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TOTAL IONIZING DOSE RADIATION TEST REPORT RH3080

April 2018

Radiation Test Report	
Product:	RH3080
Total ionizing dose level:	High dose rate: 200 krad(Si) Low dose rate: 100 krad(Si) with 1.5× overtest factor
Source:	^{60}Co gamma rays
Dose Rate:	High dose rate: 50 – 300 rad(Si)/sec Low dose rate: 10 mrad(Si)/sec
Facilities:	Cobham RAD (formally Aeroflex Rad) Defense Micro-Electronics Activity (DMEA)

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I. Introduction

This is a comprehensive report summarizing the total-ionizing dose (TID) radiation lot acceptance test (RLAT) results for the RH3080MK die. The qualification tests were carried out per MIL-STD-883 TM1019 condition A at high dose rate and condition D at low dose rate [1]. We determined that the RH3080MK die passes all electrical parametric tests up to 200 krad(Si) at high dose rate. Furthermore, the RH3080MK does not exhibit enhanced-low-dose-rate-sensitivity (ELDRS) up to 100 krad(Si), determined with an overtest factor of 1.5.

II. Device Description

The RH3080 is a 0.9 A low dropout linear regulator, featuring a precision current source and voltage follower which allows the output to be programmed to any voltage between zero and 36 V. The RH3080 is built with a proprietary process that is radiation-hardened against TID. The die was assembled in a TO-3 metal can for the irradiation tests. Table I displays the part and test information. Figure 1 shows the pin configuration. Refer to the online datasheet for details [2]. Figure 2 shows a photograph of a TO-3 packaged test sample.

Table I
Test and part information.

Part Number:	RH3080MK
Manufacturer:	Linear Technology Corp. now Analog Devices Inc.
Part Function:	Adjustable low dropout regulator
Process Technology:	1.5 µm bipolar
Package Type:	TO-3 metal can
Sample Quantity:	5 biased and 5 unbiased for each irradiation
Dose rate:	High dose rate: 50 – 300 rad(Si)/sec Low dose rate: 10 mrad(Si)/sec
TID levels:	High dose rate: 200 krad(Si) Low dose rate: 100 krad(Si) with 1.5× overtest factor
Test Equipment:	LTS2020 Automated Tester LTS2100 Family Board LTS0606 Test Fixture

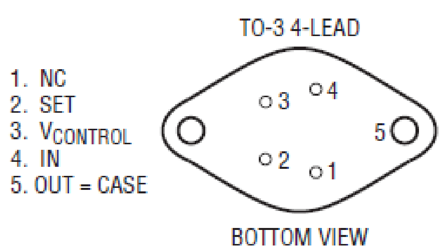

Figure 1. TO-3 pin configurations for the RH3080.

Figure 2. Photograph of a RH3080 TO-3 test sample.

III. Test Method

A. Irradiation procedures

The samples were irradiated in dose steps. The samples were characterized following each dose step, on-site for the high dose rate testing carried out at Aeroflex RAD's facility. For the low dose rate testing carried out at DMEA, the samples were shipped back on dry ice to Linear Technology's facility for characterization.

Radiation facilities: The irradiations were carried out at Aeroflex RAD's Longmire laboratories and at the Defense Micro-Electronics Activity (DMEA) facility using JL Shephard ^{60}Co gamma ray sources. The device under test (DUT) were placed inside a cavity with standard Pb/Al shielding. The irradiation procedures and dosimetry requirements conform to MIL-STD-883-K TM1019.9 [1]. Dosimetry was performed using air ionization chamber. Aeroflex RAD's dosimetry has been audited by DSCC and Aeroflex RAD has been awarded Laboratory Suitability for MIL-STD-750 and MIL-STD-883 TM 1019.

Pre-Irradiation burn-in: The test samples were burned-in prior to irradiation

Overtest: Overtest by a factor of 1.5 was included after low dose rate irradiation to 100 krad(Si) at DMEA. No overtest was included for the high dose rate irradiations.

Post-irradiation anneal: A 24-hour room temperature anneal followed by a 168-hour 100°C anneal was carried out after high dose rate irradiations on some wafers. Both anneals were performed in the same electrical bias condition as the irradiations. Electrical measurements were made following each anneal increment.

Test temperature: Room temperature controlled to 24°C±6°C.

B. Test setup

Figure 3 shows a schematic diagram of the bias circuit for devices that were irradiated under bias. For each high dose rate and low dose rate irradiation, 5 samples were biased and 5 samples had all pins grounded for each irradiation. In addition, 2 samples were used as control units.

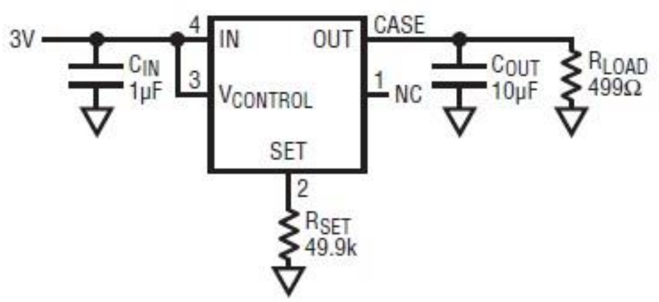

Figure 3. Bias configuration for the RH3080.

IV. Results

The radiation lot acceptance tests showed that all parts irradiated at low dose rate passed up to the highest tested TID of 170 krad(Si), and all parts irradiated at high dose rate passed up to the highest tested TID of 200 krad(Si). The parts irradiated at high dose rate also passed post-irradiation anneals of 24 hour room at temperature and 168 hours at 100^{o}C. The Appendix include plots for the characterized parameters for a wafer diffusion lot that is representative of results for all wafer lots. Appendix A includes the low dose rate data, and Appendix B includes the high dose rate data.

We discuss the degradation characteristics using examples in Figures 4 – 7, which show the radiation-induced shifts of several parameters as a function of TID. For the data shown in Figures 4 – 7, the parts were irradiated at high dose rate to 100 krad(Si) and annealed at room temperature for 24 hours and at 100^{o}C for 168 hours. The anneal data provides comparisons with the low dose rate response.

As shown in Figure 4, the parts irradiated at low dose rate exhibited higher degradation levels than the parts irradiated at high dose rate. Nevertheless, the parametric shifts for both high dose rate and low dose rate irradiated parts are well within specification limits. Additionally, the parts irradiated under bias showed slightly higher degradation levels on average than the parts irradiated with pins grounded. However, the low dose rate data also showed relatively significant standard deviations from part-to-part variability, which dominates the differences in radiation-induced shifts from bias sensitivity. The radiation-induced shifts for the output offset voltage and control pin current shown in Figure 5 and 6, respectively, showed similar characteristics as the I_{SET}. However, as Figure 7 shows, the output offset load regulation exhibited different trends for the parts irradiated at low dose rate and high dose rate. The high dose rate irradiated parts showed a positive parametric drift, while the low dose rate irradiated parts showed a negative parametric drift.

Figures 4 − 7 also show the results of annealing for the parts irradiated at high dose rate. The 24 hour room temperature anneal produced negligible change to the parameters. The 168 hour elevated temperature anneal generally caused the parametric shifts to further increase in magnitude, following the same trend as the post-irradiation drift. The figures show that the parametric shifts after high dose rate irradiation and anneal do not correlate well with the shifts after low dose rate irradiation. In most cases, the combination of high dose rate irradiation and anneal is less conservative than low dose rate irradiation. In the case of the output offset load regulation in Figure 7, the parameter continued to drift in the positive direction after annealing, thereby further worsening the magnitude of error to the low dose rate data, which drifted in the negative direction.

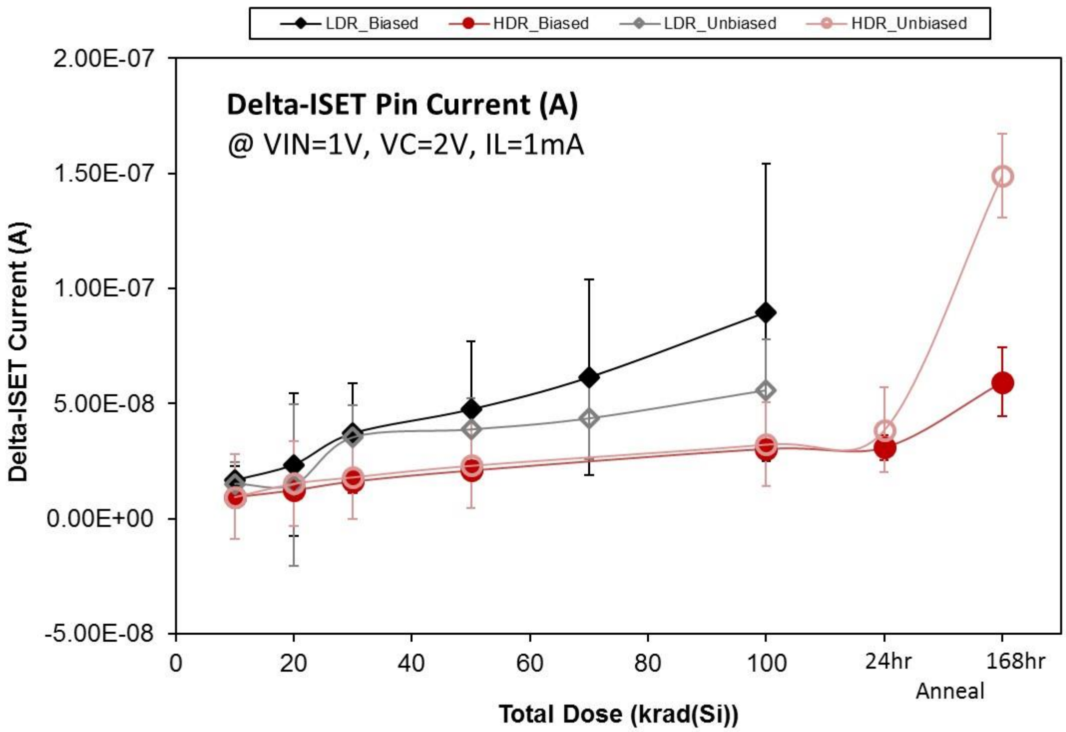

Figure 4. ΔI_{SET} vs. TID for the RH3080 irradiated at low dose rate and high dose rate.

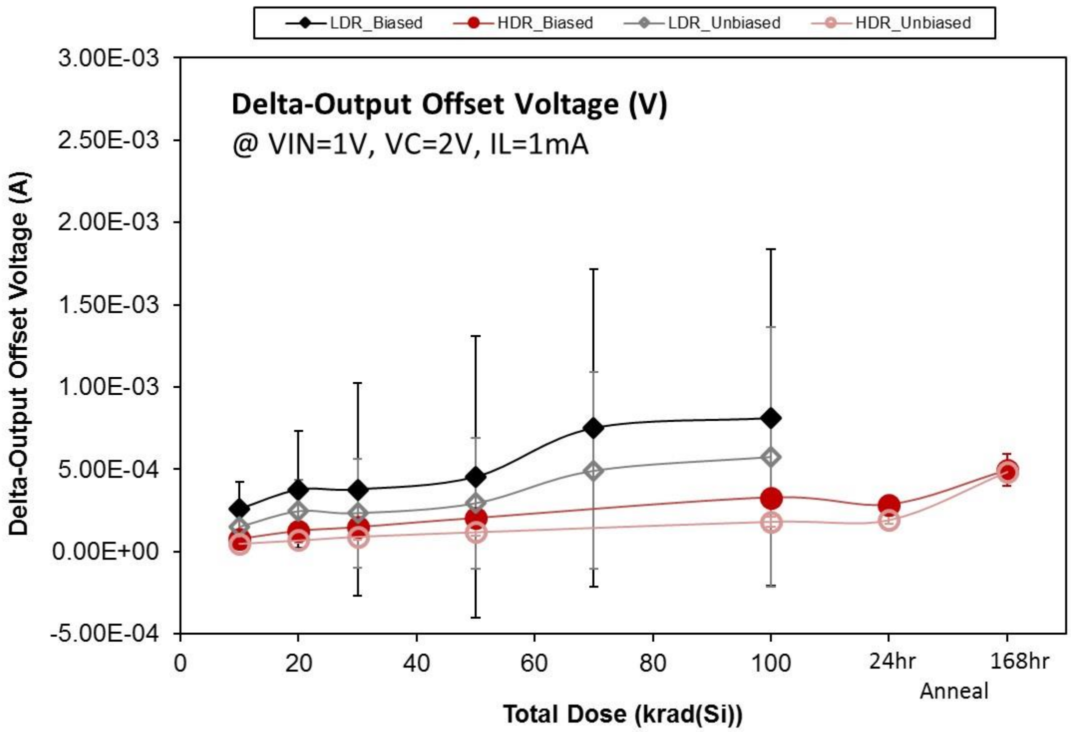

Figure 5. ΔV_{OS} vs. TID for the RH3080 irradiated at low dose rate and high dose rate.

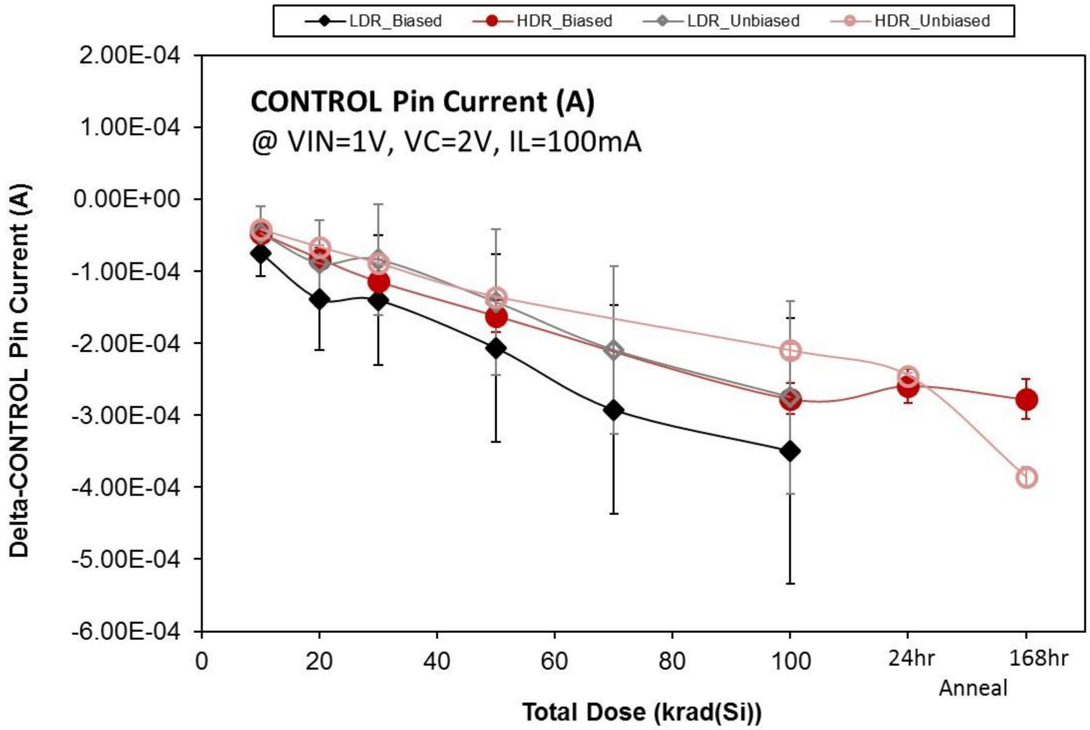

Figure 6. $\Delta I_{CONTROL}$ vs. TID for the RH3080 irradiated at low dose rate and high dose rate.

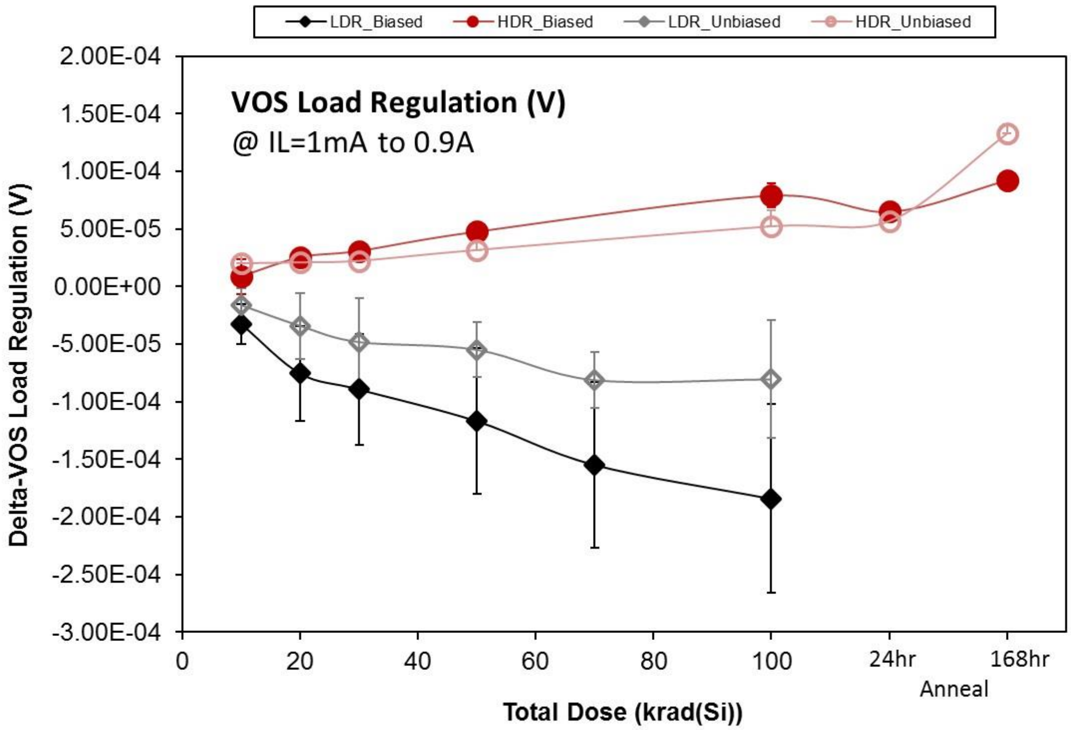

Figure 7. ΔV_{OS} Load Regulation vs. TID for the RH3080 irradiated at low dose rate and high dose rate.

V. Reference

1. MIL-STD-883-K, Test Method 1019.9, Ionizing Radiation (Total Dose) Test Procedure Feb. 22, 2017.
2. Analog Devices, Inc. (2017) "*RH3080MK - Radiation Hardened Adjustable 0.9A Single Resistor Low Dropout Regulator*" [Online]. Available: http://cds.linear.com/docs/en/datasheet/rh3080mkfc.pdf, Accessed on: November 27, 2017.

Appendix-A

Appendix-A includes the low dose rate irradiation data.

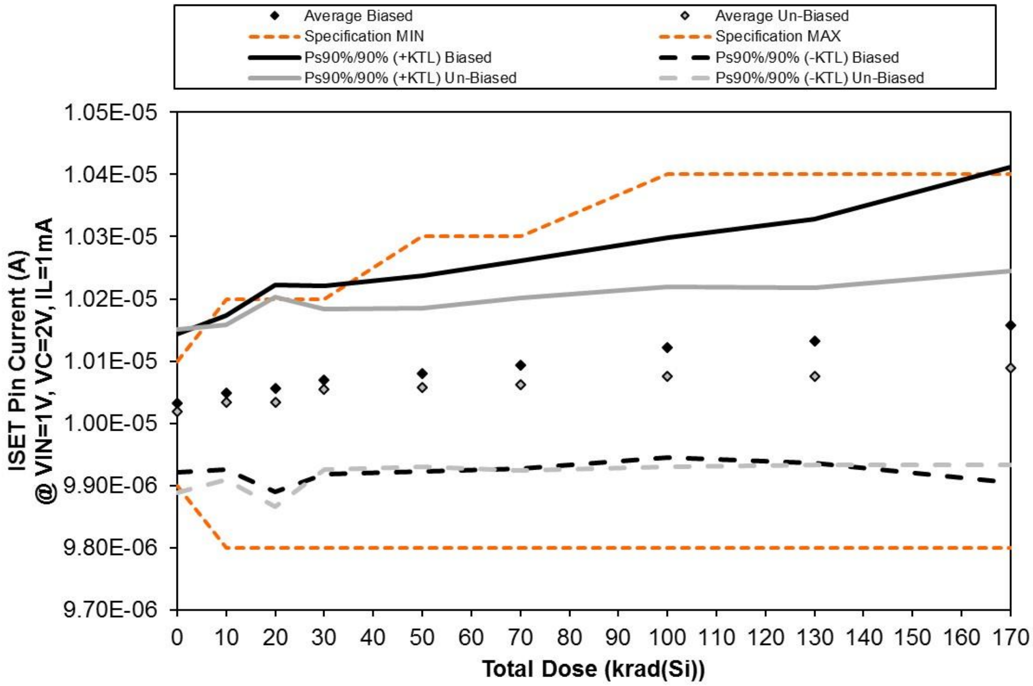

Figure A-1. I_{SET} vs. TID for the RH3080 irradiated at low dose rate.

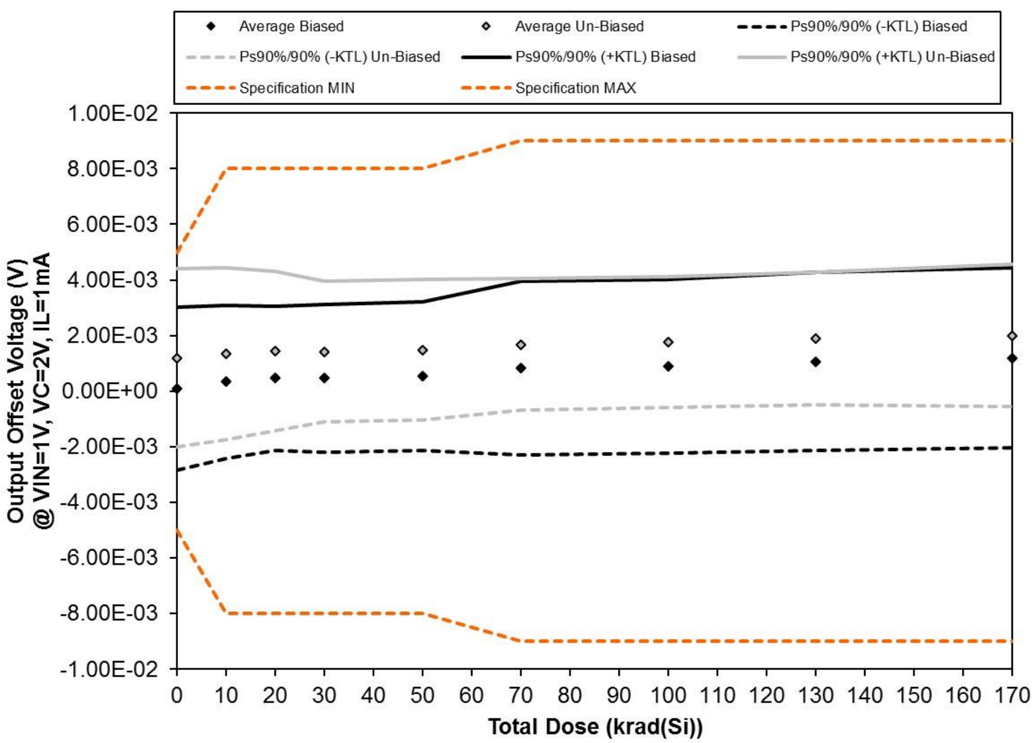

Figure A-2. Output offset voltage vs. TID for the RH3080 irradiated at low dose rate.

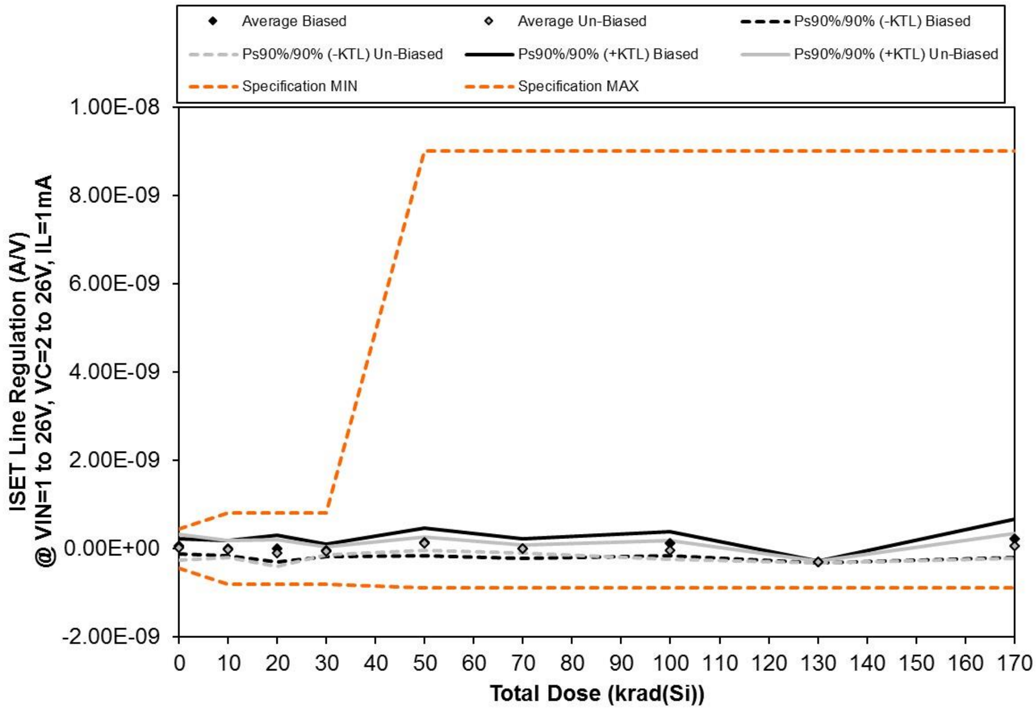

Figure A-3. I_{SET} line regulation vs. TID for the RH3080 irradiated at low dose rate.

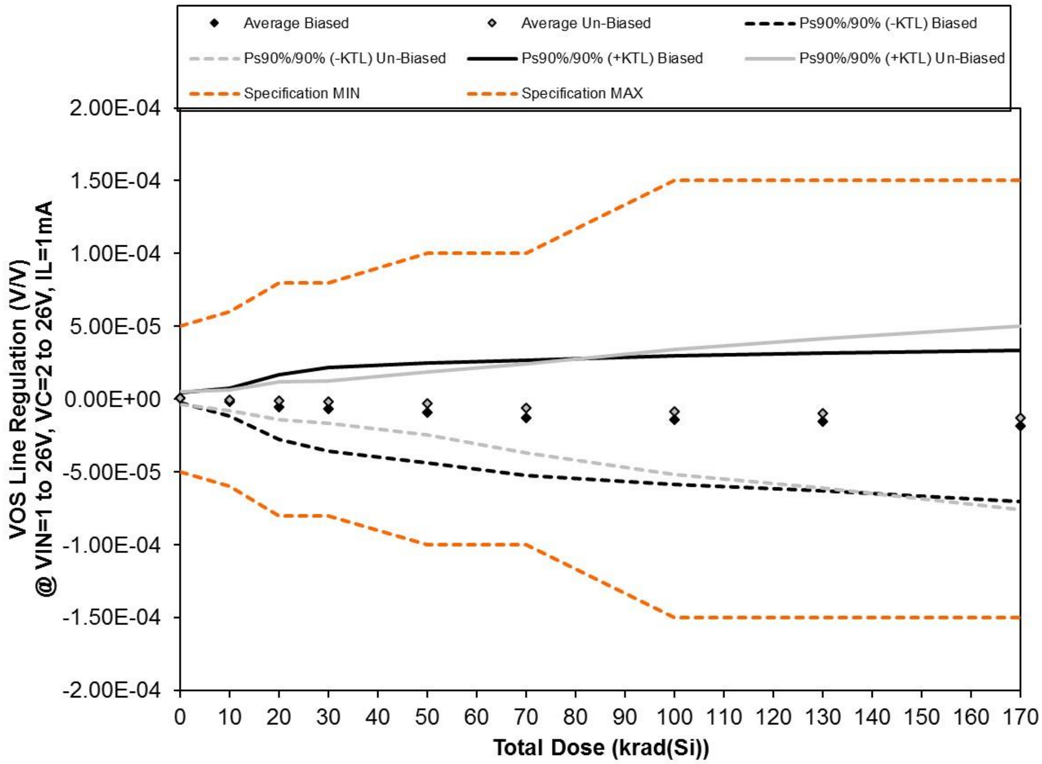

Figure A-4. Output offset voltage line regulation vs. TID for the RH3080 irradiated at low dose rate.

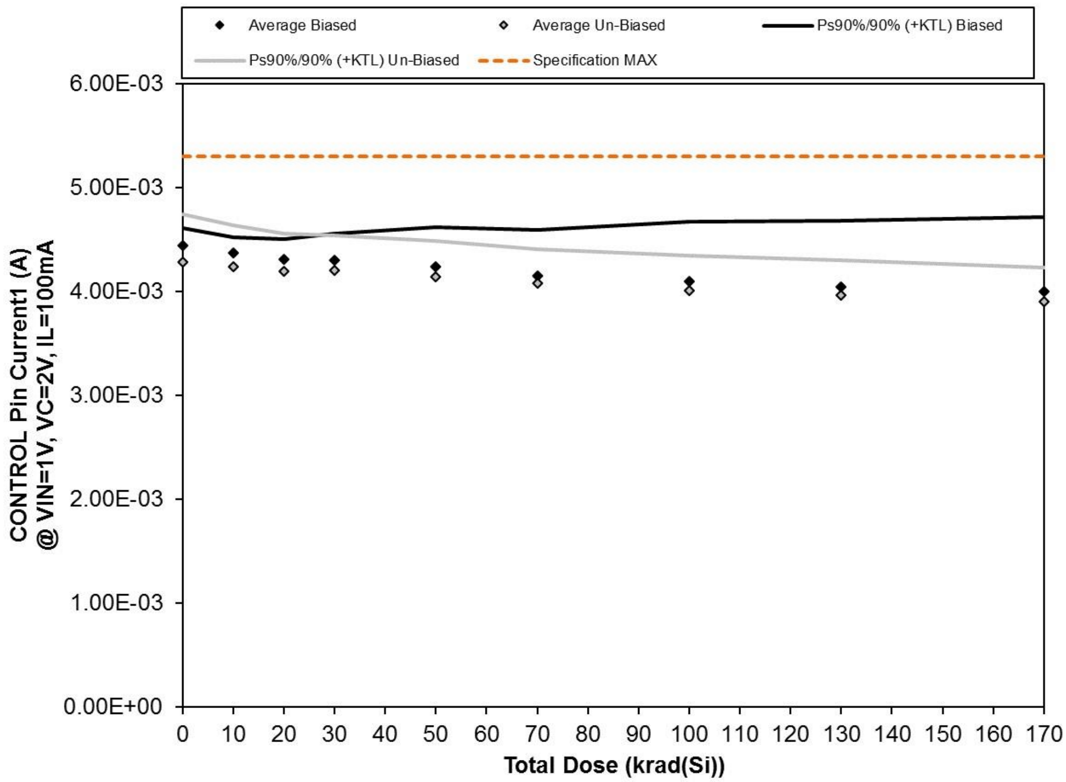

Figure A-5. Control pin current vs. TID for the RH3080 irradiated at low dose rate.

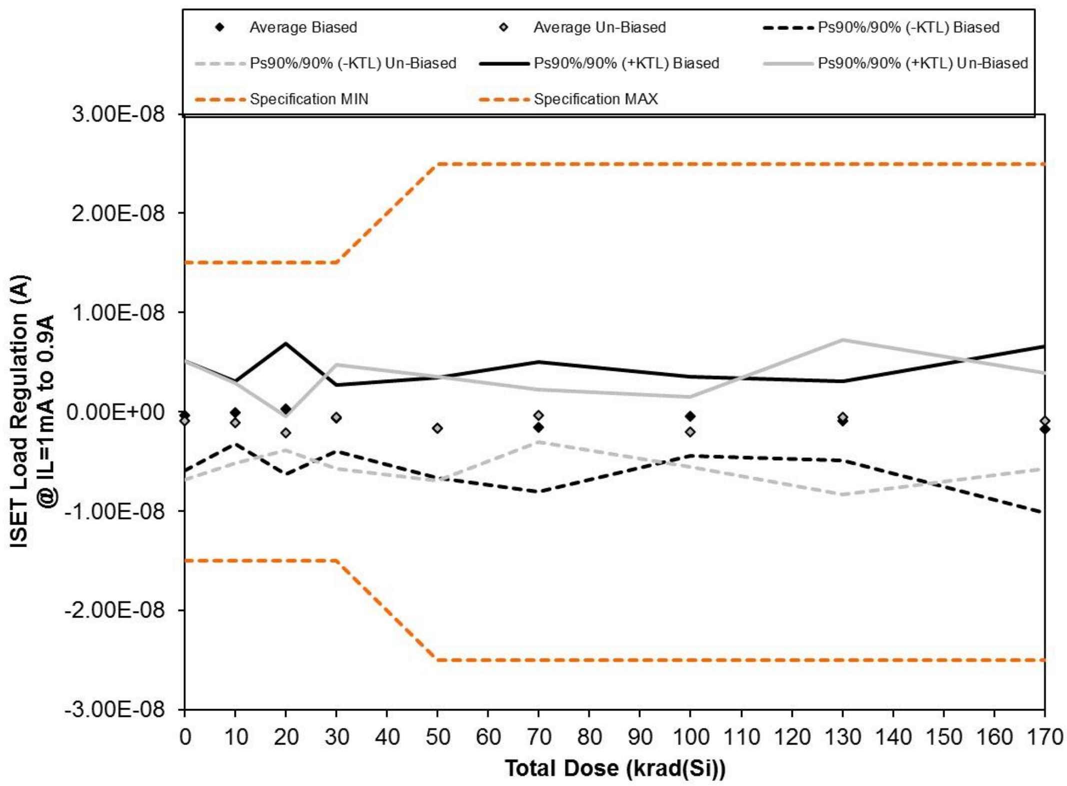

Figure A-6. I_{SET} load regulation vs. TID for the RH3080 irradiated at low dose rate.

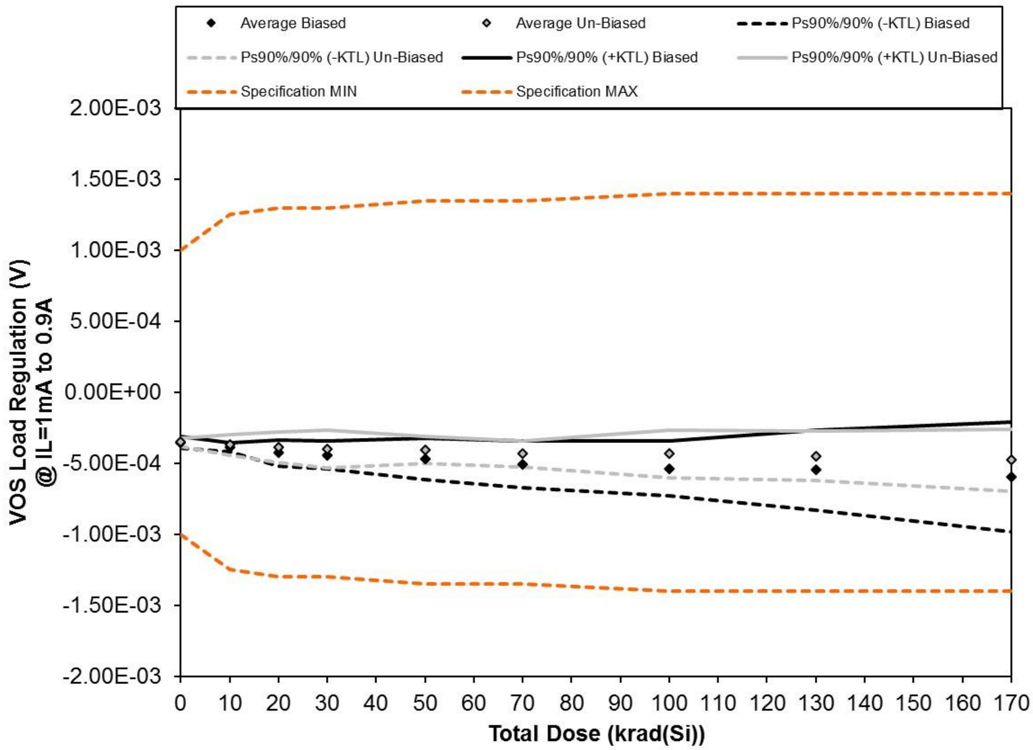

Figure A-7. Output offset voltage load regulation vs. TID for the RH3080 irradiated at low dose rate.

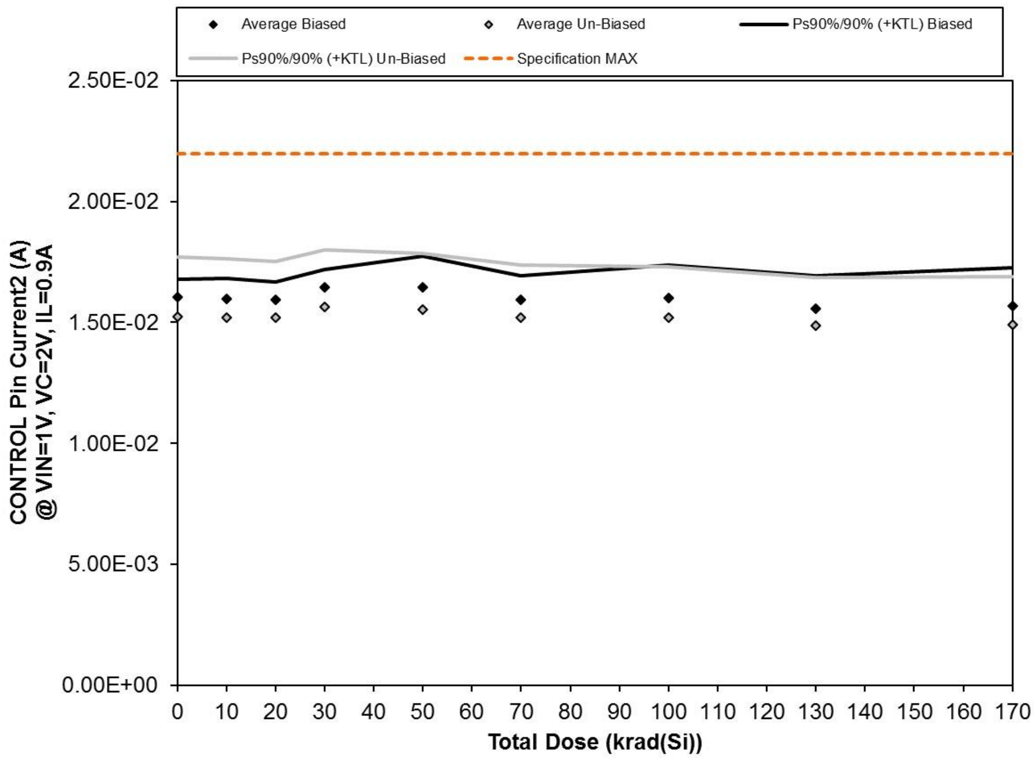

Figure A-8. I_{SET}_2 vs. TID for the RH3080 irradiated at low dose rate.

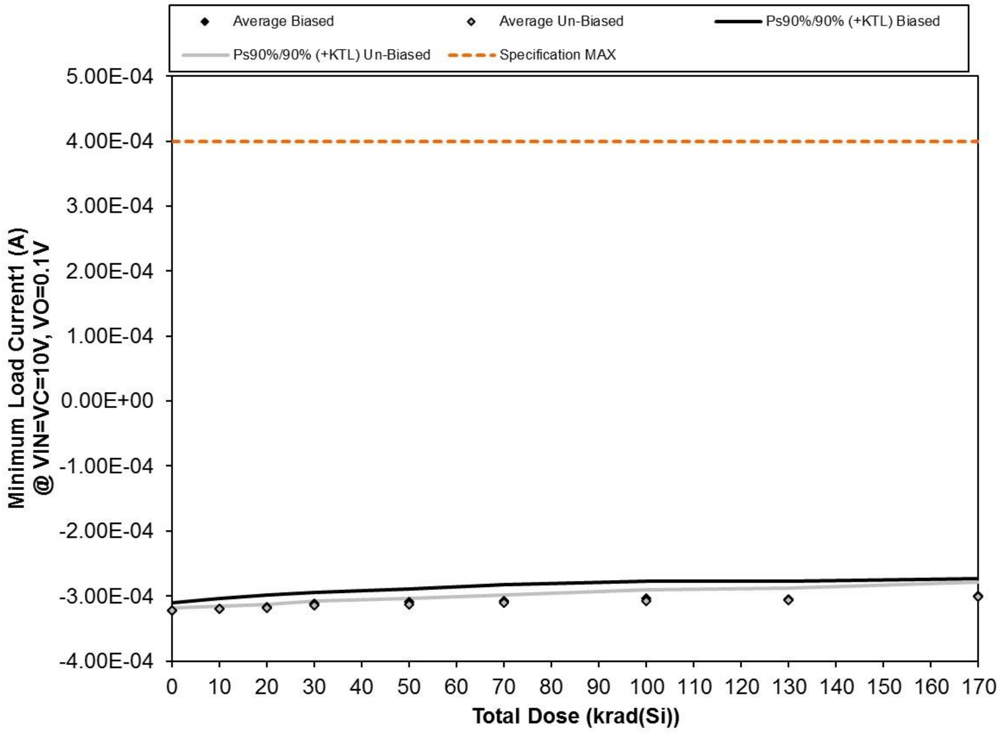

Figure A-9. Minimum load current vs. TID for the RH3080 irradiated at low dose rate.

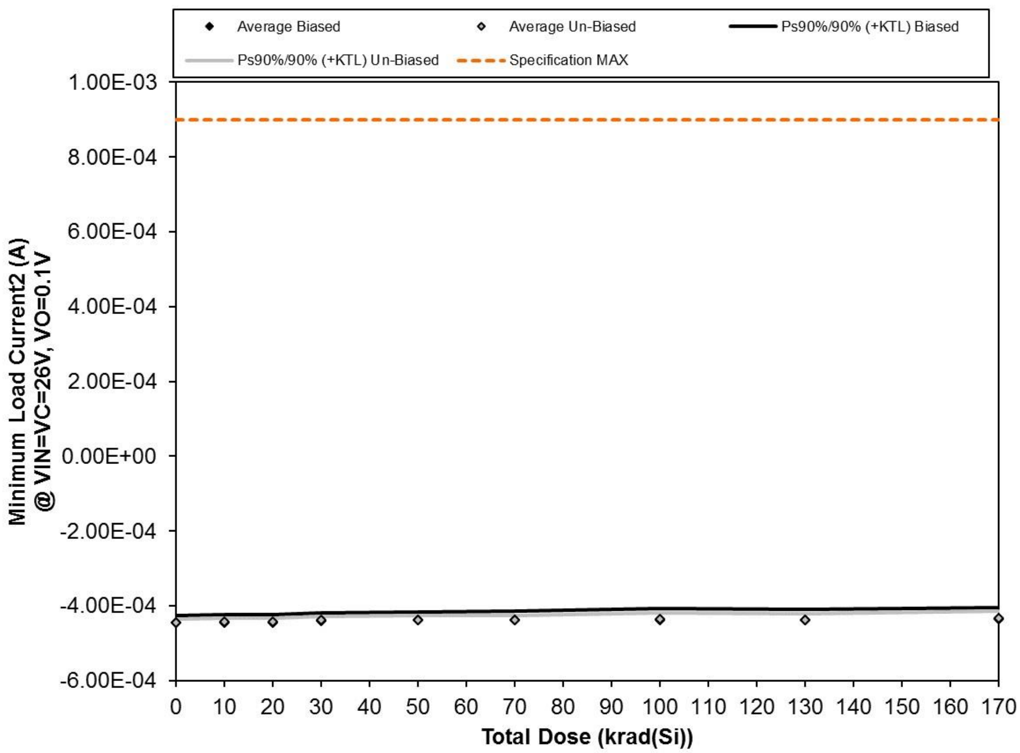

Figure A-10. Minimum load current_2 vs. TID for the RH3080 irradiated at low dose rate.

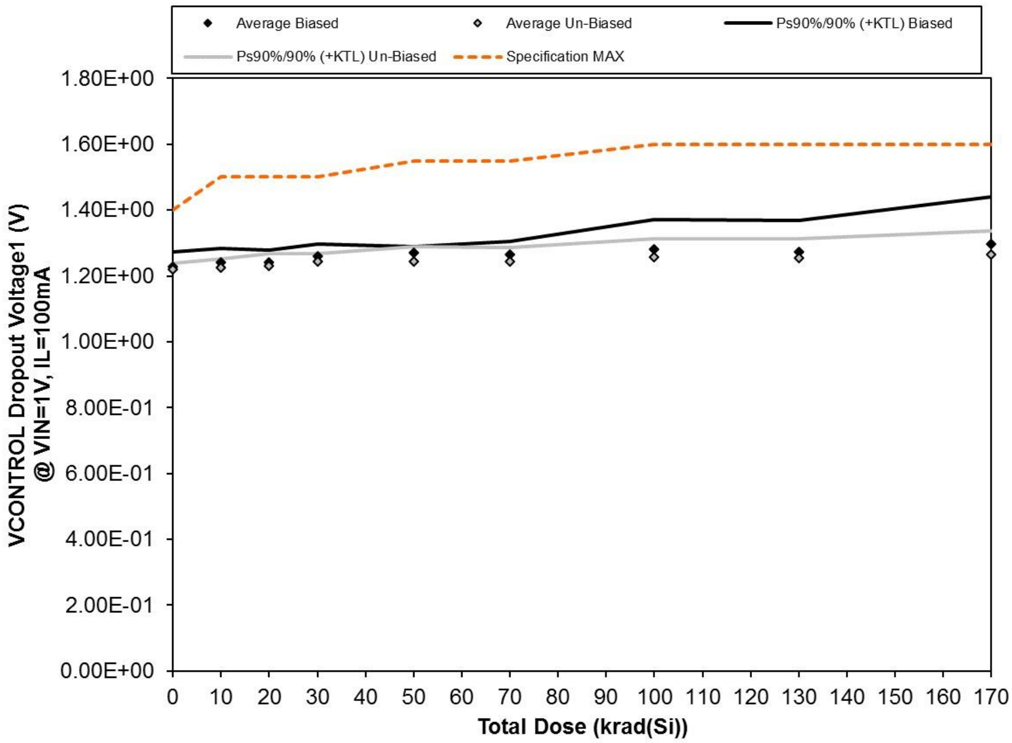

Figure A-11. $V_{CONTROL}$ dropout voltage vs. TID for the RH3080 irradiated at low dose rate.

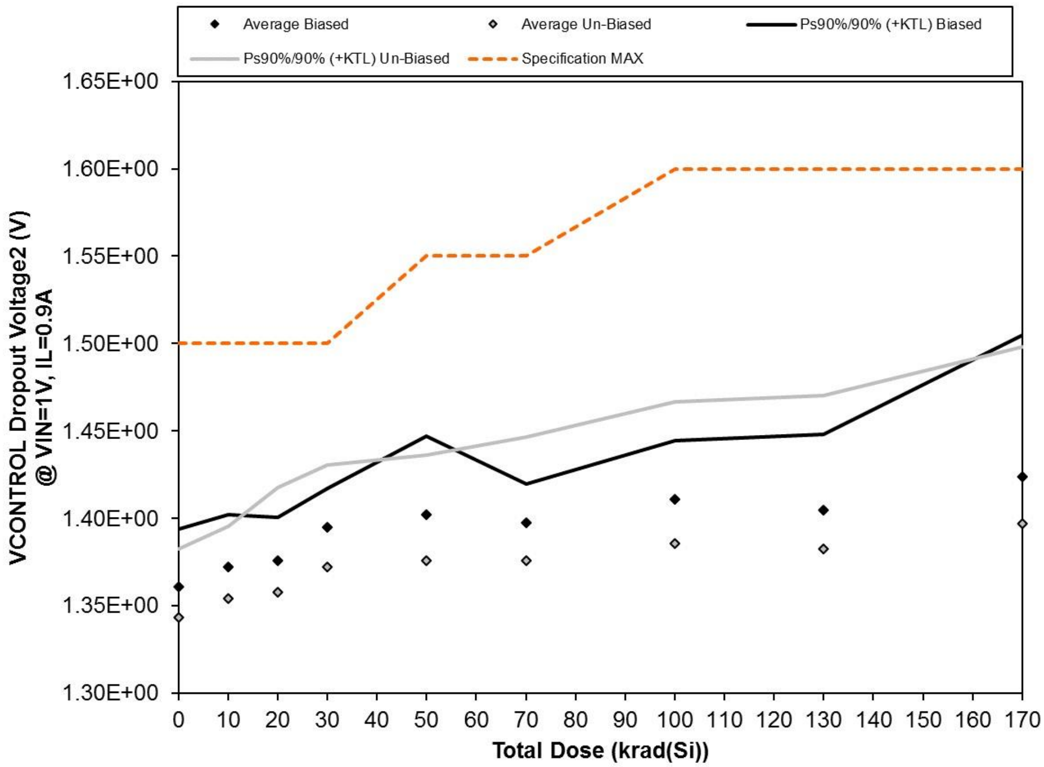

Figure A-12. $V_{CONTROL}$ dropout voltage 2 vs. TID for the RH3080 irradiated at low dose rate.

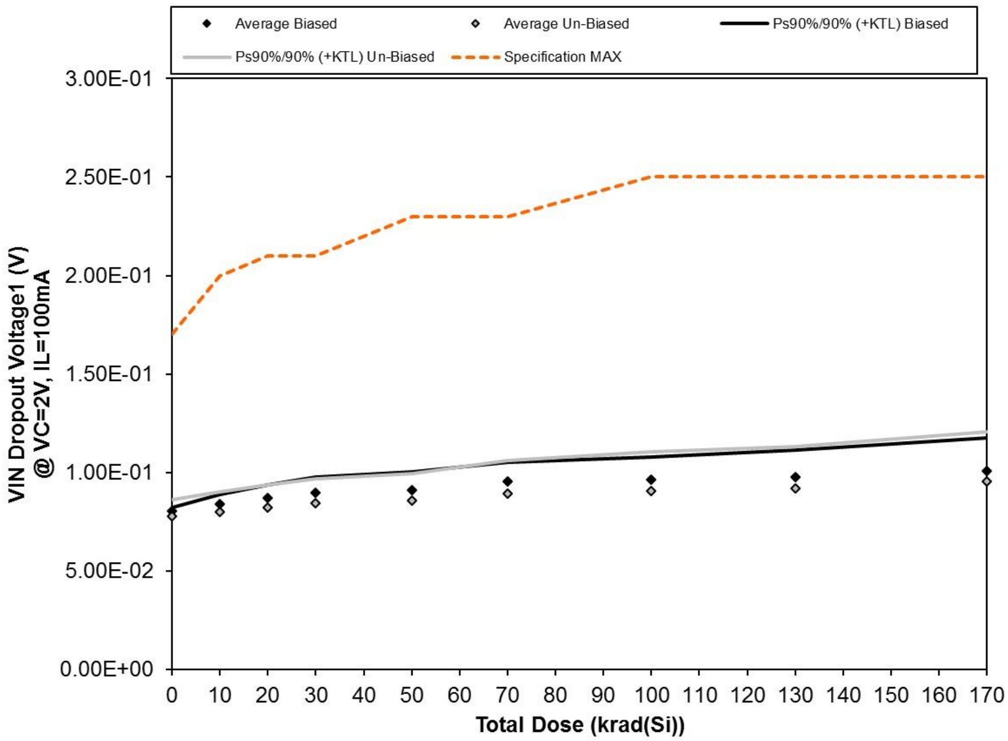

Figure A-13. V_{IN} dropout voltage vs. TID for the RH3080 irradiated at low dose rate.

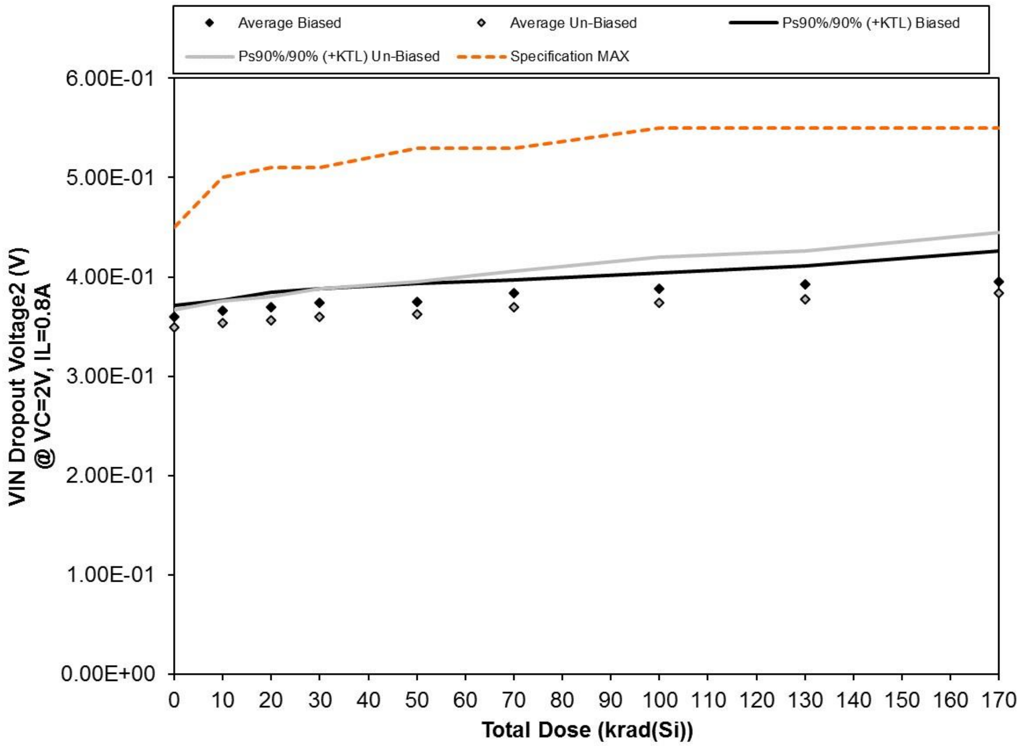

Figure A-14. V_{IN} dropout voltage 2 vs. TID for the RH3080 irradiated at low dose rate.

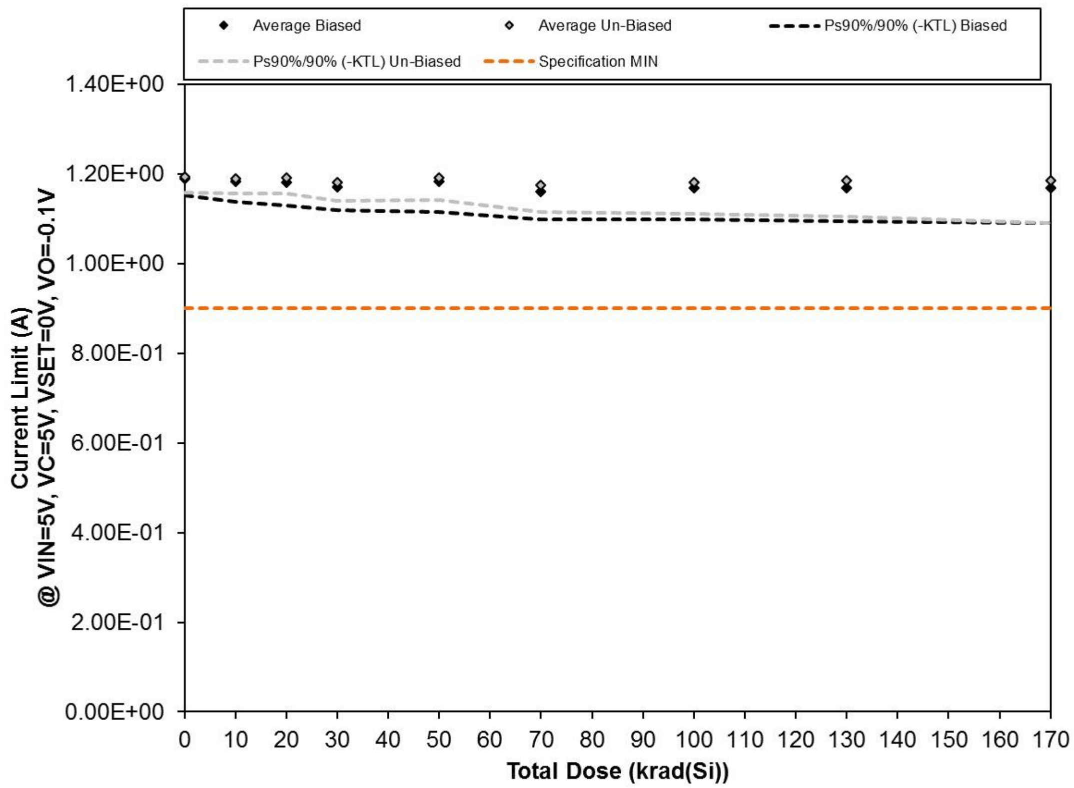

Figure A-15. Current limit vs. TID for the RH3080 irradiated at low dose rate.

Appendix-B

Appendix-B includes the high dose rate irradiation data.

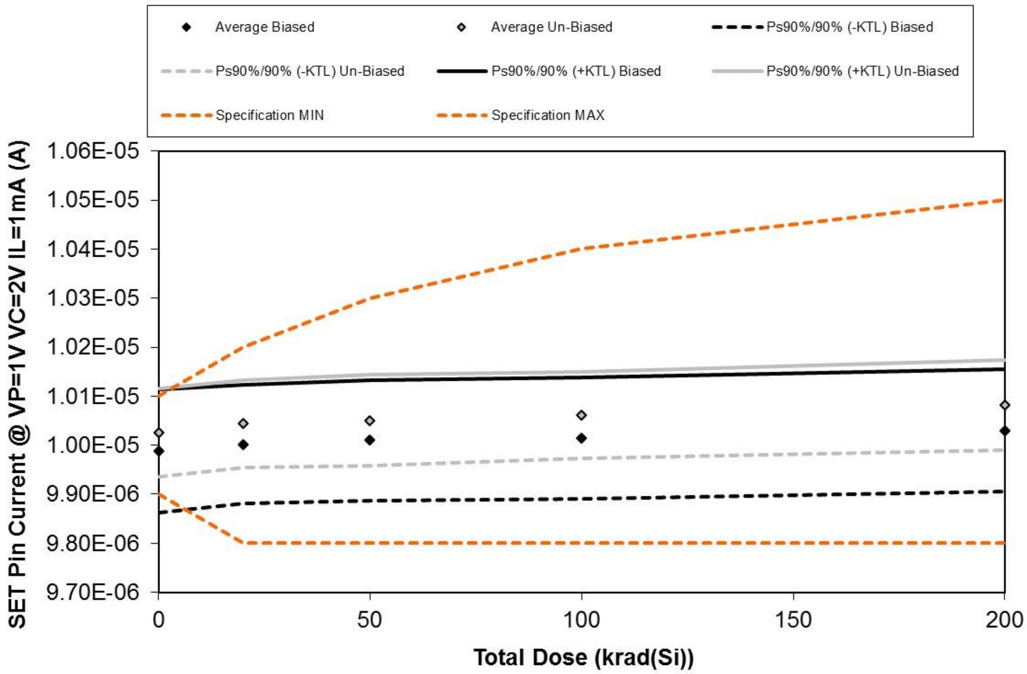

Figure B-1. I_{SET} vs. TID for the RH3080 irradiated at high dose rate.

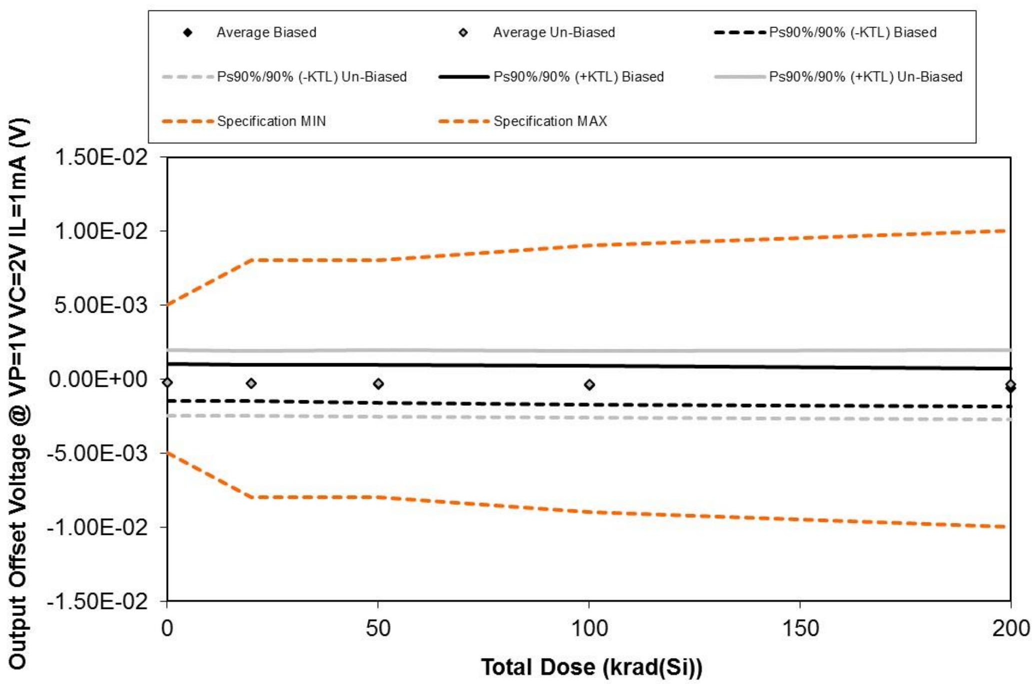

Figure B-2. Output offset voltage vs. TID for the RH3080 irradiated at high dose rate.

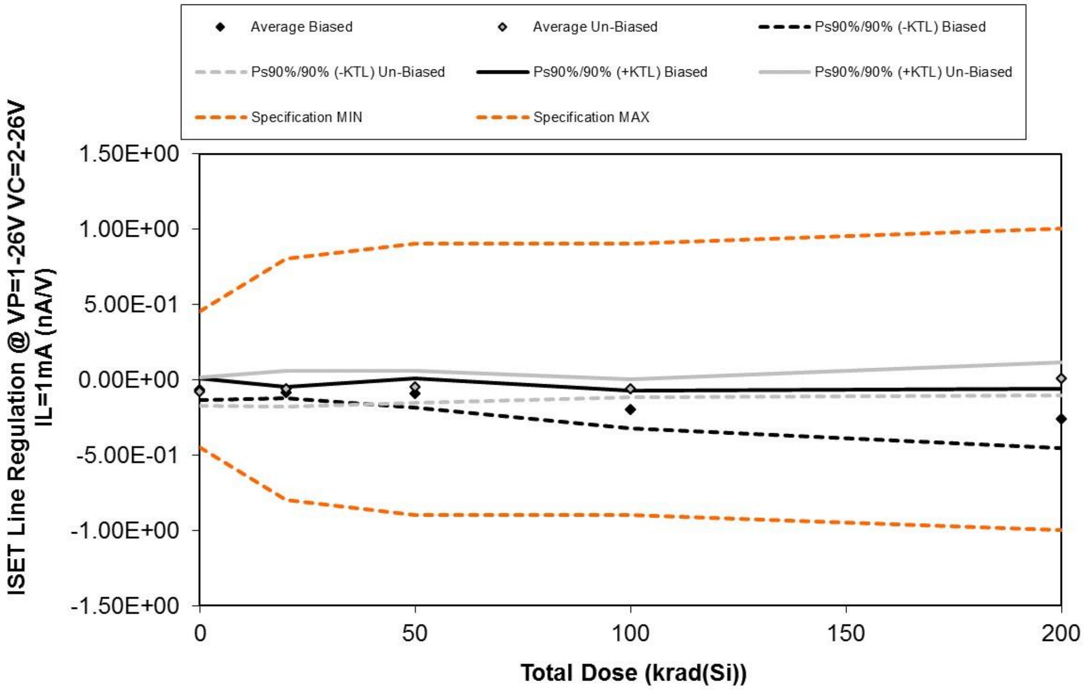

Figure B-3. I_{SET} line regulation vs. TID for the RH3080 irradiated at high dose rate.

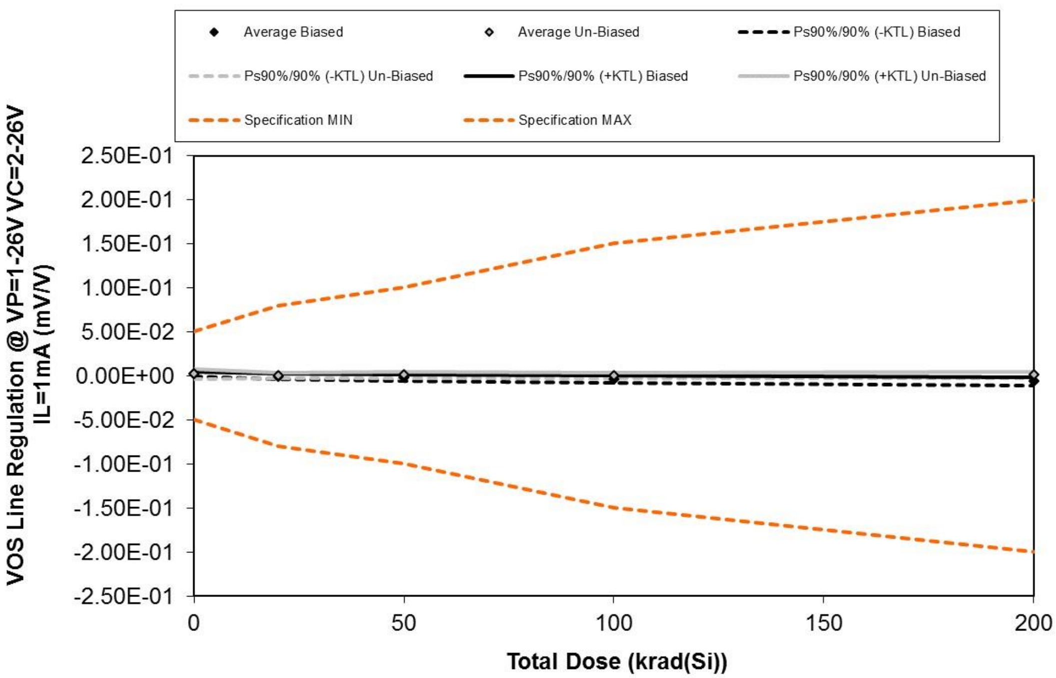

Figure B-4. Output offset voltage line regulation vs. TID for the RH3080 irradiated at high dose rate.

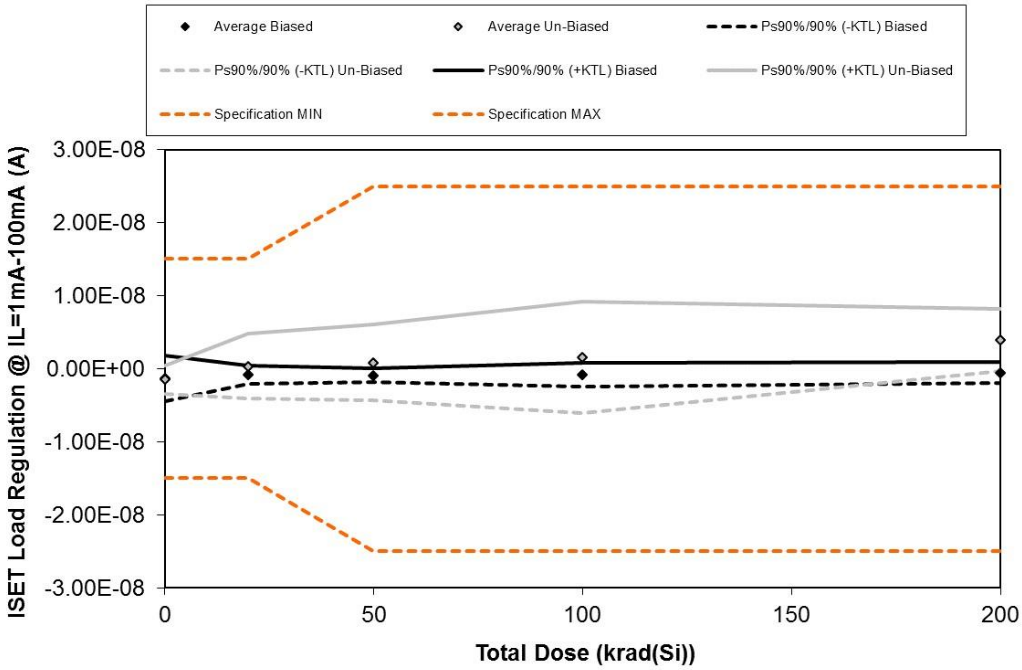

Figure B-5. I_{SET} load regulation vs. TID for the RH3080 irradiated at high dose rate.

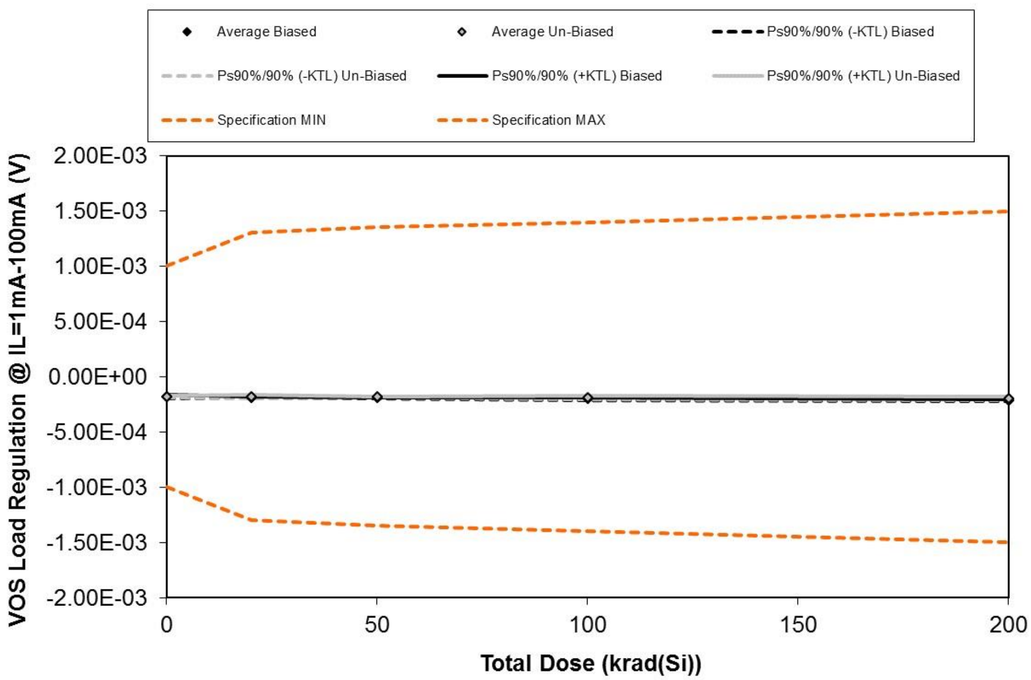

Figure B-6. Output offset voltage load regulation vs. TID for the RH3080 irradiated at high dose rate.

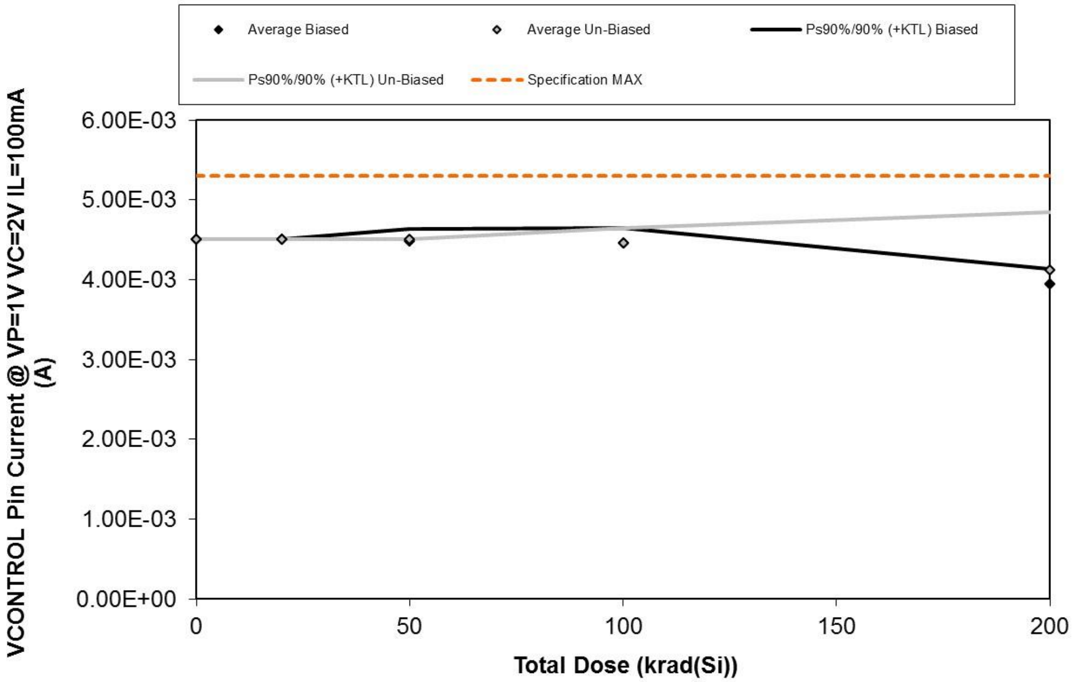

Figure B-7. $I_{CONTROL}$ vs. TID for the RH3080 irradiated at high dose rate.

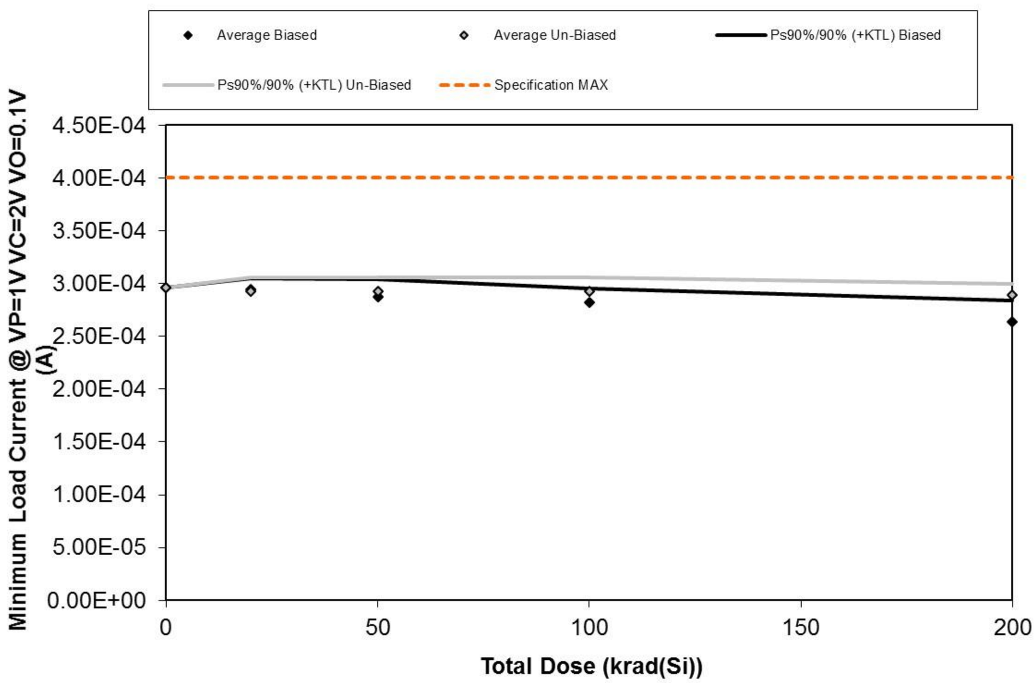

Figure B-8. Minimum load current vs. TID for the RH3080 irradiated at high dose rate.

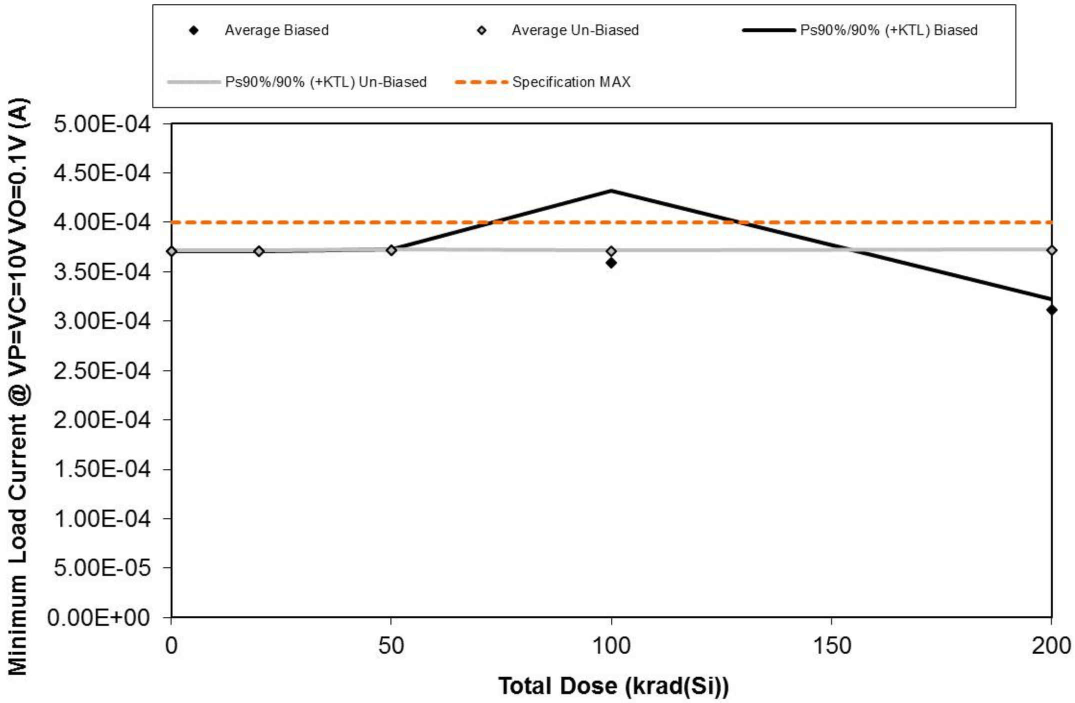

Figure B-9. Minimum load current 2 vs. TID for the RH3080 irradiated at high dose rate.

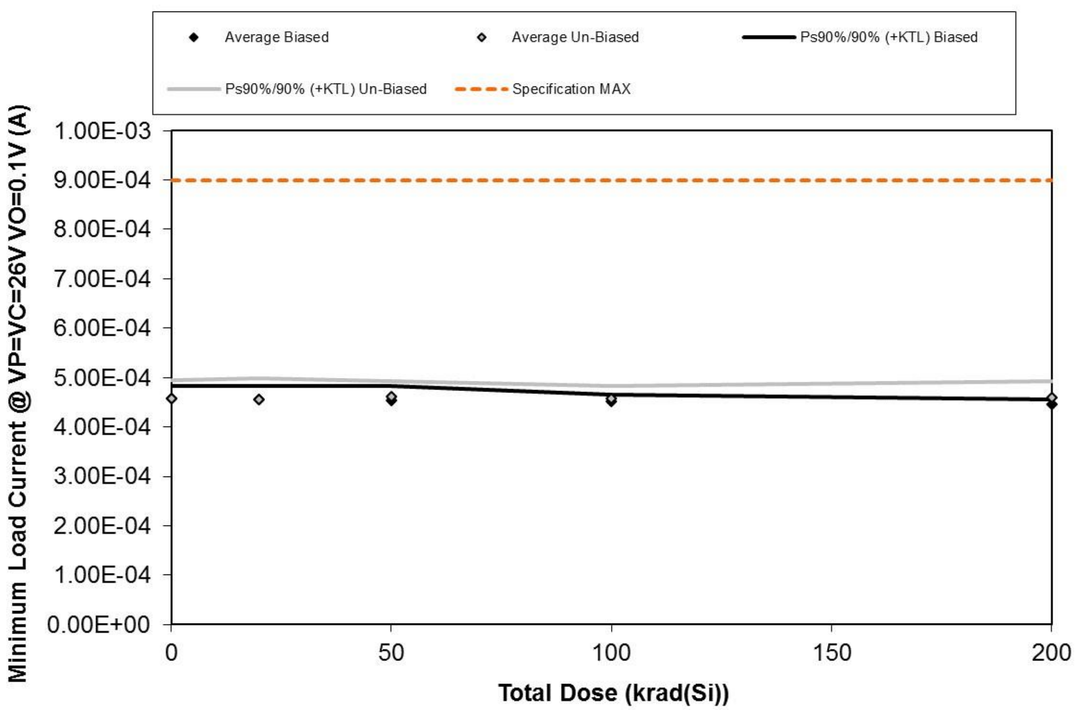

Figure B-10. Minimum load current 3 vs. TID for the RH3080 irradiated at high dose rate.

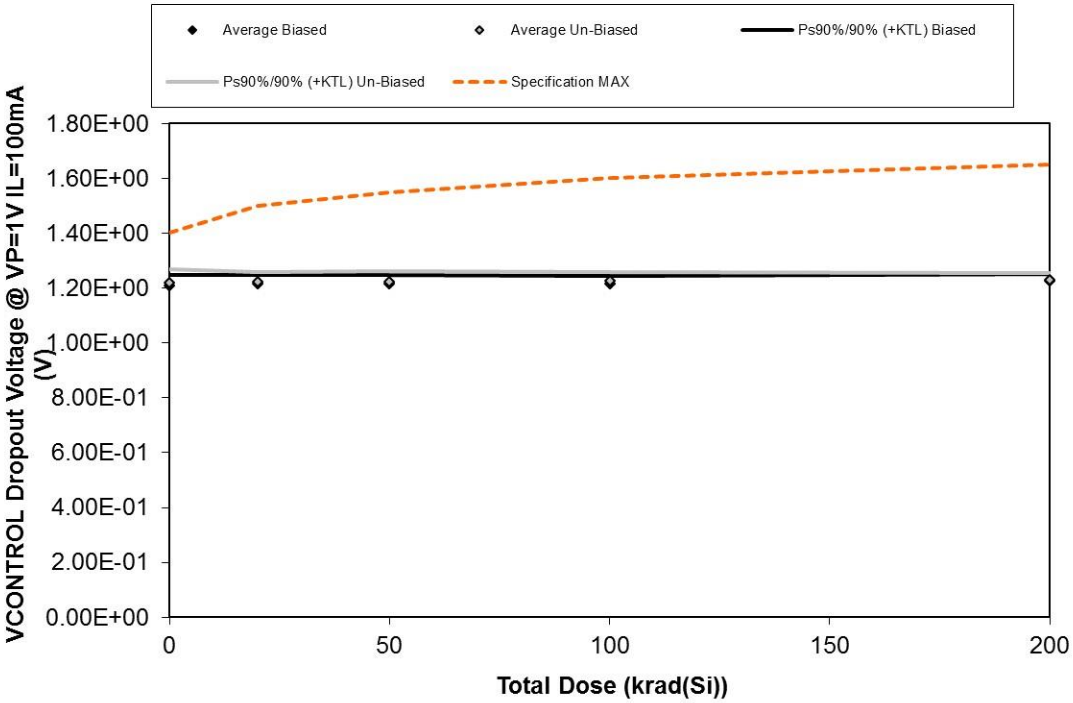

Figure B-11. $V_{CONTROL}$ dropout voltage vs. TID for the RH3080 irradiated at high dose rate.

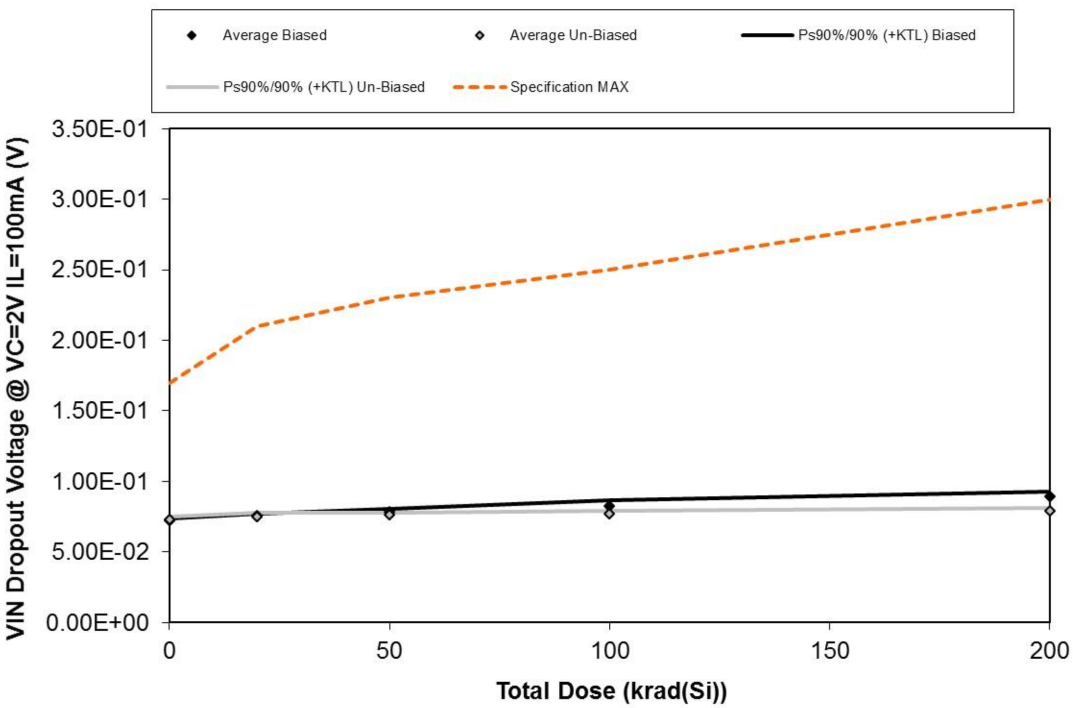

Figure B-12. V_{IN} dropout voltage vs. TID for the RH3080 irradiated at high dose rate.