



## ***Radiation Lot Acceptance Testing (RLAT) of the RH117K-Positive Adjustable Regulator for Linear Technology***

**Customer:** Linear Technology (PO# 53844L)

**RAD Job Number:** 09-413

**Part Type Tested:** Linear Technology RH117K Positive Adjustable Regulator

**Commercial Part Number:** RH117K

**Traceability Information:** Lot Date Code: 0926A, Assembly Lot# 533035.1, FAB Lot# WP1058.1, Wafer 5. Information obtained from Linear Technology PO# 53844L. See photograph of unit under test in Appendix A.

**Quantity of Units:** 12 units total, 5 units for biased irradiation, 5 units for unbiased irradiation and 2 control units. Serial numbers 108 to 112 were biased during irradiation, serial numbers 114 to 118 were unbiased during irradiation and serial numbers 119 and 121 were used as controls. See Appendix B for the radiation bias connection table.

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

**TID Dose Rate and Test Increments:** 50-300rad(Si)/s with readings at pre-irradiation, 20, 50, 100, and 200krad(Si). Note that the LINEAR TECHNOLOGY datasheet guarantees post-irradiation performance to only the 100krad(Si) dose level. Testing to 200krad(Si), as reported herein is an overtest of the datasheet guaranteed radiation performance specifications.

**TID Overtest and Post-Irradiation Anneal:** No overtest or 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:** LTS2020 Tester, 2101 Family Board, 0606 Fixture and RH117 DUT Board

**Facility and Radiation Source:** Radiation Assured Devices Longmire Laboratories, Colorado Springs, CO using the JLSA 81-24 high dose rate Co60 source. Dosimetry performed by 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 for irradiation and test controlled to 24°C ± 6°C.

**RLAT Result: PASSED. The units-under-test passed to the maximum tested dose level of 200krad(Si) with no significant degradation observed on any measured parameter.**



## **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"



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.



### **3.0. Radiation Test Conditions**

The RH117K positive adjustable regulator described in this final report was 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 B for the full bias circuits. In our opinion, 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 20krad(Si), 50krad(Si) and 100krad(Si). Electrical testing occurred within one hour following the end of each irradiation segment. For the 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 CaF<sub>2</sub>. 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 based on TLD dosimetry measurements (see previous section). The final dose rate for this work was 84.9rad(Si)/s with a precision of  $\pm 5\%$ .



#### **4.0. Tested Parameters**

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

1. Reference Voltage
2. Line Regulation
3. Load Regulation  $V_{OUT} \leq 5V$
4. Load Regulation  $V_{OUT} \geq 5V$
5. Adjust Pin Current
6. Adjust Pin Current Change
7. Minimum Load Current
8. Current Limit  $V_{DIFF} \leq 15V$
9. Current Limit  $V_{DIFF} = 40V$

The parametric data was obtained as read and record and all the raw data plus an attributes summary are contained 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 RLAT: following the radiation exposure each of the 5 pieces shall pass the specification value and the average value for the ten-piece sample 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 a failure.

#### **5.0. Total Ionizing Dose Test Results**

The RH117K positive adjustable regulator PASSED the RLAT to the maximum tested dose level of 200krad(Si) with none of the measured parameters showing any significant degradation. Figures 5.1 – 5.15 show plots of all the measured parameters versus total ionizing dose while Tables 5.1 – 5.15 show the corresponding raw data for each of these parameters. Appendix D lists all the figures used in this section for convenience.

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 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-



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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 any observed degradation was due to the radiation exposure.

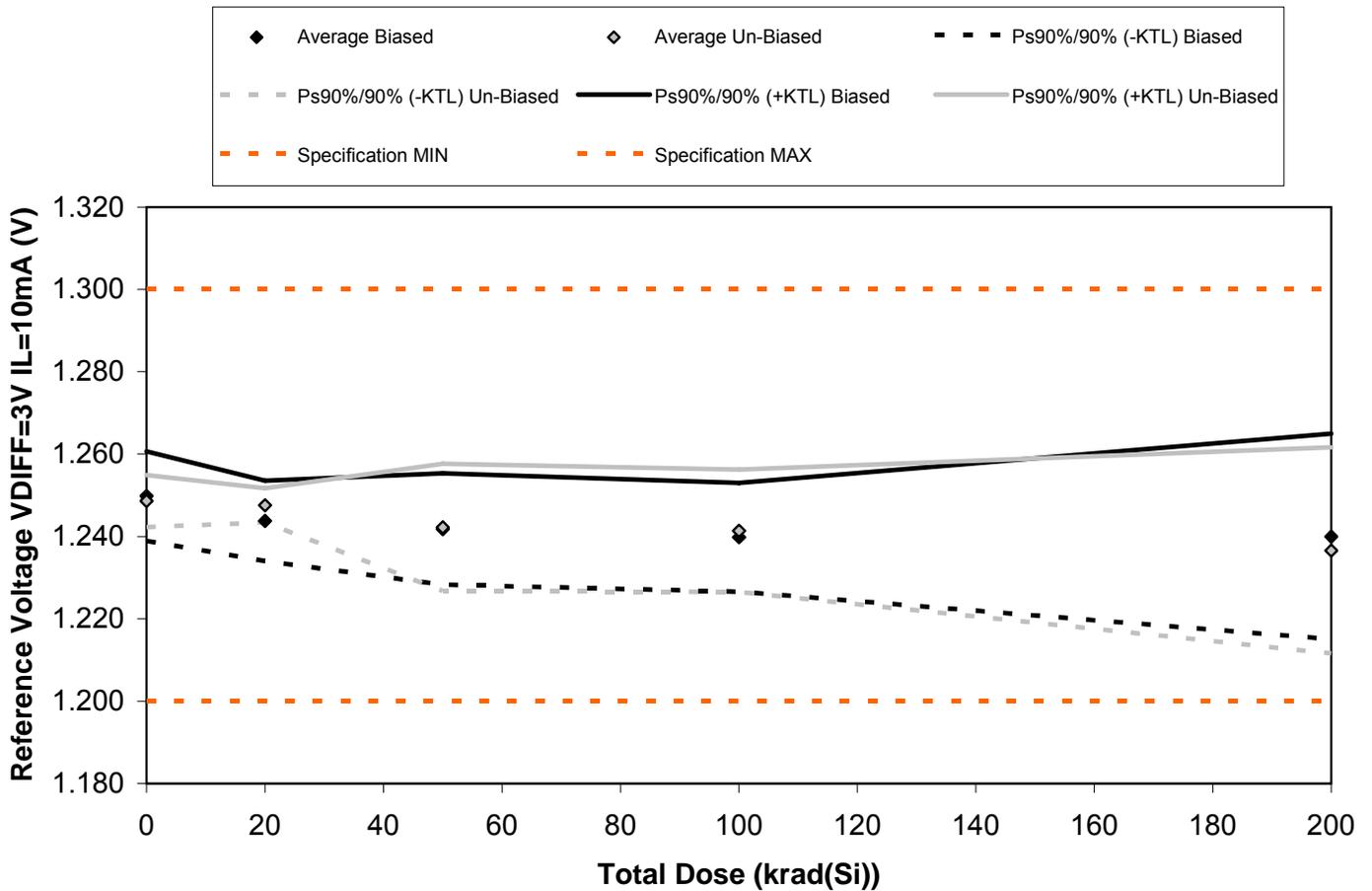


Figure 5.1. Plot of Reference Voltage VDIFF=3V IL=10mA (V) versus total dose. The data show no significant change with radiation. The solid diamonds are the average of the measured data points for the samples irradiated under electrical bias while the shaded diamonds are the average of the measured data points for the samples irradiated with all pins tied to ground. The black lines (solid and/or dashed) are the average of the data points after application of the KTL statistics on the samples irradiated under electrical bias while the gray lines (solid and/or dashed) are the average of the data points after application of the 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 Reference Voltage VDIFF=3V IL=10mA (V) versus total dose, including the statistical analysis, specification and the status of the testing (pass/fail).

Reference Voltage VDIFF=3V IL=10mA (V)	Total Dose (krad(Si))				
	0	20	50	100	200
Device					
108	1.249	1.249	1.248	1.248	1.249
109	1.256	1.241	1.238	1.238	1.249
110	1.251	1.241	1.237	1.237	1.228
111	1.247	1.242	1.240	1.240	1.239
112	1.246	1.246	1.246	1.236	1.235
114	1.249	1.249	1.234	1.234	1.233
115	1.251	1.248	1.239	1.239	1.235
116	1.248	1.248	1.248	1.248	1.246
117	1.250	1.248	1.245	1.245	1.245
118	1.245	1.245	1.245	1.241	1.224
119	1.251	1.251	1.252	1.252	1.252
121	1.250	1.250	1.249	1.249	1.250
<b>Biased Statistics</b>					
Average Biased	1.250	1.244	1.242	1.240	1.240
Std Dev Biased	0.004	0.004	0.005	0.005	0.009
Ps90%/90% (+KTL) Biased	1.261	1.254	1.255	1.253	1.265
Ps90%/90% (-KTL) Biased	1.239	1.234	1.228	1.227	1.215
<b>Un-Biased Statistics</b>					
Average Un-Biased	1.249	1.248	1.242	1.241	1.237
Std Dev Un-Biased	0.002	0.002	0.006	0.005	0.009
Ps90%/90% (+KTL) Un-Biased	1.255	1.252	1.258	1.256	1.262
Ps90%/90% (-KTL) Un-Biased	1.242	1.243	1.227	1.227	1.212
<b>Specification MIN</b>	<b>1.200</b>	<b>1.200</b>	<b>1.200</b>	<b>1.200</b>	<b>1.200</b>
Status	PASS	PASS	PASS	PASS	PASS
<b>Specification MAX</b>	<b>1.300</b>	<b>1.300</b>	<b>1.300</b>	<b>1.300</b>	<b>1.300</b>
Status	PASS	PASS	PASS	PASS	PASS

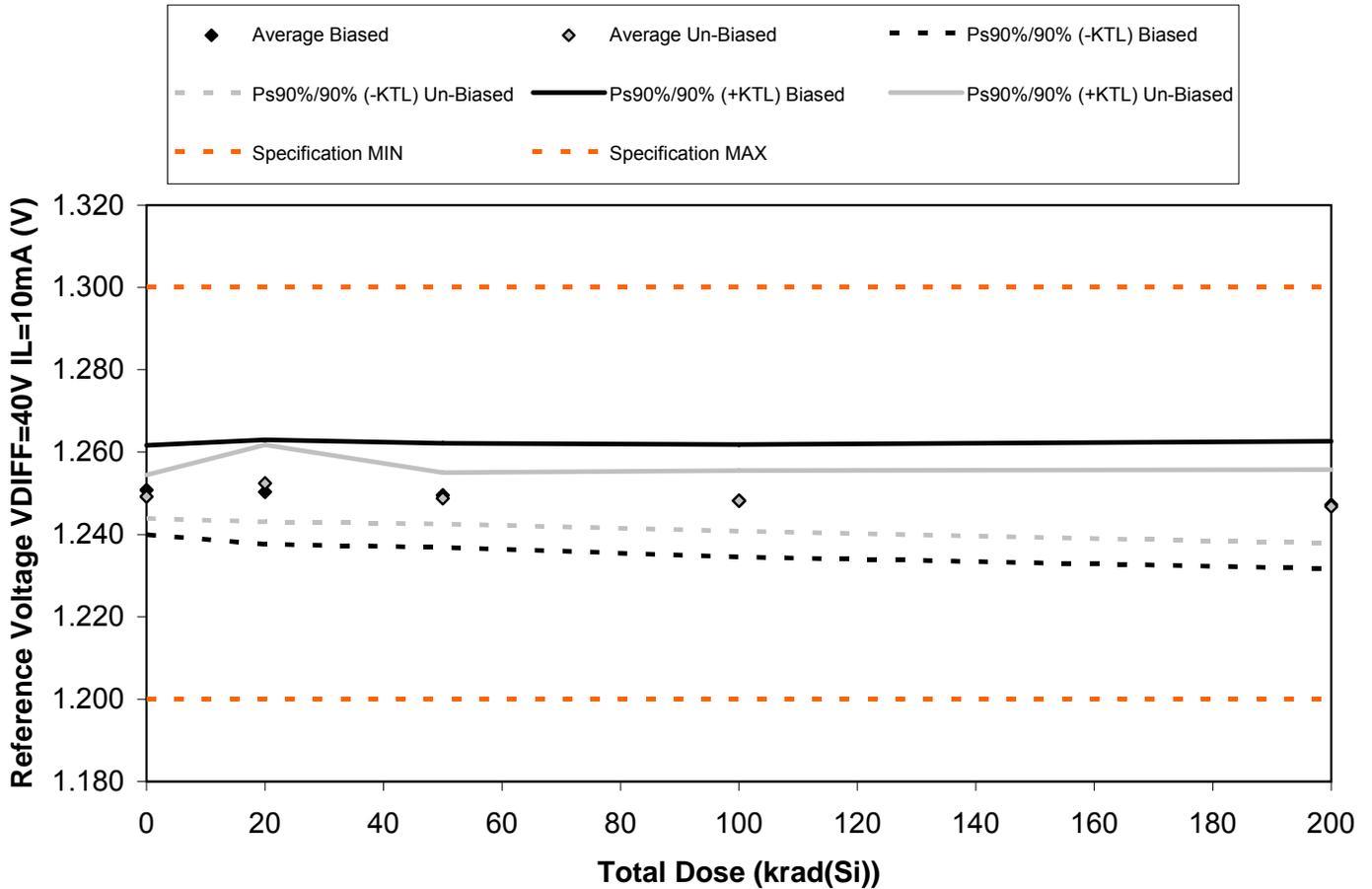


Figure 5.2. Plot of Reference Voltage VDIFF=40V IL=10mA (V) versus total dose. The data show no significant change with radiation. The solid diamonds are the average of the measured data points for the samples irradiated under electrical bias while the shaded diamonds are the average of the measured data points for the samples irradiated with all pins tied to ground. The black lines (solid and/or dashed) are the average of the data points after application of the KTL statistics on the samples irradiated under electrical bias while the gray lines (solid and/or dashed) are the average of the data points after application of the 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 Reference Voltage VDIFF=40V IL=10mA (V) versus total dose, including the statistical analysis, specification and the status of the testing (pass/fail).

Reference Voltage VDIFF=40V IL=10mA (V)	Total Dose (krad(Si))				
	0	20	50	100	200
Device					
108	1.250	1.250	1.249	1.249	1.249
109	1.257	1.257	1.256	1.255	1.254
110	1.252	1.252	1.252	1.250	1.250
111	1.248	1.248	1.246	1.245	1.243
112	1.247	1.245	1.245	1.242	1.240
114	1.250	1.249	1.249	1.248	1.248
115	1.251	1.257	1.251	1.251	1.250
116	1.249	1.251	1.251	1.250	1.249
117	1.250	1.250	1.247	1.248	1.245
118	1.246	1.256	1.246	1.244	1.242
119	1.252	1.251	1.252	1.252	1.252
121	1.251	1.251	1.251	1.252	1.251
<b>Biased Statistics</b>					
Average Biased	1.251	1.250	1.250	1.248	1.247
Std Dev Biased	0.004	0.005	0.005	0.005	0.006
Ps90%/90% (+KTL) Biased	1.262	1.263	1.262	1.262	1.263
Ps90%/90% (-KTL) Biased	1.240	1.238	1.237	1.235	1.232
<b>Un-Biased Statistics</b>					
Average Un-Biased	1.249	1.252	1.249	1.248	1.247
Std Dev Un-Biased	0.002	0.003	0.002	0.003	0.003
Ps90%/90% (+KTL) Un-Biased	1.254	1.262	1.255	1.256	1.256
Ps90%/90% (-KTL) Un-Biased	1.244	1.243	1.243	1.241	1.238
<b>Specification MIN</b>	<b>1.200</b>	<b>1.200</b>	<b>1.200</b>	<b>1.200</b>	<b>1.200</b>
Status	PASS	PASS	PASS	PASS	PASS
<b>Specification MAX</b>	<b>1.300</b>	<b>1.300</b>	<b>1.300</b>	<b>1.300</b>	<b>1.300</b>
Status	PASS	PASS	PASS	PASS	PASS

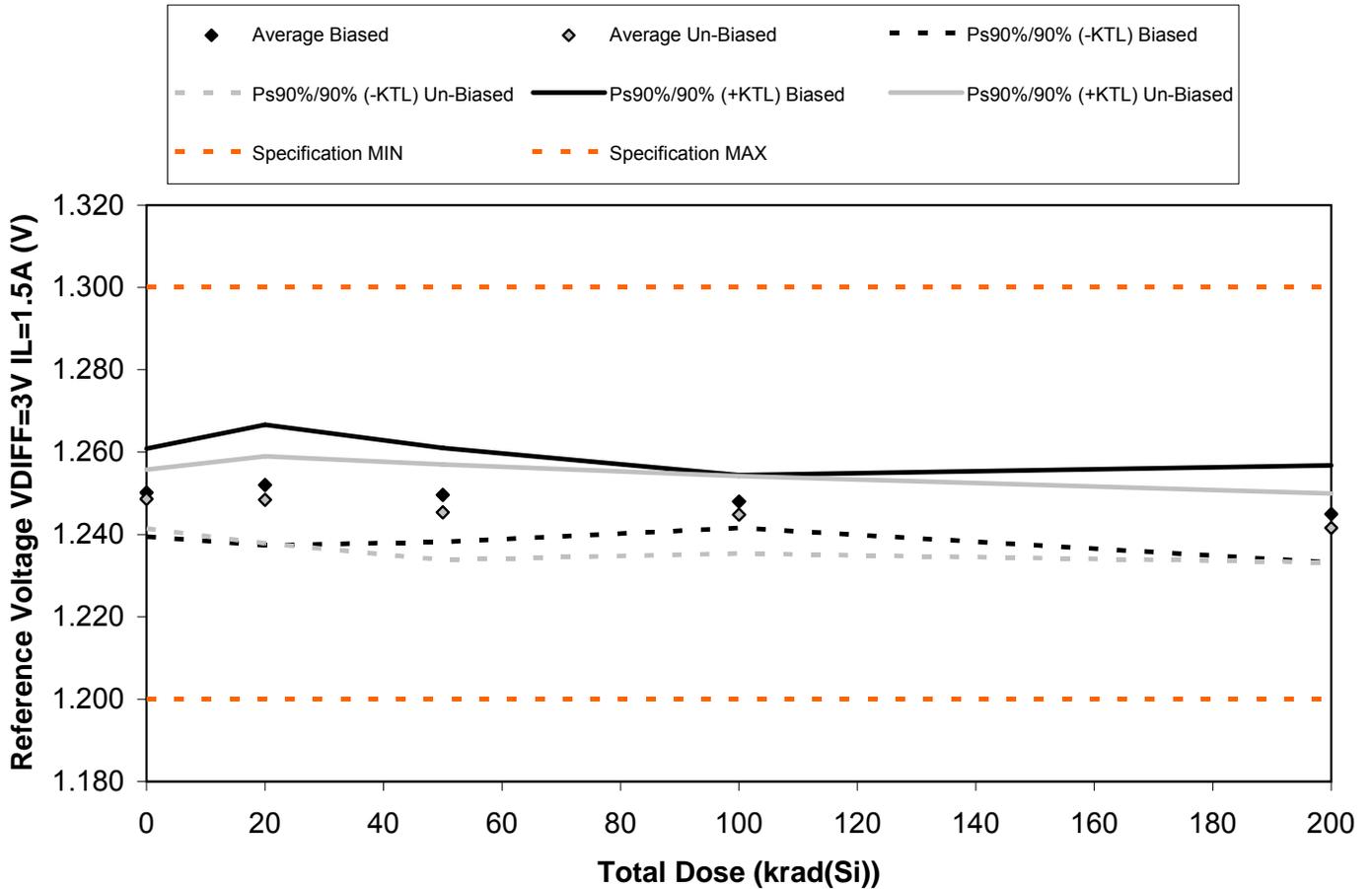


Figure 5.3. Plot of Reference Voltage VDIFF=3V IL=1.5A (V) versus total dose. The data show no significant change with radiation. The solid diamonds are the average of the measured data points for the samples irradiated under electrical bias while the shaded diamonds are the average of the measured data points for the samples irradiated with all pins tied to ground. The black lines (solid and/or dashed) are the average of the data points after application of the KTL statistics on the samples irradiated under electrical bias while the gray lines (solid and/or dashed) are the average of the data points after application of the 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 Reference Voltage VDIFF=3V IL=1.5A (V) versus total dose, including the statistical analysis, specification and the status of the testing (pass/fail).

Reference Voltage VDIFF=3V IL=1.5A (V)	Total Dose (krad(Si))				
Device	0	20	50	100	200
108	1.249	1.248	1.247	1.247	1.244
109	1.256	1.261	1.256	1.251	1.250
110	1.252	1.252	1.250	1.250	1.249
111	1.248	1.248	1.245	1.246	1.241
112	1.246	1.251	1.250	1.246	1.241
114	1.248	1.248	1.243	1.245	1.240
115	1.252	1.252	1.242	1.243	1.240
116	1.248	1.250	1.250	1.248	1.247
117	1.250	1.250	1.250	1.248	1.241
118	1.245	1.242	1.242	1.240	1.240
119	1.252	1.252	1.252	1.251	1.252
121	1.250	1.249	1.250	1.250	1.250
<b>Biased Statistics</b>					
Average Biased	1.250	1.252	1.250	1.248	1.245
Std Dev Biased	0.004	0.005	0.004	0.002	0.004
Ps90%/90% (+KTL) Biased	1.261	1.267	1.261	1.254	1.257
Ps90%/90% (-KTL) Biased	1.240	1.237	1.238	1.242	1.233
<b>Un-Biased Statistics</b>					
Average Un-Biased	1.249	1.248	1.245	1.245	1.242
Std Dev Un-Biased	0.003	0.004	0.004	0.003	0.003
Ps90%/90% (+KTL) Un-Biased	1.256	1.259	1.257	1.254	1.250
Ps90%/90% (-KTL) Un-Biased	1.241	1.238	1.234	1.235	1.233
<b>Specification MIN</b>	<b>1.200</b>	<b>1.200</b>	<b>1.200</b>	<b>1.200</b>	<b>1.200</b>
Status	PASS	PASS	PASS	PASS	PASS
<b>Specification MAX</b>	<b>1.300</b>	<b>1.300</b>	<b>1.300</b>	<b>1.300</b>	<b>1.300</b>
Status	PASS	PASS	PASS	PASS	PASS

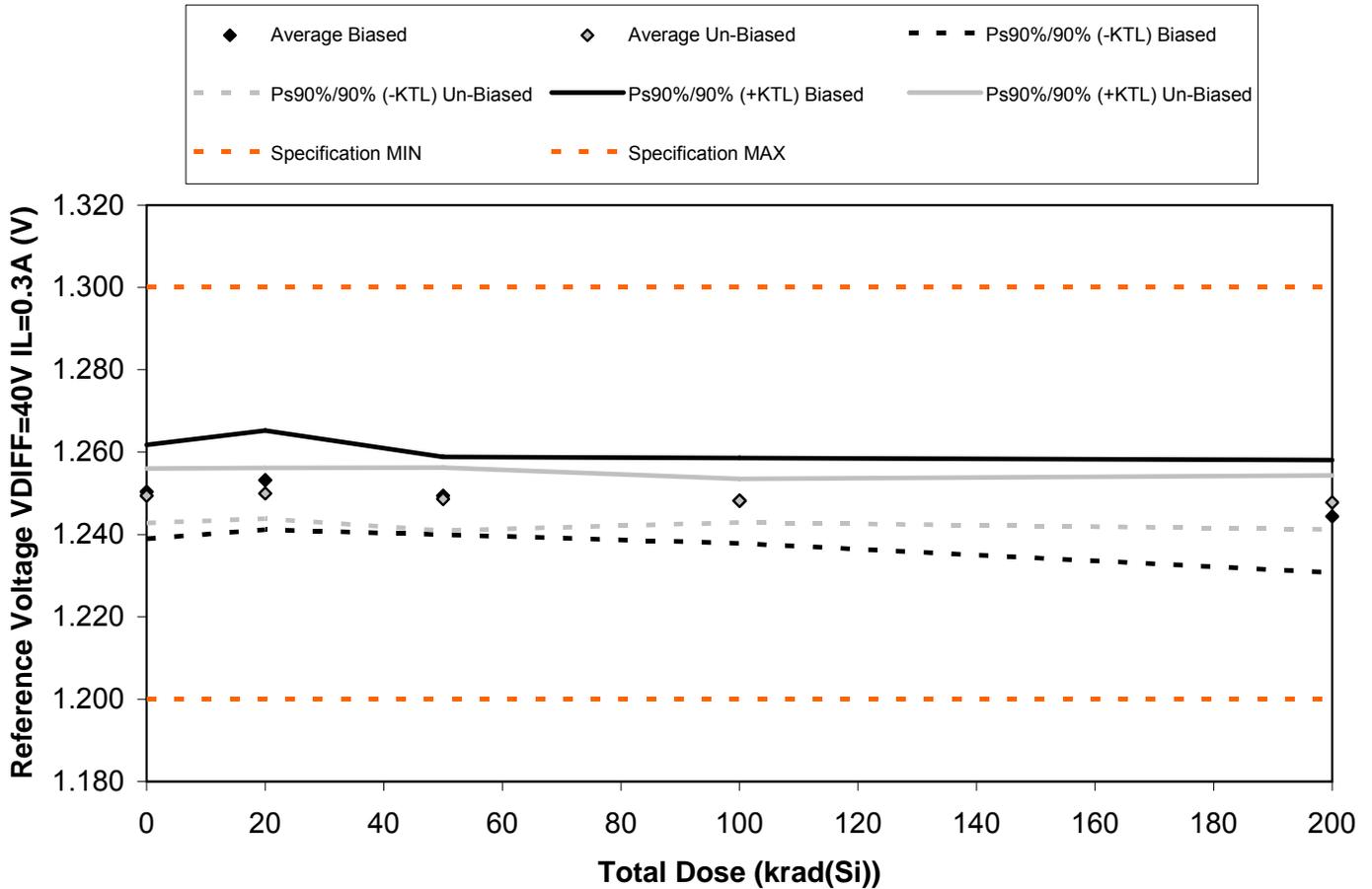


Figure 5.4. Plot of Reference Voltage VDIFF=40V IL=0.3A (V) versus total dose. The data show no significant change with radiation. The solid diamonds are the average of the measured data points for the samples irradiated under electrical bias while the shaded diamonds are the average of the measured data points for the samples irradiated with all pins tied to ground. The black lines (solid and/or dashed) are the average of the data points after application of the KTL statistics on the samples irradiated under electrical bias while the gray lines (solid and/or dashed) are the average of the data points after application of the 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 Reference Voltage VDIFF=40V IL=0.3A (V) versus total dose, including the statistical analysis, specification and the status of the testing (pass/fail).

Reference Voltage VDIFF=40V IL=0.3A (V)	Total Dose (krad(Si))				
Device	0	20	50	100	200
108	1.250	1.251	1.250	1.250	1.247
109	1.257	1.261	1.255	1.254	1.252
110	1.251	1.251	1.248	1.246	1.241
111	1.248	1.251	1.248	1.245	1.241
112	1.246	1.252	1.246	1.246	1.241
114	1.250	1.251	1.251	1.249	1.249
115	1.252	1.251	1.250	1.250	1.250
116	1.248	1.251	1.248	1.248	1.247
117	1.251	1.251	1.250	1.249	1.249
118	1.246	1.246	1.244	1.245	1.244
119	1.252	1.251	1.252	1.252	1.252
121	1.251	1.251	1.251	1.250	1.250
<b>Biased Statistics</b>					
Average Biased	1.250	1.253	1.249	1.248	1.244
Std Dev Biased	0.004	0.004	0.003	0.004	0.005
Ps90%/90% (+KTL) Biased	1.262	1.265	1.259	1.259	1.258
Ps90%/90% (-KTL) Biased	1.239	1.241	1.240	1.238	1.231
<b>Un-Biased Statistics</b>					
Average Un-Biased	1.249	1.250	1.249	1.248	1.248
Std Dev Un-Biased	0.002	0.002	0.003	0.002	0.002
Ps90%/90% (+KTL) Un-Biased	1.256	1.256	1.256	1.253	1.254
Ps90%/90% (-KTL) Un-Biased	1.243	1.244	1.241	1.243	1.241
<b>Specification MIN</b>	<b>1.200</b>	<b>1.200</b>	<b>1.200</b>	<b>1.200</b>	<b>1.200</b>
Status	PASS	PASS	PASS	PASS	PASS
<b>Specification MAX</b>	<b>1.300</b>	<b>1.300</b>	<b>1.300</b>	<b>1.300</b>	<b>1.300</b>
Status	PASS	PASS	PASS	PASS	PASS

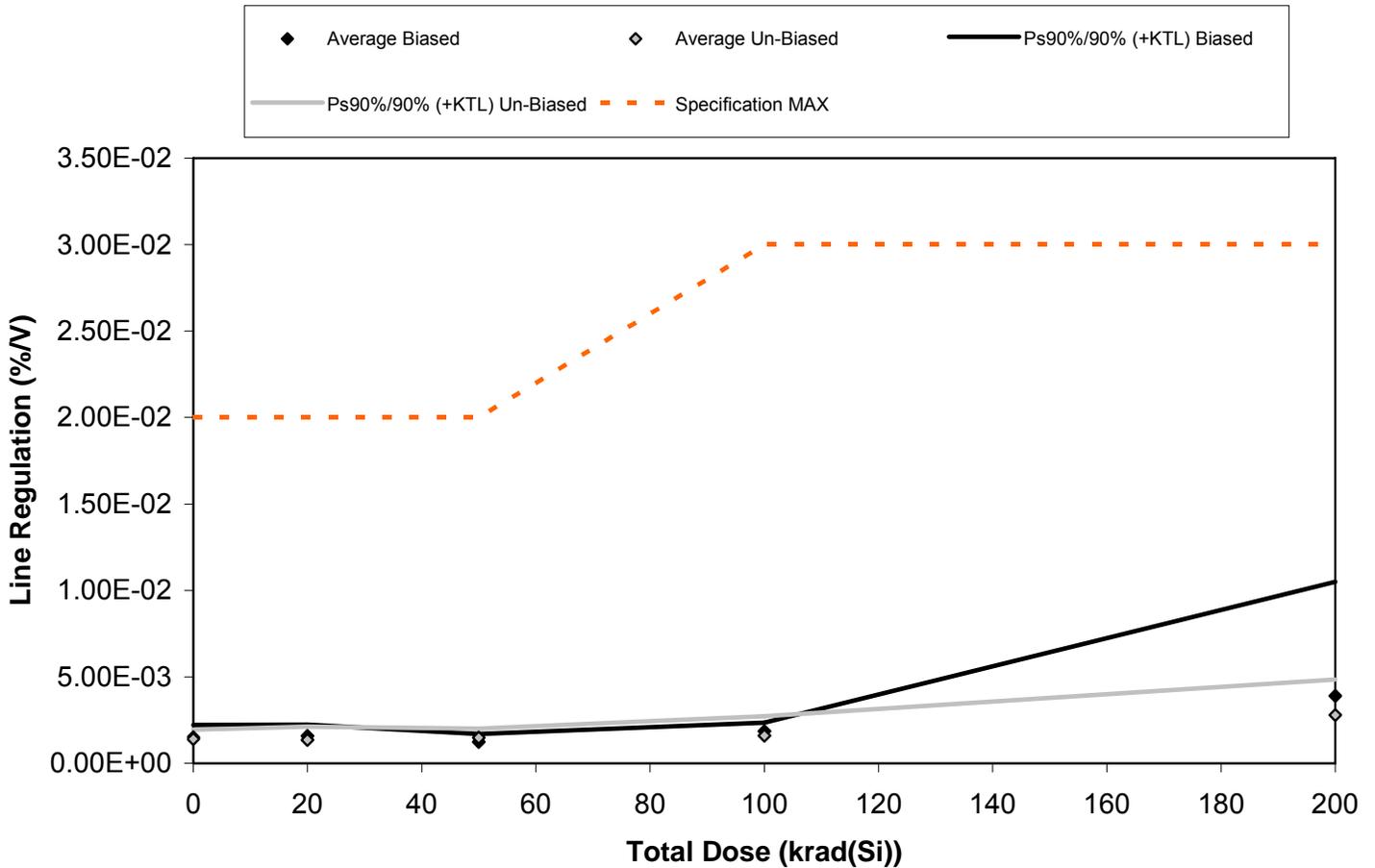


Figure 5.5. Plot of Line Regulation (%/V) versus total dose. The data show no significant change with radiation. The solid diamonds are the average of the measured data points for the samples irradiated under electrical bias while the shaded diamonds are the average of the measured data points for the samples irradiated with all pins tied to ground. The black lines (solid and/or dashed) are the average of the data points after application of the KTL statistics on the samples irradiated under electrical bias while the gray lines (solid and/or dashed) are the average of the data points after application of the 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 Line Regulation (%/V) versus total dose, including the statistical analysis, specification and the status of the testing (pass/fail).

Line Regulation (%/V)	Total Dose (krad(Si))				
	0	20	50	100	200
Device					
108	1.80E-03	1.50E-03	1.30E-03	1.60E-03	2.00E-03
109	1.40E-03	1.80E-03	1.10E-03	1.80E-03	1.90E-03
110	1.10E-03	1.20E-03	1.10E-03	1.90E-03	5.70E-03
111	1.60E-03	1.70E-03	1.50E-03	1.90E-03	2.70E-03
112	1.60E-03	1.70E-03	1.20E-03	2.10E-03	7.20E-03
114	1.50E-03	1.30E-03	1.50E-03	2.10E-03	2.50E-03
115	1.50E-03	1.10E-03	1.20E-03	1.30E-03	2.50E-03
116	1.10E-03	1.70E-03	1.40E-03	1.10E-03	2.70E-03
117	1.30E-03	1.10E-03	1.70E-03	1.90E-03	4.10E-03
118	1.60E-03	1.60E-03	1.60E-03	1.60E-03	2.20E-03
119	1.30E-03	1.20E-03	8.00E-04	1.30E-03	1.80E-03
121	9.00E-04	1.60E-03	1.10E-03	1.50E-03	1.50E-03
<b>Biased Statistics</b>					
Average Biased	1.50E-03	1.58E-03	1.24E-03	1.86E-03	3.90E-03
Std Dev Biased	2.65E-04	2.39E-04	1.67E-04	1.82E-04	2.41E-03
Ps90%/90% (+KTL) Biased	2.23E-03	2.23E-03	1.70E-03	2.36E-03	1.05E-02
Ps90%/90% (-KTL) Biased	7.75E-04	9.25E-04	7.81E-04	1.36E-03	-2.70E-03
<b>Un-Biased Statistics</b>					
Average Un-Biased	1.40E-03	1.36E-03	1.48E-03	1.60E-03	2.80E-03
Std Dev Un-Biased	2.00E-04	2.79E-04	1.92E-04	4.12E-04	7.48E-04
Ps90%/90% (+KTL) Un-Biased	1.95E-03	2.13E-03	2.01E-03	2.73E-03	4.85E-03
Ps90%/90% (-KTL) Un-Biased	8.52E-04	5.94E-04	9.53E-04	4.69E-04	7.48E-04
<b>Specification MAX</b>	<b>2.00E-02</b>	<b>2.00E-02</b>	<b>2.00E-02</b>	<b>3.00E-02</b>	<b>3.00E-02</b>
Status	PASS	PASS	PASS	PASS	PASS

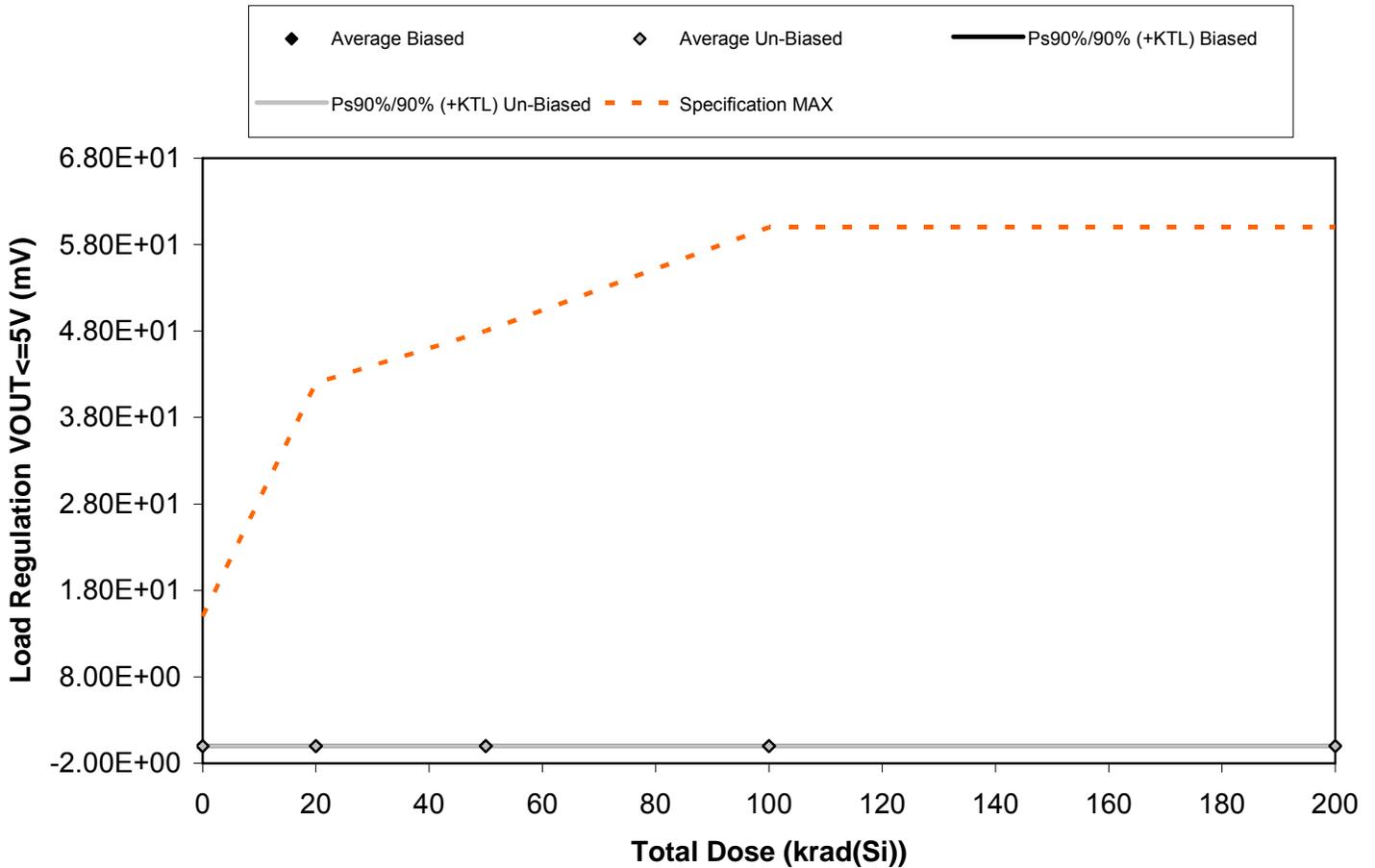


Figure 5.6. Plot of Load Regulation VOUT<=5V (mV) versus total dose. The data show no significant change with radiation. The solid diamonds are the average of the measured data points for the samples irradiated under electrical bias while the shaded diamonds are the average of the measured data points for the samples irradiated with all pins tied to ground. The black lines (solid and/or dashed) are the average of the data points after application of the KTL statistics on the samples irradiated under electrical bias while the gray lines (solid and/or dashed) are the average of the data points after application of the 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 Load Regulation  $V_{OUT} \leq 5V$  (mV) versus total dose, including the statistical analysis, specification and the status of the testing (pass/fail).

Load Regulation $V_{OUT} \leq 5V$ (mV)	Total Dose (krad(Si))				
	0	20	50	100	200
Device					
108	-5.39E-04	-2.66E-03	-1.70E-05	3.20E-04	7.08E-04
109	1.79E-03	2.02E-04	6.07E-04	3.54E-04	1.89E-03
110	2.06E-03	-3.37E-04	-5.10E-05	8.09E-04	1.03E-03
111	1.67E-03	-1.70E-05	4.72E-04	8.76E-04	1.23E-03
112	9.10E-04	-2.36E-04	5.22E-04	4.55E-04	1.35E-03
114	-2.19E-04	5.22E-04	5.05E-04	1.13E-03	5.05E-04
115	1.06E-03	1.85E-04	8.09E-04	5.39E-04	4.04E-04
116	-1.80E-03	2.53E-04	4.38E-04	1.01E-03	1.16E-03
117	7.75E-04	-3.20E-04	1.11E-03	2.53E-04	1.42E-03
118	-3.54E-04	4.21E-04	6.57E-04	3.88E-04	4.72E-04
119	-5.10E-05	-2.86E-04	-1.70E-05	2.86E-04	-4.72E-04
121	1.70E-03	8.26E-04	8.59E-04	2.02E-04	-2.02E-04
<b>Biased Statistics</b>					
Average Biased	1.18E-03	-6.10E-04	3.07E-04	5.63E-04	1.24E-03
Std Dev Biased	1.05E-03	1.17E-03	3.15E-04	2.61E-04	4.35E-04
Ps90%/90% (+KTL) Biased	4.05E-03	2.59E-03	1.17E-03	1.28E-03	2.43E-03
Ps90%/90% (-KTL) Biased	-1.70E-03	-3.81E-03	-5.57E-04	-1.53E-04	4.63E-05
<b>Un-Biased Statistics</b>					
Average Un-Biased	-1.08E-04	2.12E-04	7.04E-04	6.64E-04	7.92E-04
Std Dev Un-Biased	1.13E-03	3.26E-04	2.69E-04	3.86E-04	4.64E-04
Ps90%/90% (+KTL) Un-Biased	2.99E-03	1.11E-03	1.44E-03	1.72E-03	2.06E-03
Ps90%/90% (-KTL) Un-Biased	-3.20E-03	-6.82E-04	-3.42E-05	-3.96E-04	-4.80E-04
<b>Specification MAX</b>	<b>1.50E+01</b>	<b>4.20E+01</b>	<b>4.80E+01</b>	<b>6.00E+01</b>	<b>6.00E+01</b>
Status	PASS	PASS	PASS	PASS	PASS

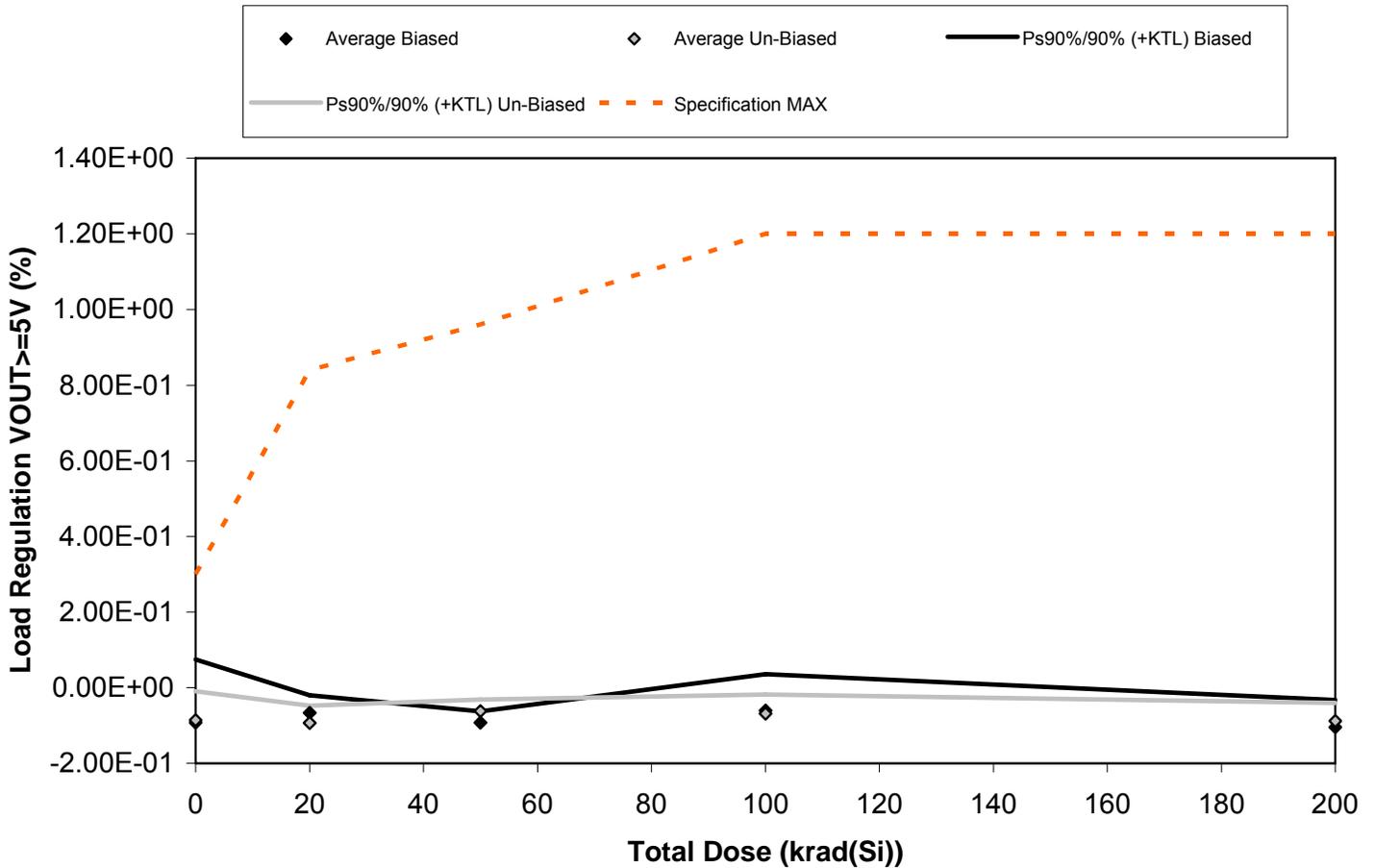


Figure 5.7. Plot of Load Regulation VOUT >= 5V (%) versus total dose. The data show no significant change with radiation. The solid diamonds are the average of the measured data points for the samples irradiated under electrical bias while the shaded diamonds are the average of the measured data points for the samples irradiated with all pins tied to ground. The black lines (solid and/or dashed) are the average of the data points after application of the KTL statistics on the samples irradiated under electrical bias while the gray lines (solid and/or dashed) are the average of the data points after application of the 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 Load Regulation  $V_{OUT} \geq 5V$  (%) versus total dose, including the statistical analysis, specification and the status of the testing (pass/fail).

Load Regulation $V_{OUT} \geq 5V$ (%)	Total Dose (krad(Si))				
	0	20	50	100	200
Device					
108	-1.26E-01	-8.00E-02	-1.00E-01	-1.08E-01	-1.15E-01
109	-8.10E-02	-5.80E-02	-1.00E-01	-5.10E-02	-7.30E-02
110	-9.00E-03	-4.10E-02	-7.70E-02	-8.10E-02	-1.34E-01
111	-1.72E-01	-8.10E-02	-1.00E-01	-1.60E-02	-8.10E-02
112	-7.40E-02	-7.10E-02	-8.50E-02	-4.70E-02	-1.18E-01
114	-9.40E-02	-1.13E-01	-6.20E-02	-5.00E-02	-7.10E-02
115	-9.10E-02	-6.70E-02	-6.50E-02	-6.60E-02	-7.70E-02
116	-7.80E-02	-9.90E-02	-5.60E-02	-1.00E-01	-8.10E-02
117	-1.21E-01	-9.30E-02	-4.80E-02	-6.10E-02	-1.14E-01
118	-4.50E-02	-9.40E-02	-7.80E-02	-6.70E-02	-9.80E-02
119	-8.80E-02	-3.70E-02	-4.60E-02	-4.80E-02	-5.80E-02
121	-1.76E-01	-8.80E-02	-6.90E-02	-5.60E-02	-4.30E-02
<b>Biased Statistics</b>					
Average Biased	-9.24E-02	-6.62E-02	-9.24E-02	-6.06E-02	-1.04E-01
Std Dev Biased	6.10E-02	1.68E-02	1.08E-02	3.51E-02	2.60E-02
Ps90%/90% (+KTL) Biased	7.49E-02	-2.00E-02	-6.28E-02	3.57E-02	-3.29E-02
Ps90%/90% (-KTL) Biased	-2.60E-01	-1.12E-01	-1.22E-01	-1.57E-01	-1.76E-01
<b>Un-Biased Statistics</b>					
Average Un-Biased	-8.58E-02	-9.32E-02	-6.18E-02	-6.88E-02	-8.82E-02
Std Dev Un-Biased	2.77E-02	1.67E-02	1.11E-02	1.87E-02	1.76E-02
Ps90%/90% (+KTL) Un-Biased	-9.97E-03	-4.75E-02	-3.12E-02	-1.75E-02	-4.00E-02
Ps90%/90% (-KTL) Un-Biased	-1.62E-01	-1.39E-01	-9.24E-02	-1.20E-01	-1.36E-01
<b>Specification MAX</b>	<b>3.00E-01</b>	<b>8.40E-01</b>	<b>9.60E-01</b>	<b>1.20E+00</b>	<b>1.20E+00</b>
Status	PASS	PASS	PASS	PASS	PASS

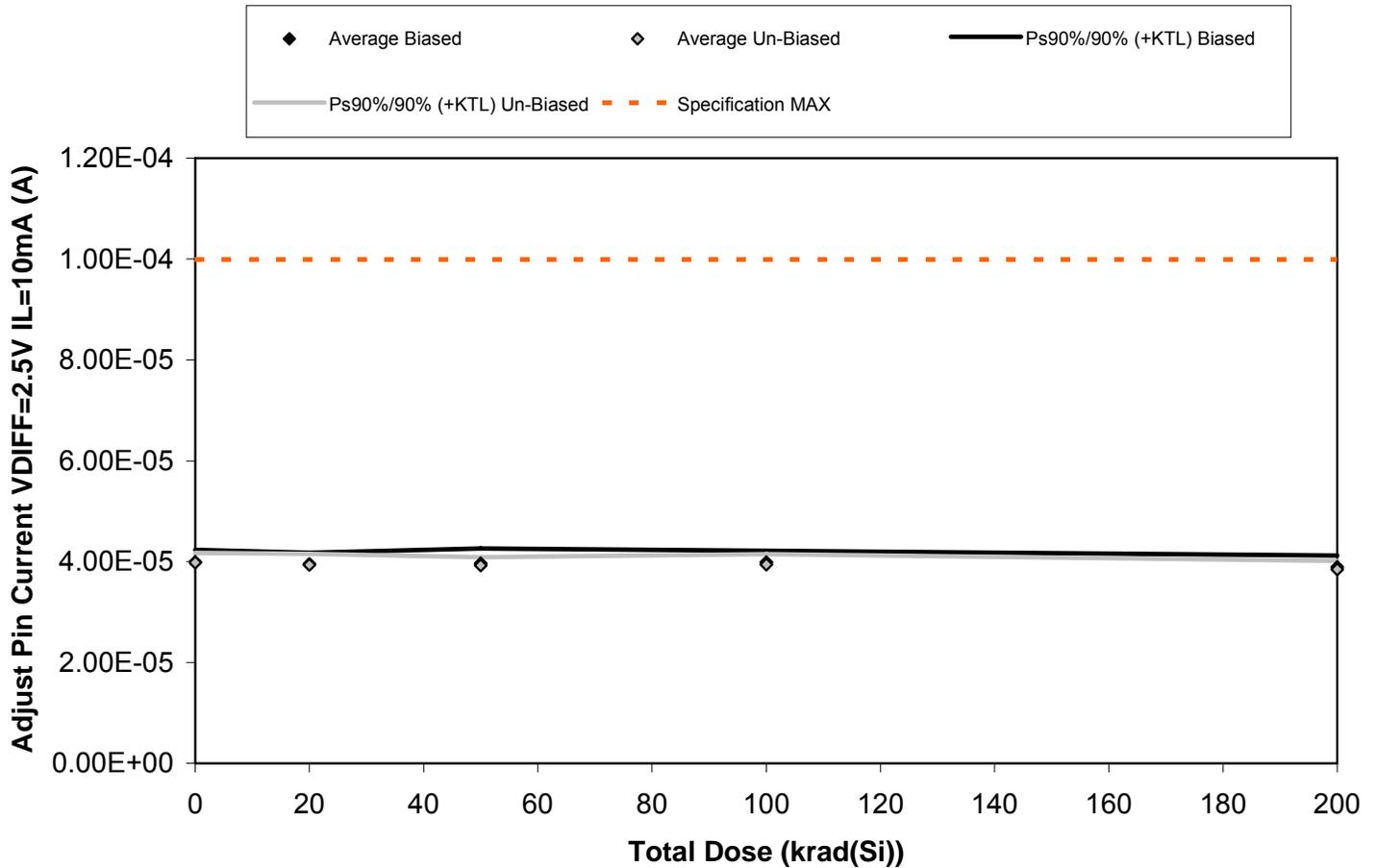


Figure 5.8. Plot of Adjust Pin Current VDIFF=2.5V IL=10mA (A) versus total dose. The data show no significant change with radiation. The solid diamonds are the average of the measured data points for the samples irradiated under electrical bias while the shaded diamonds are the average of the measured data points for the samples irradiated with all pins tied to ground. The black lines (solid and/or dashed) are the average of the data points after application of the KTL statistics on the samples irradiated under electrical bias while the gray lines (solid and/or dashed) are the average of the data points after application of the 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 Adjust Pin Current VDIFF=2.5V IL=10mA (A) versus total dose, including the statistical analysis, specification and the status of the testing (pass/fail).

Adjust Pin Current VDIFF=2.5V IL=10mA (A)	Total Dose (krad(Si))				
	0	20	50	100	200
Device					
108	4.01E-05	3.94E-05	3.93E-05	3.97E-05	3.89E-05
109	4.04E-05	3.98E-05	4.03E-05	4.07E-05	3.97E-05
110	3.84E-05	3.83E-05	3.83E-05	3.86E-05	3.76E-05
111	4.02E-05	3.97E-05	3.94E-05	3.97E-05	3.89E-05
112	4.06E-05	4.06E-05	4.11E-05	4.05E-05	3.96E-05
114	4.07E-05	3.98E-05	3.98E-05	4.02E-05	3.92E-05
115	3.95E-05	3.91E-05	3.91E-05	3.93E-05	3.81E-05
116	3.93E-05	3.89E-05	3.86E-05	3.90E-05	3.80E-05
117	4.04E-05	4.06E-05	4.00E-05	4.01E-05	3.92E-05
118	3.91E-05	3.86E-05	3.89E-05	3.85E-05	3.80E-05
119	4.01E-05	3.96E-05	4.06E-05	4.04E-05	4.01E-05
121	4.01E-05	3.96E-05	4.00E-05	4.02E-05	3.98E-05
<b>Biased Statistics</b>					
Average Biased	3.99E-05	3.96E-05	3.97E-05	3.99E-05	3.89E-05
Std Dev Biased	8.78E-07	8.16E-07	1.07E-06	8.42E-07	8.36E-07
Ps90%/90% (+KTL) Biased	4.23E-05	4.18E-05	4.26E-05	4.22E-05	4.12E-05
Ps90%/90% (-KTL) Biased	3.75E-05	3.73E-05	3.67E-05	3.76E-05	3.66E-05
<b>Un-Biased Statistics</b>					
Average Un-Biased	3.98E-05	3.94E-05	3.93E-05	3.94E-05	3.85E-05
Std Dev Un-Biased	6.99E-07	7.91E-07	5.92E-07	7.48E-07	6.13E-07
Ps90%/90% (+KTL) Un-Biased	4.17E-05	4.16E-05	4.09E-05	4.15E-05	4.02E-05
Ps90%/90% (-KTL) Un-Biased	3.79E-05	3.72E-05	3.76E-05	3.74E-05	3.68E-05
<b>Specification MAX</b>	<b>1.00E-04</b>	<b>1.00E-04</b>	<b>1.00E-04</b>	<b>1.00E-04</b>	<b>1.00E-04</b>
Status	PASS	PASS	PASS	PASS	PASS

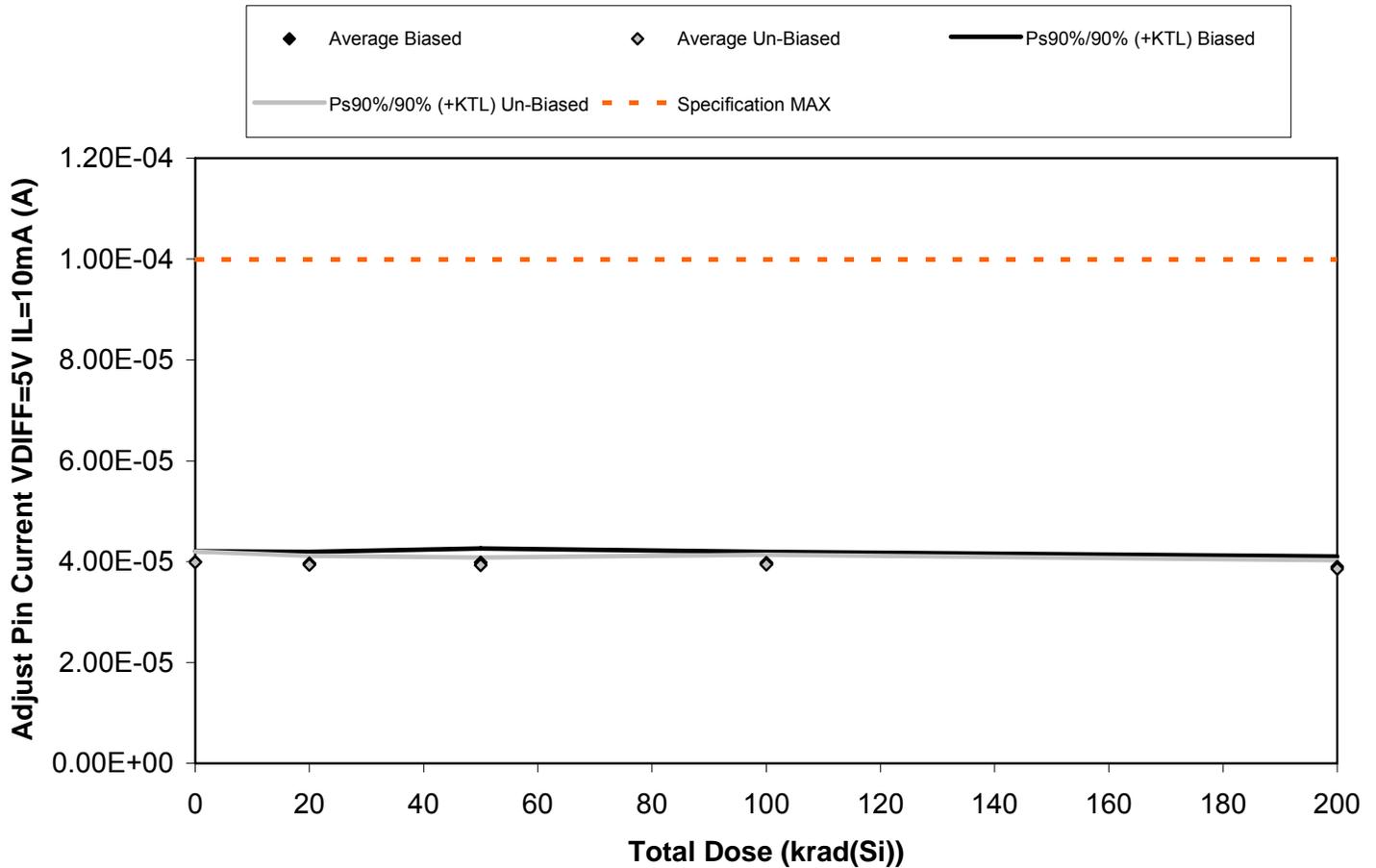


Figure 5.9. Plot of Adjust Pin Current VDIFF=5V IL=10mA (A) versus total dose. The data show no significant change with radiation. The solid diamonds are the average of the measured data points for the samples irradiated under electrical bias while the shaded diamonds are the average of the measured data points for the samples irradiated with all pins tied to ground. The black lines (solid and/or dashed) are the average of the data points after application of the KTL statistics on the samples irradiated under electrical bias while the gray lines (solid and/or dashed) are the average of the data points after application of the 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 Adjust Pin Current VDIFF=5V IL=10mA (A) versus total dose, including the statistical analysis, specification and the status of the testing (pass/fail).

Adjust Pin Current VDIFF=5V IL=10mA (A)	Total Dose (krad(Si))				
	0	20	50	100	200
Device					
108	4.01E-05	3.92E-05	3.95E-05	3.97E-05	3.89E-05
109	4.05E-05	4.03E-05	4.05E-05	4.04E-05	3.95E-05
110	3.89E-05	3.84E-05	3.85E-05	3.85E-05	3.78E-05
111	3.97E-05	3.97E-05	3.94E-05	3.98E-05	3.89E-05
112	4.09E-05	4.05E-05	4.11E-05	4.05E-05	3.98E-05
114	4.05E-05	4.00E-05	3.99E-05	4.00E-05	3.92E-05
115	3.97E-05	3.90E-05	3.90E-05	3.93E-05	3.81E-05
116	3.92E-05	3.89E-05	3.89E-05	3.89E-05	3.81E-05
117	4.09E-05	4.02E-05	3.99E-05	4.04E-05	3.93E-05
118	3.92E-05	3.88E-05	3.89E-05	3.88E-05	3.82E-05
119	4.01E-05	3.95E-05	4.05E-05	4.02E-05	4.01E-05
121	4.00E-05	3.97E-05	4.00E-05	4.00E-05	3.99E-05
<b>Biased Statistics</b>					
Average Biased	4.00E-05	3.96E-05	3.98E-05	3.98E-05	3.90E-05
Std Dev Biased	7.55E-07	8.41E-07	1.02E-06	7.96E-07	7.52E-07
Ps90%/90% (+KTL) Biased	4.21E-05	4.19E-05	4.26E-05	4.19E-05	4.10E-05
Ps90%/90% (-KTL) Biased	3.79E-05	3.73E-05	3.70E-05	3.76E-05	3.69E-05
<b>Un-Biased Statistics</b>					
Average Un-Biased	3.99E-05	3.94E-05	3.93E-05	3.94E-05	3.86E-05
Std Dev Un-Biased	7.77E-07	6.50E-07	5.49E-07	6.98E-07	6.20E-07
Ps90%/90% (+KTL) Un-Biased	4.20E-05	4.12E-05	4.08E-05	4.14E-05	4.03E-05
Ps90%/90% (-KTL) Un-Biased	3.77E-05	3.76E-05	3.78E-05	3.75E-05	3.69E-05
<b>Specification MAX</b>	<b>1.00E-04</b>	<b>1.00E-04</b>	<b>1.00E-04</b>	<b>1.00E-04</b>	<b>1.00E-04</b>
Status	PASS	PASS	PASS	PASS	PASS

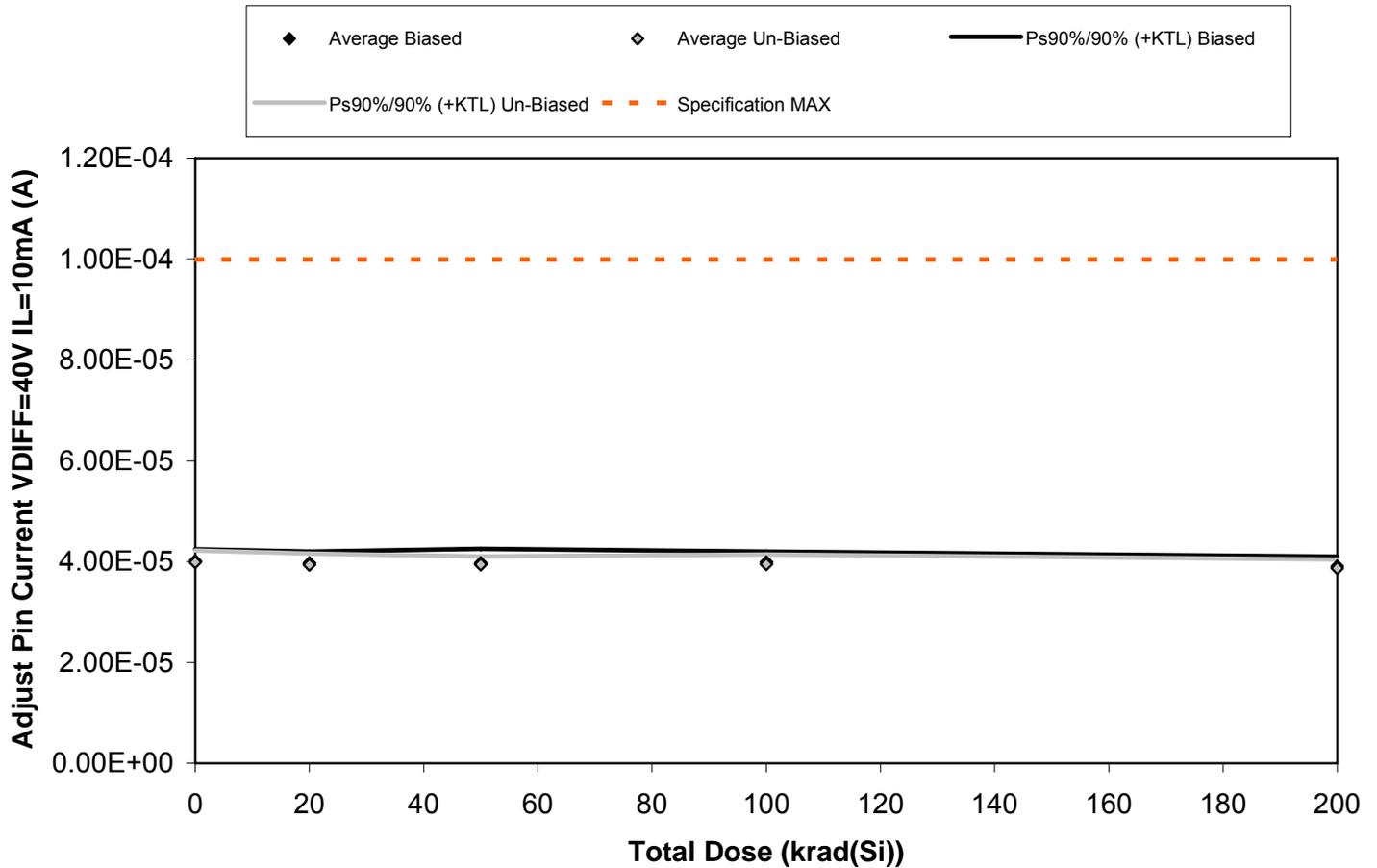


Figure 5.10. Plot of Adjust Pin Current VDIFF=40V IL=10mA (A) versus total dose. The data show no significant change with radiation. The solid diamonds are the average of the measured data points for the samples irradiated under electrical bias while the shaded diamonds are the average of the measured data points for the samples irradiated with all pins tied to ground. The black lines (solid and/or dashed) are the average of the data points after application of the KTL statistics on the samples irradiated under electrical bias while the gray lines (solid and/or dashed) are the average of the data points after application of the 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 Adjust Pin Current VDIFF=40V IL=10mA (A) versus total dose, including the statistical analysis, specification and the status of the testing (pass/fail).

Adjust Pin Current VDIFF=40V IL=10mA (A)	Total Dose (krad(Si))				
	0	20	50	100	200
Device					
108	4.02E-05	3.94E-05	3.95E-05	3.97E-05	3.89E-05
109	4.07E-05	4.02E-05	4.04E-05	4.04E-05	3.96E-05
110	3.88E-05	3.85E-05	3.83E-05	3.86E-05	3.80E-05
111	3.99E-05	3.97E-05	3.95E-05	3.99E-05	3.89E-05
112	4.10E-05	4.07E-05	4.10E-05	4.06E-05	3.98E-05
114	4.05E-05	3.99E-05	4.00E-05	4.02E-05	3.94E-05
115	3.97E-05	3.90E-05	3.90E-05	3.93E-05	3.82E-05
116	3.92E-05	3.90E-05	3.89E-05	3.89E-05	3.82E-05
117	4.09E-05	4.05E-05	4.01E-05	4.03E-05	3.94E-05
118	3.90E-05	3.86E-05	3.90E-05	3.88E-05	3.82E-05
119	4.03E-05	3.97E-05	4.05E-05	4.02E-05	4.05E-05
121	4.00E-05	3.96E-05	4.01E-05	4.01E-05	3.99E-05
<b>Biased Statistics</b>					
Average Biased	4.01E-05	3.97E-05	3.97E-05	3.99E-05	3.90E-05
Std Dev Biased	8.59E-07	8.38E-07	1.03E-06	7.82E-07	7.15E-07
Ps90%/90% (+KTL) Biased	4.25E-05	4.20E-05	4.26E-05	4.20E-05	4.10E-05
Ps90%/90% (-KTL) Biased	3.77E-05	3.74E-05	3.69E-05	3.77E-05	3.71E-05
<b>Un-Biased Statistics</b>					
Average Un-Biased	3.99E-05	3.94E-05	3.94E-05	3.95E-05	3.87E-05
Std Dev Un-Biased	8.57E-07	7.99E-07	5.90E-07	7.08E-07	6.39E-07
Ps90%/90% (+KTL) Un-Biased	4.22E-05	4.16E-05	4.10E-05	4.14E-05	4.04E-05
Ps90%/90% (-KTL) Un-Biased	3.75E-05	3.72E-05	3.78E-05	3.76E-05	3.69E-05
<b>Specification MAX</b>	<b>1.00E-04</b>	<b>1.00E-04</b>	<b>1.00E-04</b>	<b>1.00E-04</b>	<b>1.00E-04</b>
Status	PASS	PASS	PASS	PASS	PASS

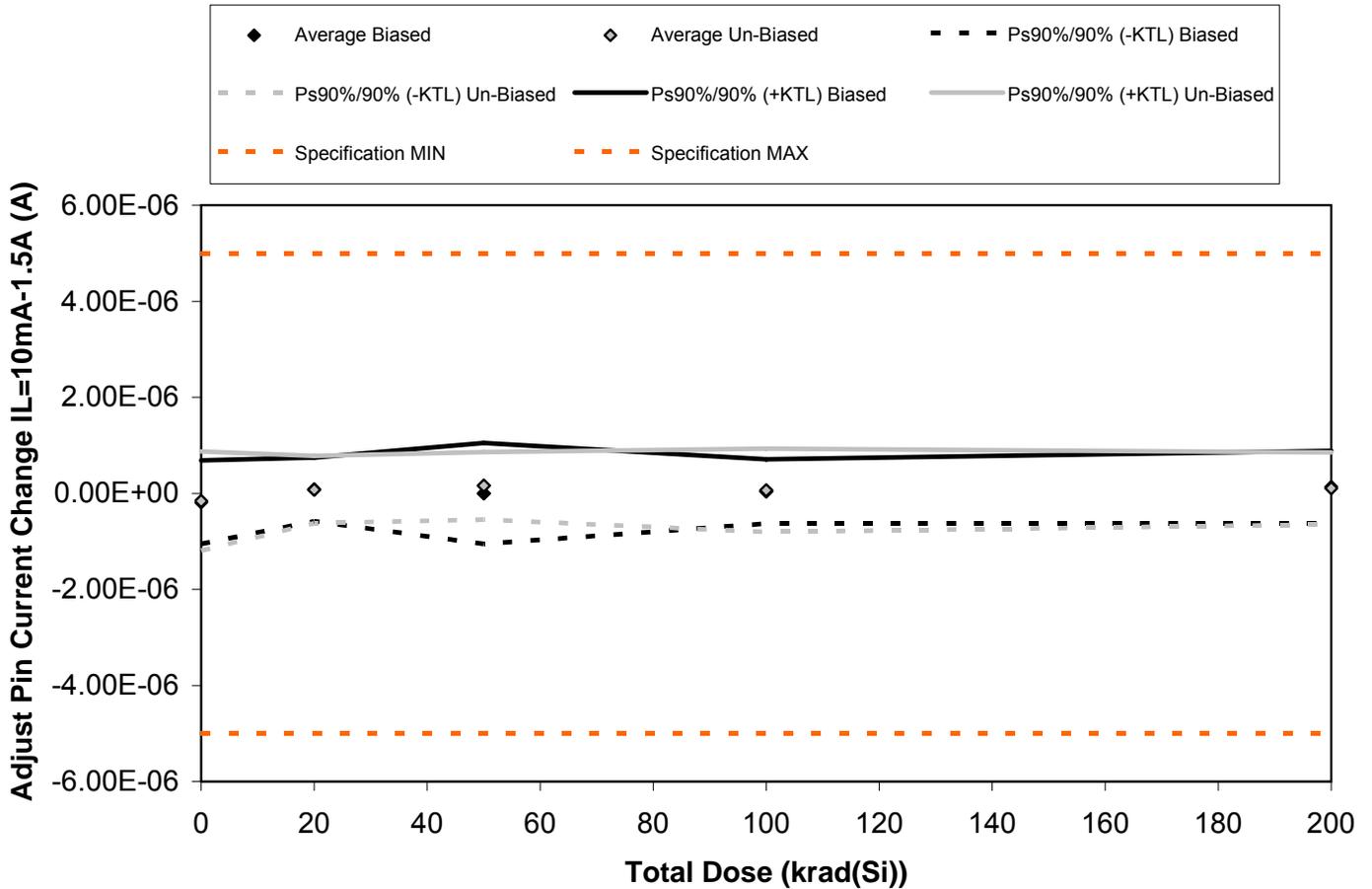


Figure 5.11. Plot of Adjust Pin Current Change IL=10mA-1.5A (A) versus total dose. The data show no significant change with radiation. The solid diamonds are the average of the measured data points for the samples irradiated under electrical bias while the shaded diamonds are the average of the measured data points for the samples irradiated with all pins tied to ground. The black lines (solid and/or dashed) are the average of the data points after application of the KTL statistics on the samples irradiated under electrical bias while the gray lines (solid and/or dashed) are the average of the data points after application of the 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 Adjust Pin Current Change IL=10mA-1.5A (A) versus total dose, including the statistical analysis, specification and the status of the testing (pass/fail).

Adjust Pin Current Change IL=10mA-1.5A (A)	Total Dose (krad(Si))				
	0	20	50	100	200
Device					
108	0.00E+00	0.00E+00	-2.90E-07	2.00E-08	-2.00E-07
109	-3.10E-07	-4.00E-08	5.10E-07	1.60E-07	2.50E-07
110	-6.50E-07	1.80E-07	3.10E-07	9.00E-08	5.30E-07
111	1.80E-07	-1.80E-07	-2.70E-07	-3.60E-07	7.00E-08
112	-1.30E-07	4.50E-07	-2.70E-07	2.90E-07	0.00E+00
114	-6.20E-07	4.00E-08	0.00E+00	0.00E+00	4.50E-07
115	-3.60E-07	2.00E-08	2.70E-07	5.30E-07	-4.00E-08
116	1.80E-07	0.00E+00	-4.00E-08	2.00E-07	-2.00E-07
117	-2.70E-07	-1.80E-07	0.00E+00	-2.90E-07	3.30E-07
118	2.70E-07	5.10E-07	5.60E-07	-1.30E-07	-2.00E-08
119	1.80E-07	2.00E-07	2.50E-07	1.30E-07	-4.50E-07
121	0.00E+00	-4.00E-08	0.00E+00	3.10E-07	-8.70E-07
<b>Biased Statistics</b>					
Average Biased	-1.82E-07	8.20E-08	-2.00E-09	4.00E-08	1.30E-07
Std Dev Biased	3.17E-07	2.43E-07	3.83E-07	2.45E-07	2.76E-07
Ps90%/90% (+KTL) Biased	6.88E-07	7.47E-07	1.05E-06	7.11E-07	8.86E-07
Ps90%/90% (-KTL) Biased	-1.05E-06	-5.83E-07	-1.05E-06	-6.31E-07	-6.26E-07
<b>Un-Biased Statistics</b>					
Average Un-Biased	-1.60E-07	7.80E-08	1.58E-07	6.20E-08	1.04E-07
Std Dev Un-Biased	3.76E-07	2.57E-07	2.57E-07	3.17E-07	2.74E-07
Ps90%/90% (+KTL) Un-Biased	8.70E-07	7.83E-07	8.61E-07	9.32E-07	8.54E-07
Ps90%/90% (-KTL) Un-Biased	-1.19E-06	-6.27E-07	-5.45E-07	-8.08E-07	-6.46E-07
<b>Specification MIN</b>	<b>-5.00E-06</b>	<b>-5.00E-06</b>	<b>-5.00E-06</b>	<b>-5.00E-06</b>	<b>-5.00E-06</b>
Status	PASS	PASS	PASS	PASS	PASS
<b>Specification MAX</b>	<b>5.00E-06</b>	<b>5.00E-06</b>	<b>5.00E-06</b>	<b>5.00E-06</b>	<b>5.00E-06</b>
Status	PASS	PASS	PASS	PASS	PASS

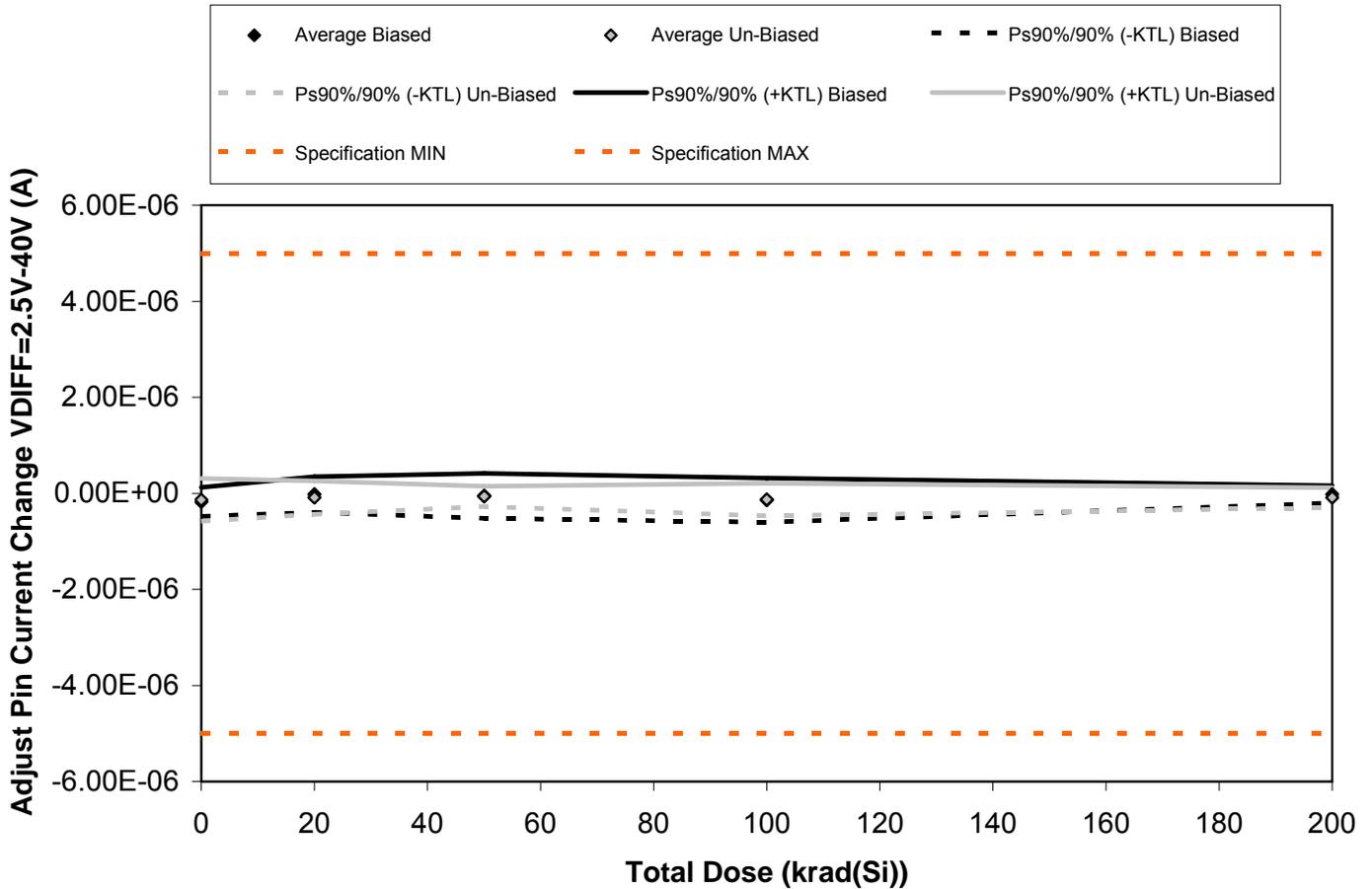


Figure 5.12. Plot of Adjust Pin Current Change VDIFF=2.5V-40V (A) versus total dose. The data show no significant change with radiation. The solid diamonds are the average of the measured data points for the samples irradiated under electrical bias while the shaded diamonds are the average of the measured data points for the samples irradiated with all pins tied to ground. The black lines (solid and/or dashed) are the average of the data points after application of the KTL statistics on the samples irradiated under electrical bias while the gray lines (solid and/or dashed) are the average of the data points after application of the 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 Adjust Pin Current Change VDIFF=2.5V-40V (A) versus total dose, including the statistical analysis, specification and the status of the testing (pass/fail).

Adjust Pin Current Change VDIFF=2.5V-40V (A)	Total Dose (krad(Si))				
	0	20	50	100	200
Device					
108	-1.80E-07	-1.80E-07	-1.60E-07	-2.50E-07	7.00E-08
109	-2.70E-07	-1.60E-07	-2.20E-07	-1.80E-07	-7.00E-08
110	-1.80E-07	4.00E-08	-2.00E-08	-4.00E-08	-9.00E-08
111	0.00E+00	9.00E-08	-9.00E-08	9.00E-08	2.00E-08
112	-2.70E-07	9.00E-08	2.20E-07	-3.30E-07	-4.00E-08
114	0.00E+00	2.00E-08	4.00E-08	-1.80E-07	-2.00E-07
115	-3.10E-07	-1.30E-07	-1.30E-07	9.00E-08	-9.00E-08
116	-1.80E-07	4.00E-08	0.00E+00	-2.00E-07	-4.00E-08
117	7.00E-08	-1.10E-07	-1.10E-07	-1.60E-07	-1.10E-07
118	-2.50E-07	-2.70E-07	-1.10E-07	-2.00E-07	0.00E+00
119	1.80E-07	2.00E-08	0.00E+00	-1.80E-07	2.00E-08
121	-3.60E-07	2.00E-08	-1.80E-07	2.00E-08	-4.00E-08
<b>Biased Statistics</b>					
Average Biased	-1.80E-07	-2.40E-08	-5.40E-08	-1.42E-07	-2.20E-08
Std Dev Biased	1.10E-07	1.35E-07	1.71E-07	1.68E-07	6.61E-08
Ps90%/90% (+KTL) Biased	1.22E-07	3.46E-07	4.14E-07	3.18E-07	1.59E-07
Ps90%/90% (-KTL) Biased	-4.82E-07	-3.94E-07	-5.22E-07	-6.02E-07	-2.03E-07
<b>Un-Biased Statistics</b>					
Average Un-Biased	-1.34E-07	-9.00E-08	-6.20E-08	-1.30E-07	-8.80E-08
Std Dev Un-Biased	1.63E-07	1.26E-07	7.66E-08	1.24E-07	7.60E-08
Ps90%/90% (+KTL) Un-Biased	3.13E-07	2.55E-07	1.48E-07	2.10E-07	1.20E-07
Ps90%/90% (-KTL) Un-Biased	-5.81E-07	-4.35E-07	-2.72E-07	-4.70E-07	-2.96E-07
<b>Specification MIN</b>	<b>-5.00E-06</b>	<b>-5.00E-06</b>	<b>-5.00E-06</b>	<b>-5.00E-06</b>	<b>-5.00E-06</b>
Status	PASS	PASS	PASS	PASS	PASS
<b>Specification MAX</b>	<b>5.00E-06</b>	<b>5.00E-06</b>	<b>5.00E-06</b>	<b>5.00E-06</b>	<b>5.00E-06</b>
Status	PASS	PASS	PASS	PASS	PASS

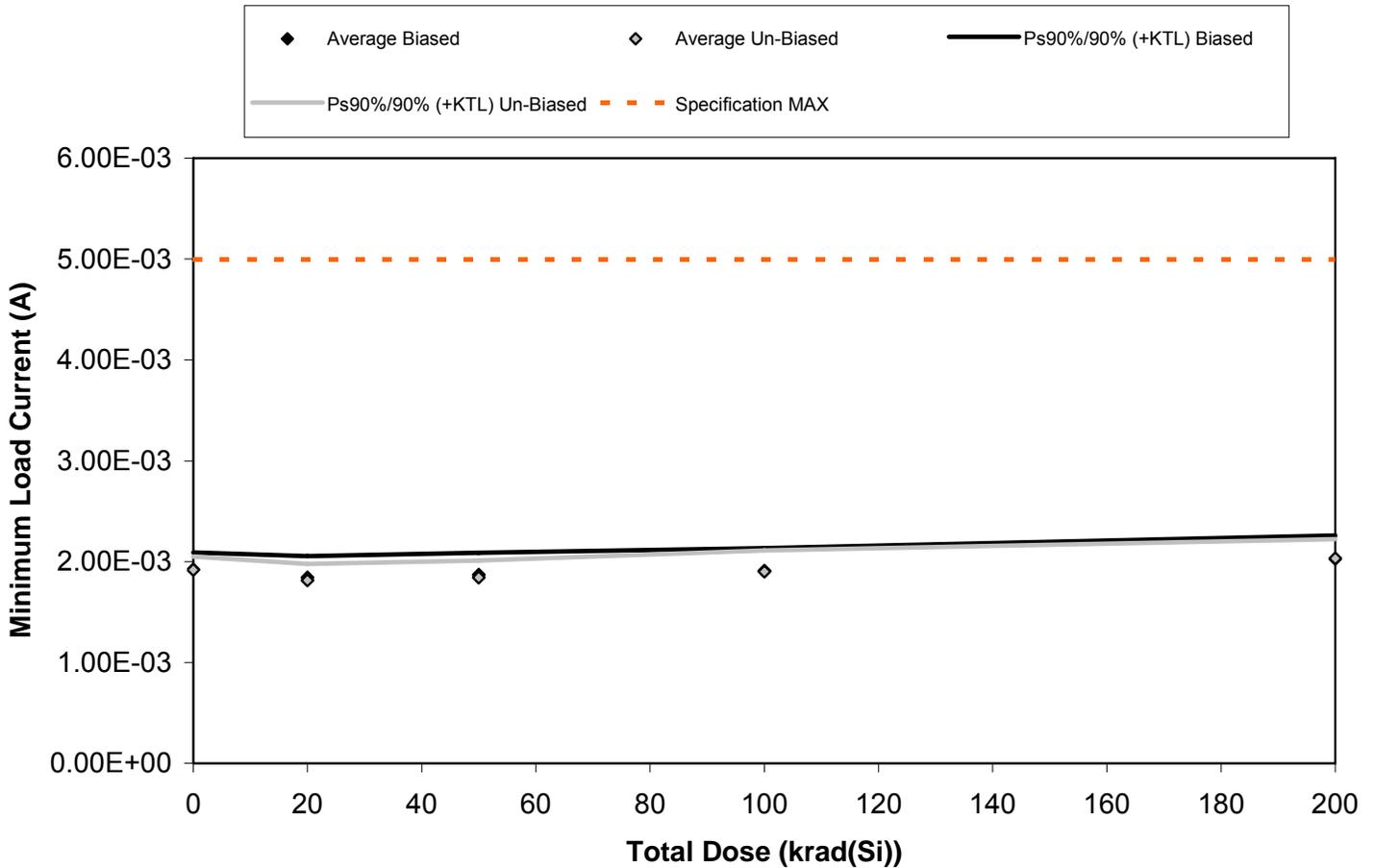


Figure 5.13. Plot of Minimum Load Current (A) versus total dose. The data show no significant change with radiation. The solid diamonds are the average of the measured data points for the samples irradiated under electrical bias while the shaded diamonds are the average of the measured data points for the samples irradiated with all pins tied to ground. The black lines (solid and/or dashed) are the average of the data points after application of the KTL statistics on the samples irradiated under electrical bias while the gray lines (solid and/or dashed) are the average of the data points after application of the 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 5.13. Raw data for Minimum Load Current (A) versus total dose, including the statistical analysis, specification and the status of the testing (pass/fail).

Minimum Load Current (A)	Total Dose (krad(Si))				
	0	20	50	100	200
Device					
108	1.86E-03	1.85E-03	1.87E-03	1.90E-03	2.02E-03
109	1.92E-03	1.92E-03	1.94E-03	1.96E-03	2.04E-03
110	1.88E-03	1.73E-03	1.75E-03	1.79E-03	1.90E-03
111	1.92E-03	1.81E-03	1.85E-03	1.89E-03	2.04E-03
112	2.02E-03	1.90E-03	1.94E-03	2.00E-03	2.14E-03
114	1.90E-03	1.79E-03	1.83E-03	1.85E-03	1.98E-03
115	1.85E-03	1.73E-03	1.75E-03	1.81E-03	1.96E-03
116	1.92E-03	1.83E-03	1.85E-03	1.90E-03	2.02E-03
117	1.96E-03	1.87E-03	1.90E-03	2.00E-03	2.14E-03
118	1.96E-03	1.87E-03	1.89E-03	1.94E-03	2.06E-03
119	1.94E-03	1.85E-03	1.83E-03	1.85E-03	1.85E-03
121	1.87E-03	1.77E-03	1.77E-03	1.79E-03	1.79E-03
<b>Biased Statistics</b>					
Average Biased	1.92E-03	1.84E-03	1.87E-03	1.91E-03	2.03E-03
Std Dev Biased	6.14E-05	7.84E-05	8.03E-05	8.16E-05	8.39E-05
Ps90%/90% (+KTL) Biased	2.09E-03	2.06E-03	2.09E-03	2.13E-03	2.26E-03
Ps90%/90% (-KTL) Biased	1.75E-03	1.63E-03	1.65E-03	1.68E-03	1.80E-03
<b>Un-Biased Statistics</b>					
Average Un-Biased	1.92E-03	1.82E-03	1.84E-03	1.90E-03	2.03E-03
Std Dev Un-Biased	4.70E-05	5.94E-05	6.08E-05	7.66E-05	6.97E-05
Ps90%/90% (+KTL) Un-Biased	2.05E-03	1.98E-03	2.01E-03	2.11E-03	2.22E-03
Ps90%/90% (-KTL) Un-Biased	1.79E-03	1.65E-03	1.68E-03	1.69E-03	1.84E-03
<b>Specification MAX</b>	<b>5.00E-03</b>	<b>5.00E-03</b>	<b>5.00E-03</b>	<b>5.00E-03</b>	<b>5.00E-03</b>
Status	PASS	PASS	PASS	PASS	PASS

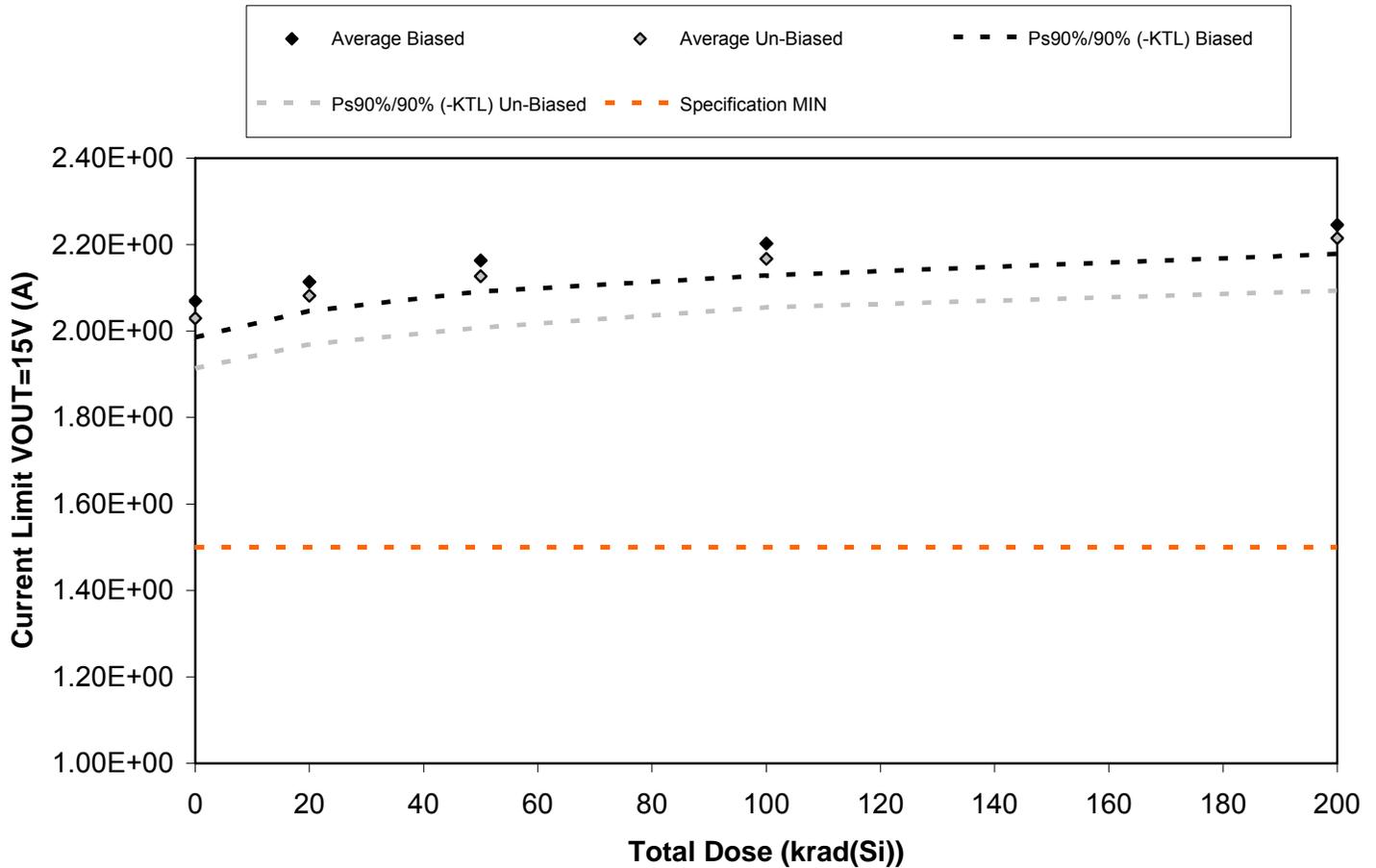


Figure 5.14. Plot of Current Limit VOUT=15V (A) versus total dose. The data show a small increase (improvement) with radiation. The solid diamonds are the average of the measured data points for the samples irradiated under electrical bias while the shaded diamonds are the average of the measured data points for the samples irradiated with all pins tied to ground. The black lines (solid and/or dashed) are the average of the data points after application of the KTL statistics on the samples irradiated under electrical bias while the gray lines (solid and/or dashed) are the average of the data points after application of the 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 5.14. Raw data for Current Limit VOUT=15V (A) versus total dose, including the statistical analysis, specification and the status of the testing (pass/fail).

Current Limit VOUT=15V (A)	Total Dose (krad(Si))				
	0	20	50	100	200
Device					
108	2.03E+00	2.09E+00	2.14E+00	2.17E+00	2.22E+00
109	2.07E+00	2.11E+00	2.16E+00	2.20E+00	2.24E+00
110	2.08E+00	2.12E+00	2.16E+00	2.21E+00	2.25E+00
111	2.06E+00	2.11E+00	2.16E+00	2.19E+00	2.25E+00
112	2.12E+00	2.15E+00	2.21E+00	2.25E+00	2.29E+00
114	2.06E+00	2.11E+00	2.15E+00	2.19E+00	2.24E+00
115	1.97E+00	2.02E+00	2.06E+00	2.10E+00	2.15E+00
116	2.06E+00	2.11E+00	2.16E+00	2.20E+00	2.25E+00
117	2.01E+00	2.06E+00	2.11E+00	2.15E+00	2.20E+00
118	2.06E+00	2.11E+00	2.16E+00	2.20E+00	2.25E+00
119	2.07E+00	2.07E+00	2.07E+00	2.07E+00	2.06E+00
121	2.00E+00	2.00E+00	2.00E+00	2.00E+00	2.00E+00
<b>Biased Statistics</b>					
Average Biased	2.07E+00	2.11E+00	2.16E+00	2.20E+00	2.25E+00
Std Dev Biased	3.05E-02	2.45E-02	2.64E-02	2.69E-02	2.46E-02
Ps90%/90% (+KTL) Biased	2.15E+00	2.18E+00	2.24E+00	2.28E+00	2.31E+00
Ps90%/90% (-KTL) Biased	1.99E+00	2.05E+00	2.09E+00	2.13E+00	2.18E+00
<b>Un-Biased Statistics</b>					
Average Un-Biased	2.03E+00	2.08E+00	2.13E+00	2.17E+00	2.21E+00
Std Dev Un-Biased	4.24E-02	4.08E-02	4.34E-02	4.09E-02	4.41E-02
Ps90%/90% (+KTL) Un-Biased	2.15E+00	2.19E+00	2.25E+00	2.28E+00	2.34E+00
Ps90%/90% (-KTL) Un-Biased	1.91E+00	1.97E+00	2.01E+00	2.06E+00	2.09E+00
<b>Specification MIN</b>	<b>1.50E+00</b>	<b>1.50E+00</b>	<b>1.50E+00</b>	<b>1.50E+00</b>	<b>1.50E+00</b>
Status	PASS	PASS	PASS	PASS	PASS

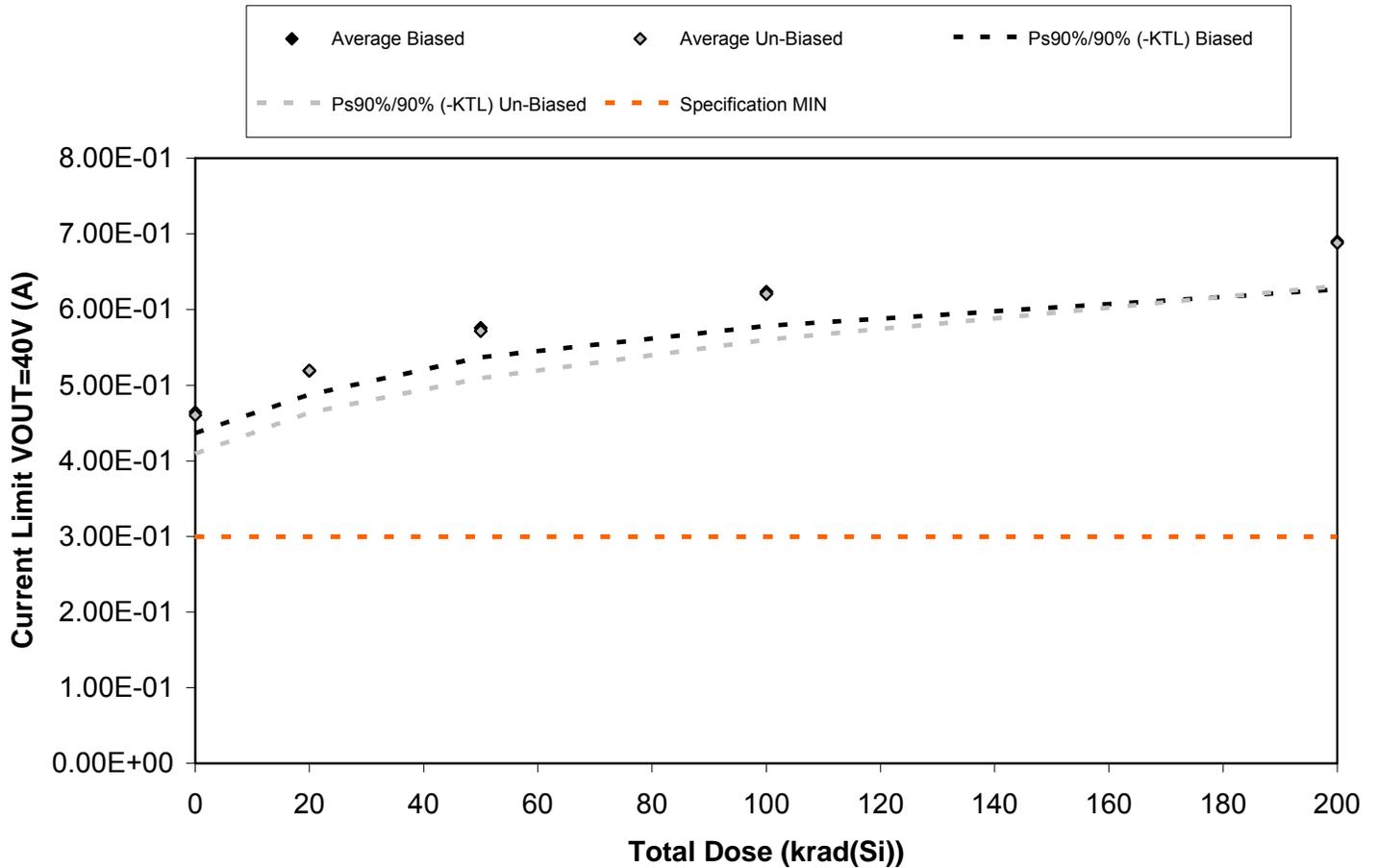


Figure 5.15. Plot of Current Limit VOUT=40V (A) versus total dose. The data show an increase (improvement) with radiation. The solid diamonds are the average of the measured data points for the samples irradiated under electrical bias while the shaded diamonds are the average of the measured data points for the samples irradiated with all pins tied to ground. The black lines (solid and/or dashed) are the average of the data points after application of the KTL statistics on the samples irradiated under electrical bias while the gray lines (solid and/or dashed) are the average of the data points after application of the 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 5.15. Raw data for Current Limit VOUT=40V (A) versus total dose, including the statistical analysis, specification and the status of the testing (pass/fail).

Current Limit VOUT=40V (A)	Total Dose (krad(Si))				
	0	20	50	100	200
Device					
108	4.64E-01	5.18E-01	5.79E-01	6.29E-01	6.90E-01
109	4.48E-01	5.01E-01	5.51E-01	5.96E-01	6.51E-01
110	4.70E-01	5.29E-01	5.85E-01	6.29E-01	7.01E-01
111	4.64E-01	5.18E-01	5.79E-01	6.24E-01	6.96E-01
112	4.75E-01	5.29E-01	5.85E-01	6.40E-01	7.12E-01
114	4.70E-01	5.24E-01	5.79E-01	6.24E-01	6.79E-01
115	4.31E-01	4.90E-01	5.35E-01	5.85E-01	6.57E-01
116	4.81E-01	5.46E-01	5.96E-01	6.46E-01	7.12E-01
117	4.57E-01	5.13E-01	5.68E-01	6.24E-01	6.96E-01
118	4.63E-01	5.24E-01	5.79E-01	6.24E-01	6.96E-01
119	4.69E-01	4.68E-01	4.68E-01	4.68E-01	4.73E-01
121	4.52E-01	4.51E-01	4.51E-01	4.46E-01	4.46E-01
<b>Biased Statistics</b>					
Average Biased	4.64E-01	5.19E-01	5.76E-01	6.24E-01	6.90E-01
Std Dev Biased	1.02E-02	1.15E-02	1.42E-02	1.65E-02	2.32E-02
Ps90%/90% (+KTL) Biased	4.92E-01	5.50E-01	6.15E-01	6.69E-01	7.54E-01
Ps90%/90% (-KTL) Biased	4.36E-01	4.88E-01	5.37E-01	5.78E-01	6.26E-01
<b>Un-Biased Statistics</b>					
Average Un-Biased	4.60E-01	5.19E-01	5.71E-01	6.21E-01	6.88E-01
Std Dev Un-Biased	1.87E-02	2.03E-02	2.27E-02	2.21E-02	2.09E-02
Ps90%/90% (+KTL) Un-Biased	5.12E-01	5.75E-01	6.34E-01	6.81E-01	7.45E-01
Ps90%/90% (-KTL) Un-Biased	4.09E-01	4.64E-01	5.09E-01	5.60E-01	6.31E-01
<b>Specification MIN</b>	<b>3.00E-01</b>	<b>3.00E-01</b>	<b>3.00E-01</b>	<b>3.00E-01</b>	<b>3.00E-01</b>
Status	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 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  $<1\text{rad(Si)/s}$  to a maximum of approximately  $120\text{rad(Si)/s}$ , 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 would be logged as an RLAT failure.

Based on these criteria, the RH117K positive adjustable regulator (from the lot of material described on the first page of this report) PASSED the RLAT to the maximum tested dose level of  $200\text{krad(Si)}$  with none of the measured parameters showing any significant degradation. Note that the LINEAR TECHNOLOGY datasheet guarantees post-irradiation performance only to the  $100\text{krad(Si)}$  dose level. Testing to  $200\text{krad(Si)}$ , as reported herein is an overtest of the datasheet guaranteed radiation performance specifications.



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





## Appendix B: TID Bias Connections

### Biased Samples:

Pin	Function	Connection / Bias
1	ADJ	2k $\Omega$ to -15V
2	VIN	To 15V, 0.1 $\mu$ F decoupling to -15V
3 CASE	VOUT	61.9 $\Omega$ to -15V

### Unbiased Samples:

Pin	Function	Connection / Bias
1	ADJ	GND
2	VIN	GND
3 CASE	VOUT	GND

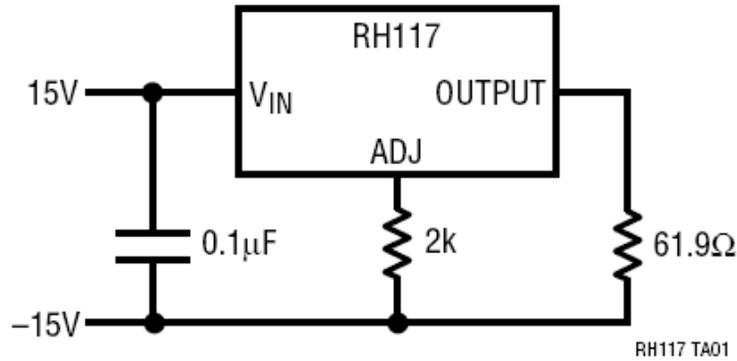


Figure B.1. Irradiation bias drawing for the units to be irradiated under electrical bias. This figure was extracted from LINEAR TECHNOLOGY CORPORATION, RH117 Datasheet.

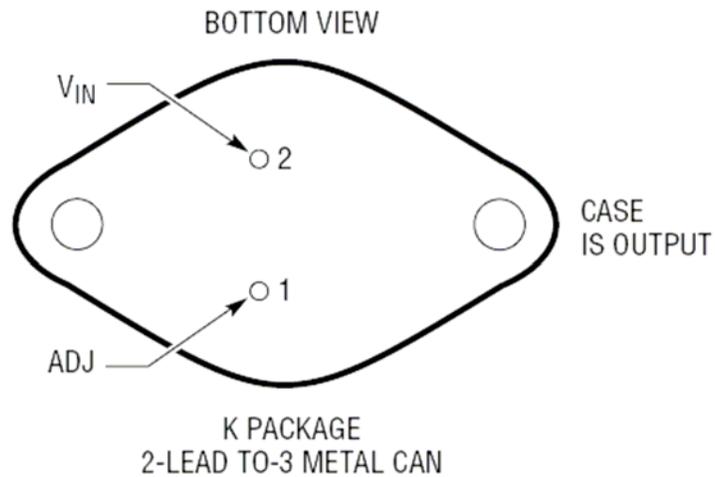


Figure B.2. K package drawing (for reference only). This figure was extracted from the LINEAR TECHNOLOGY CORPORATION RH117 Datasheet.



## **Appendix C: Electrical Test Parameters and Conditions**

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 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 tests will be conducted using the LTS-2101 Linear Family Board, LTS-0606 Socket Assembly and the RH117 DUT board. The measured parameters and test conditions are shown in Tables C.1.

A listing of the measurement precision/resolution for each parameter is shown in Tables C.2. The precision/resolution values were obtained either from test data or from the DAC resolution of the LTS-2020. 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 RH117K.

TEST DESCRIPTION	TEST CONDITIONS
Reference Voltage	$V_{DIFF}=V_{IN}-V_{OUT}=3V, I_L=10mA$
	$V_{DIFF}=40V, I_L=10mA$
	$V_{DIFF}=3V, I_L=1.5A$
	$V_{DIFF}=40V, I_L=0.3A$
Line Regulation	$V_{DIFF}=3V \text{ to } 40V, I_L=10mA$
Load Regulation $V_{OUT} \leq 5V$	$V_{DIFF}=5V, V_{IN}=6.25V, I_L=10mA \text{ to } 1.5A$
Load Regulation $V_{OUT} \geq 5V$	$V_{DIFF}=5V, V_{IN}=11.25V, I_L=10mA \text{ to } 1.5A$
Adjust Pin Current	$V_{DIFF}=2.5V, I_L=10mA$
	$V_{DIFF}=5V, I_L=10mA$
	$V_{DIFF}=40V, I_L=10mA$
Adjust Pin Current Change	$V_{DIFF}=5V, I_L=10mA \text{ to } 1.5A$
	$V_{DIFF}=2.5V \text{ to } 40V, I_L=10mA$
Minimum Load Current	$V_{DIFF}=40V$
Current Limit $V_{DIFF} \leq 15V$	$V_{DIFF}=15V$
Current Limit $V_{DIFF}=40V$	$V_{DIFF}=40V$

Table C.2. Measured parameters, pre-irradiation specifications and measurement resolutions for the RH117K.

Measured Parameter	Pre-Irradiation Specification	Measurement Resolution/Precision
Reference Voltage	1.25V±50mV	± 1.09E-03V
Line Regulation	0.02%/V MAX	± 3.40E-04%/V
Load Regulation $V_{OUT} \leq 5V$	15mV MAX	2.40E-04V
Load Regulation $V_{OUT} \geq 5V$	0.3% MAX	4.48E-03%
Adjust Pin Current	100µA MAX	2.26E-06A
Adjust Pin Current Change	± 5µA MAX	4.20E-07A
Minimum Load Current	5mA MAX	2.84E-05A
Current Limit $V_{DIFF} \leq 15V$	1.5A MAX	5.22E-03A
Current Limit $V_{DIFF}=40V$	0.3A MAX	6.53E-03A



**Appendix D: List of Figures used in Section 5 (Total Ionizing Dose Test Results):**

- 5.1 Reference Voltage  $V_{DIFF}=3V$   $I_L=10mA$  (V)
- 5.2 Reference Voltage  $V_{DIFF}=40V$   $I_L=10mA$  (V)
- 5.3 Reference Voltage  $V_{DIFF}=3V$   $I_L=1.5A$  (V)
- 5.4 Reference Voltage  $V_{DIFF}=40V$   $I_L=0.3A$  (V)
- 5.5 Line Regulation (%/V)
- 5.6 Load Regulation  $V_{OUT}\leq 5V$  (mV)
- 5.7 Load Regulation  $V_{OUT}\geq 5V$  (%)
- 5.8 Adjust Pin Current  $V_{DIFF}=2.5V$   $I_L=10mA$  (A)
- 5.9 Adjust Pin Current  $V_{DIFF}=5V$   $I_L=10mA$  (A)
- 5.10 Adjust Pin Current  $V_{DIFF}=40V$   $I_L=10mA$  (A)
- 5.11 Adjust Pin Current Change  $I_L=10mA-1.5A$  (A)
- 5.12 Adjust Pin Current Change  $V_{DIFF}=2.5V-40V$  (A)
- 5.13 Minimum Load Current (A)
- 5.14 Current Limit  $V_{OUT}=15V$  (A)
- 5.15 Current Limit  $V_{OUT}=40V$  (A)