un-Biased	1.60E-09	1.60E-09	1.00E-09	2.00E-09	2.20E-09
Std Dev Un-Biased	1.34E-09	5.48E-10	7.07E-10	1.58E-09	1.30E-09
Ps90%/90% (+KTL) Un-Biased	5.28E-09	3.10E-09	2.94E-09	6.34E-09	5.78E-09
Ps90%/90% (-KTL) Un-Biased	-2.08E-09	9.81E-11	-9.39E-10	-2.34E-09	-1.38E-09
Specification MAX	2.00E-06	2.00E-06	2.00E-06	2.00E-06	2.00E-06
Status	PASS	PASS	PASS	PASS	PASS

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6.0. Summary / Conclusions

The total ionizing dose testing described in this final report was performed using the facilities at Radiation Assured Devices' Longmire Laboratories in Colorado Springs, CO. The high dose rate total ionizing dose (TID) source is a JLSA 84-21 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 120rad(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 were presented in this report. The attributes data contains the average, standard deviation and the average with the KTL values applied. The KTL value used was 2.742 per MIL HDBK 814 using one-sided tolerance limits of 90/90 and a 5-piece sample size. Note that the following criteria was used to determine the outcome of the testing: following the radiation exposure each parameter had to pass the specification value and the average value for the five-piece sample must pass the specification value when the KTL limits are applied. If these conditions were not both satisfied following the radiation exposure, then the lot could be logged as an RLAT failure.

The units passed the radiation lot acceptance test with only minor degradation to the input offset and input bias current parameters and no significant degradation to any other measured parameter.

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Appendix A: TID Bias Connections

Biased Samples:

Pin	Function	Connection / Bias
1	OUT1	+15V Via 10kΩ
2	GND1	GND
3	+IN1	To Pin 8 and –15V via 10kΩ
4	-IN1	To Pin 9 and +15V via 10kΩ and Pin 8 via 100Ω
5	V-	-15V
6	OUT2	+15V Via 10kΩ
7	GND2	GND
8	+IN2	To Pin 3 and –15V via 10kΩ and Pin 4 via 100Ω
9	-IN2	To Pin 4 and +15V via 10kΩ
10	V+	+15V

Unbiased Samples:

Pin	Function	Connection / Bias
1	OUT1	GND
2	GND1	GND
3	+IN1	GND
4	-IN1	GND
5	V-	GND
6	OUT2	GND
7	GND2	GND
8	+IN2	GND
9	-IN2	GND
10	V+	GND

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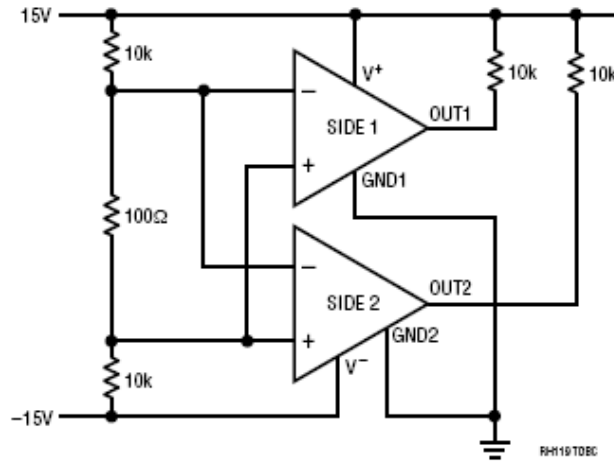**(719) 531-0800**

Figure A.1. Irradiation bias drawing for the units to be irradiated under electrical bias. This figure was extracted from LINEAR TECHNOLOGY CORPORATION, RH119 Datasheet.
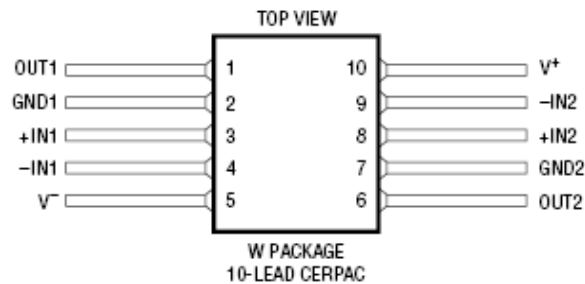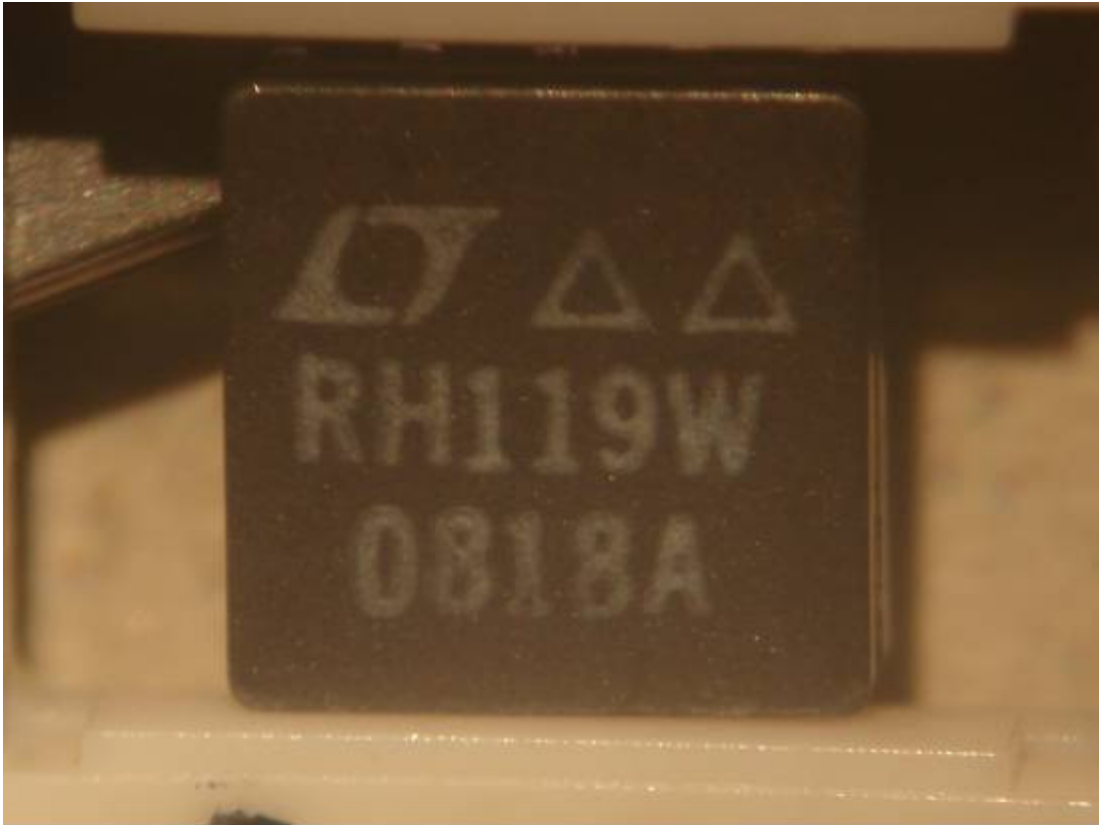

Figure A.2. Package drawing (for reference only). This figure was extracted from LINEAR TECHNOLOGY CORPORATION, RH119 Datasheet.

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Appendix B: Photograph of device-under-test to show part markings

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Appendix C: Electrical Test Parameters and Conditions (All Subgroup 1 Parameters)

All electrical tests for this device are performed on one of Radiation Assured Device's 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 dual comparators, 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 either 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.

Table C.1. Measured parameters and test conditions for the RH119W.

TEST DESCRIPTION	TEST CONDITIONS
Input Offset Voltage, V_{OS1}, V_{OS2}	$V_S = \pm15V$, $V_{CM} = 0V$
Common Mode Rejection Ratio, CMRR1, CMRR2	$V_S = \pm15V$
Input Offset Current, I_{OS1}, I_{OS2}	$V_S = \pm15V$, $V_{CM} = 0V$
Input Bias Current, Non-Inverting Input, $+I_{B1}$, $+I_{B2}$	$V_S = \pm15V$, $V_{CM} = 0V$
Input Bias Current, Inverting Input, $-I_{B1}$, $-I_{B2}$	$V_S = \pm15V$, $V_{CM} = 0V$
Large Signal Voltage Gain, A_{VOL1}, A_{VOL2}	$V_S = \pm15V$, $V_{CM} = 0V$
Saturation Voltage, V_{SAT1}, V_{SAT2}	$+V_S = +4.5V$, $-V_S = 0V$, $I_{SINK} = 3.2mA$
Saturation Voltage, V_{SAT3}, V_{SAT4}	$V_S = \pm15V$, $I_{OUT} = 25mA$
Output Leakage Current, I_{CEX1}, I_{CEX2}	$V_{IN}=5mV$, V_{OUT} to $V- = 35V$
Positive Supply Current, $+I_S$	$V_S = \pm15V$
Negative Supply Current, $-I_S$	$V_S = \pm15V$

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Table C.2. Measured parameters, pre-irradiation specifications and measurement resolution for the RH119W. The resolution is based either on test data or the LSB of the DAC for a given measurement.

Measured Parameter	Pre-Irradiation Specification	Measurement Resolution/Precision
Input Offset Voltage, V_{OS1}, V_{OS2}	4mV MAX	±3.38E-05V
Common Mode Rejection Ratio, CMRR1, CMRR2	90dB MIN	±9.70E+00dB
Input Offset Current, I_{OS1}, I_{OS2}	75nA MAX	±9.24E-09A
Input Bias Current, Non-Inverting Input, $+I_{B1}$, $+I_{B2}$	500nA MAX	±1.00E-08A
Input Bias Current, Inverting Input, $-I_{B1}$, $-I_{B2}$	500nA MAX	±1.00E-08A
Large Signal Voltage Gain, A_{VOL1}, A_{VOL2}	10V/mV MIN	±2.06E+01V/mV
Large Signal Voltage Gain, A_{VOL1}, A_{VOL2}	80dB MIN	±2.29E+00dB
Saturation Voltage, V_{SAT1}, V_{SAT2}	0.4V MAX	±1.00E-03V
Saturation Voltage, V_{SAT3}, V_{SAT4}	1.5V MAX	±5.00E-03V
Output Leakage Current, I_{CEX1}, I_{CEX2}	2μA MAX	±3.24E-09A
Positive Supply Current, $+I_S$	11.5mA MAX	±6.54E-05 A
Negative Supply Current, $-I_S$	4.5mA MAX	±9.97E-06A

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