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Total-Ionizing Dose Test Report for the RH1028M Ultralow Noise Precision High Speed Op Amps

March 2018

Radiation Test Report	
Product:	RH1028M
Gamma:	HDR: 25k, 50k, 100k, 200k LDR: 28k, 50k, 78.25, 100k
Gamma Source:	Co60/TM1019
Dose Rate:	High dose rate: 50 – 300 rad(Si)/sec Low dose rate: 10 mrad(Si)/sec
Facilities:	Defense Micro-Electronics Activity (DMEA)
Tested:	Nov 2017 – Mar 2018

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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 RH1028M. 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 RH1028M passes all electrical parametric tests up to 200 krad(Si) at high dose rate. Furthermore, the RH1028M does not exhibit enhanced-low-dose-rate-sensitivity (ELDRS) up to 100 krad(Si).

II. Device Description

The RH1028M is an Ultralow Noise Precision High Speed Operational Amplifier. The RH1028M is built with a proprietary process that is radiation-hardened against TID. The part is assembled in a W Package 10 lead CERPAC. 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 W10 packaged test sample.

Table I

Test and part information.

Part Number:	RH1028MW
Manufacturer:	Linear Technology Corp. now Analog Devices Inc.
Part Function:	Adjustable low dropout regulator
Process Technology:	7 µm bipolar
Package Type:	W Package 10 lead CERPAC
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
Test Equipment:	LTX TS80 Automated Tester LT1028 Family Board

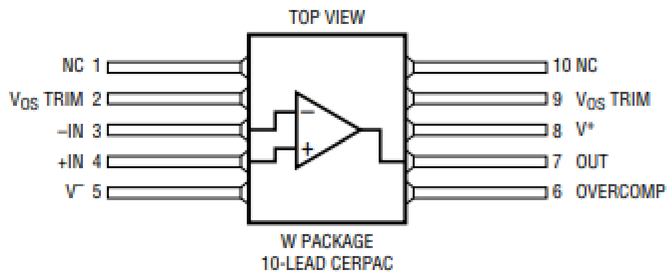

Figure 1. W Package 10 lead CERPAC pin configurations for the RH1028M.

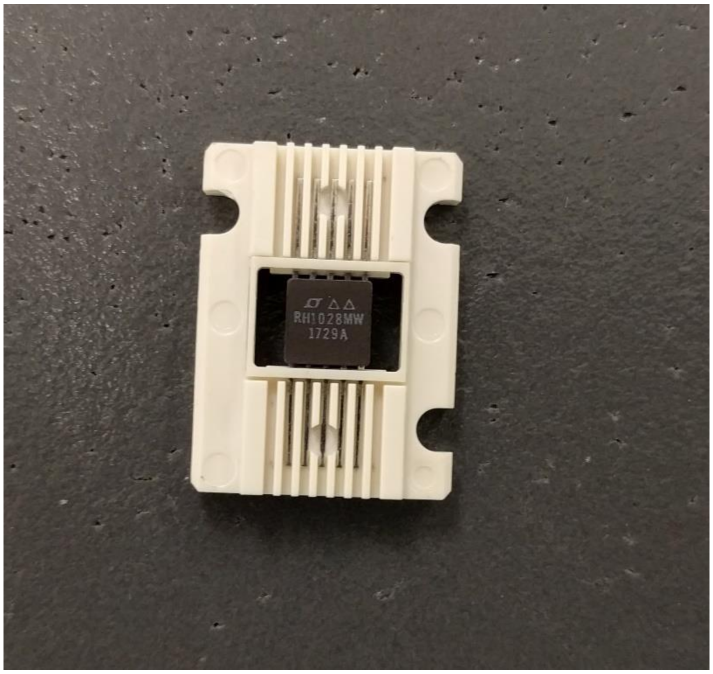

Figure 2. Photograph of a RH1028M W10 test sample.

III. Test Method

A. Irradiation procedures

The samples were irradiated in dose steps. For both the low dose rate and high dose rate testing carried out at DMEA, the samples were shipped back and forth on dry ice to Linear Technology's facility for characterization.

Radiation facilities: The irradiations were carried out at 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.

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

Overtest: No overtest was included.

Post-irradiation anneal: No annealing was performed.

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. High dose rate irradiation was performed on 22 units. There were 5 unique units biased and 5 unique units unbiased at each incremental dose step as well as 4 controls. 5 samples were biased and 5 samples had all pins grounded for each dose step across the low dose rate irradiation. In addition, 2 samples were used as control units.

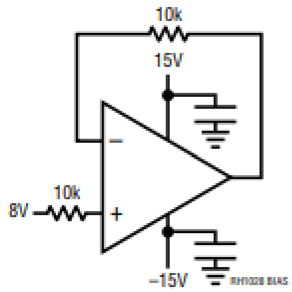

Figure 3. Bias configuration for the RH1028M.

IV. Results

The radiation lot acceptance tests showed that all parts irradiated at low dose rate passed up to the highest tested TID of 100 krad(Si), and all parts irradiated at high dose rate passed up to the highest tested TID of 200 krad(Si). 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 – 9, which show the radiation-induced shifts of several parameters as a function of TID, for high and low dose rate irradiation up to 100krad(Si).

As shown in Figure 6 and 7, the input bias current degradation showed bias dependence, where biased parts exhibited a slightly higher degradation levels compared with parts irradiated with all pins grounded. Nevertheless, the parametric shifts for both high dose rate and low dose rate irradiated parts are well within specification limits. Additionally, there was no observable dose rate dependence. Therefore, the RH1028MW does not exhibit ELDRS up to 100 krad(Si). The leakage currents increased with increasing TID. The slew rate decreased over irradiation. There also seemed to be a unique radiation-induced shifts for the input bias current and slew rate shown in Figure 6 through 9, respectively, showed higher degradation for the -Input Bias Current and -Slew Rate. Lastly, we did see a larger KTL value at the 50 krad(Si) step for Input Offset Current this was due to one unbiased part having a largely negative current reading. This anomaly was related to the tester and not a valid reading and not a failure of the part. Figure A-2 in Appendix A shows the data with the large KTL shift at the 50 krad(Si), while Figure A-3 shows the corrected data with the anomalous data removed.

Based on all the information from this testing the RH1028M has passed all irradiation requirements.

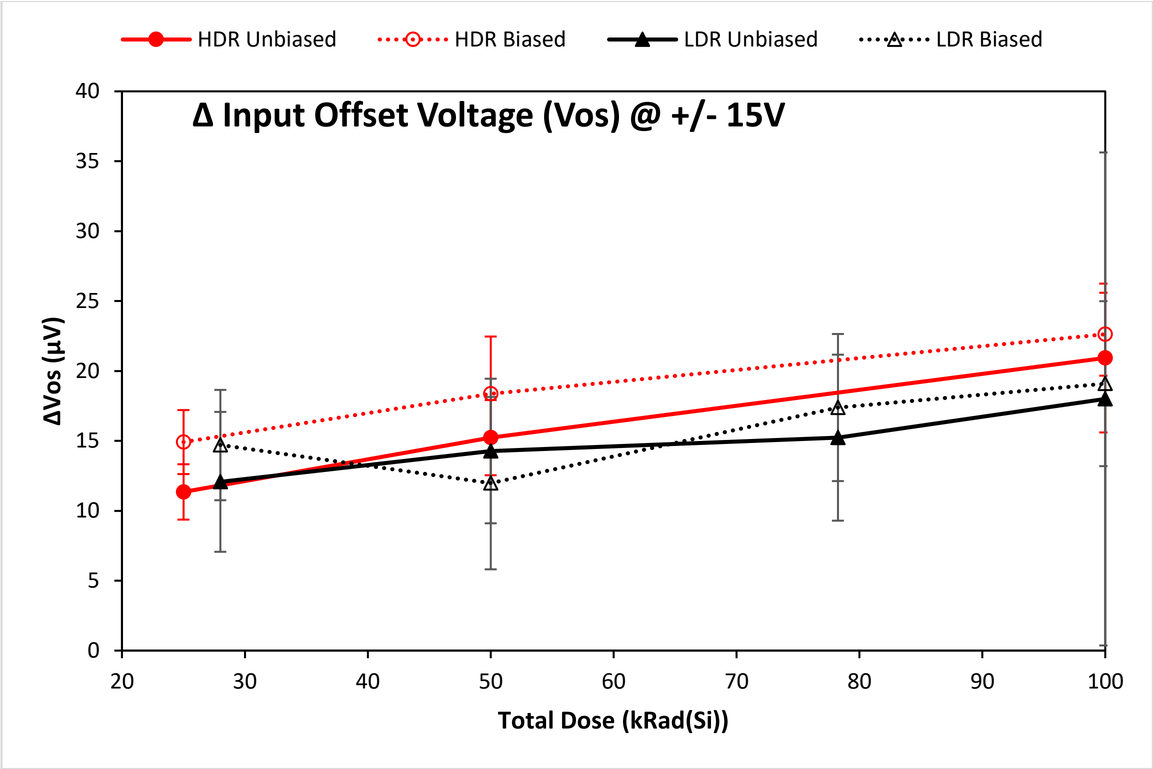

Figure 4. ΔV_{OS} vs. TID for the RH1028M irradiated at low dose rate and high dose rate.

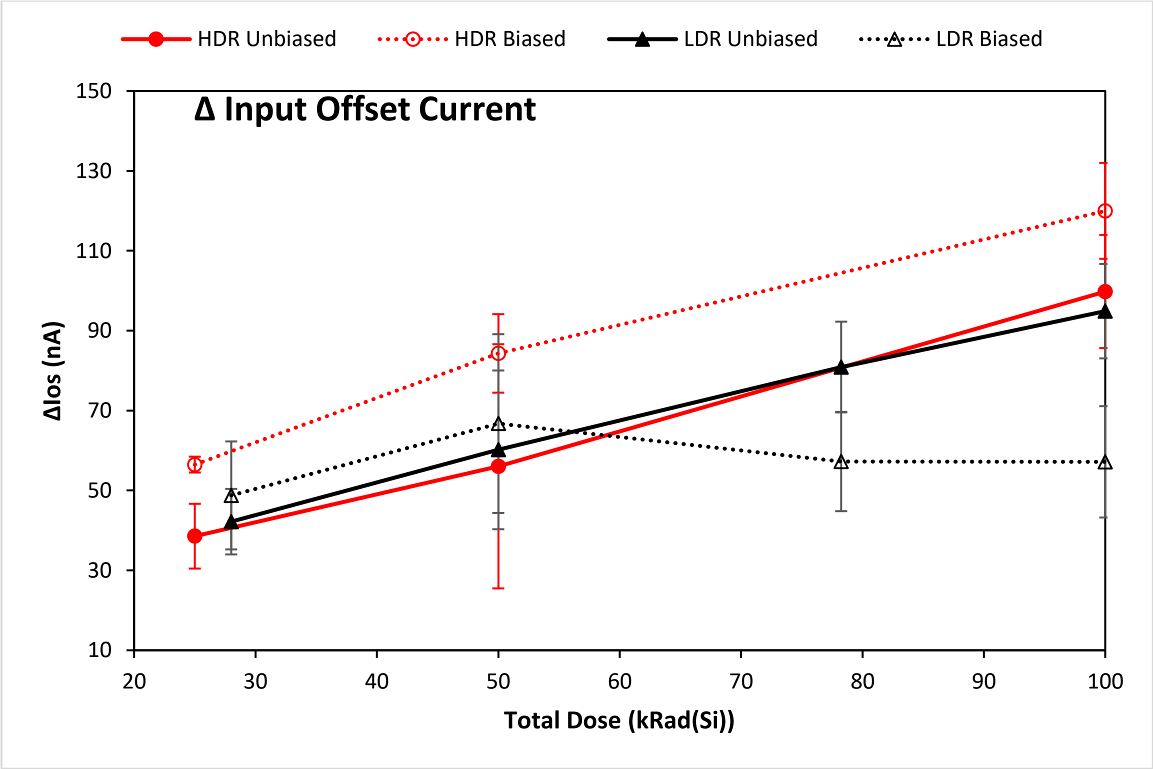

Figure 5. ΔI_{OS} vs. TID for the RH1028M irradiated at low dose rate and high dose rate.

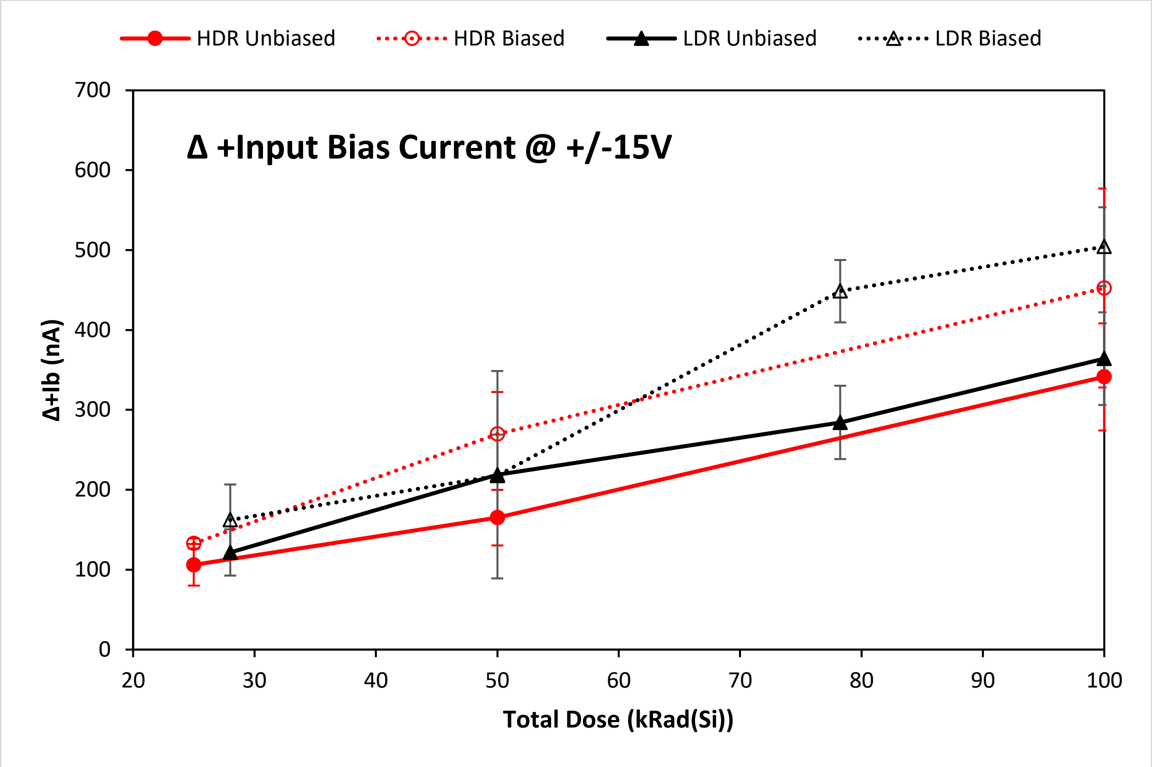

Figure 6. Δ+I_B vs. TID for the RH1028M irradiated at low dose rate and high dose rate.

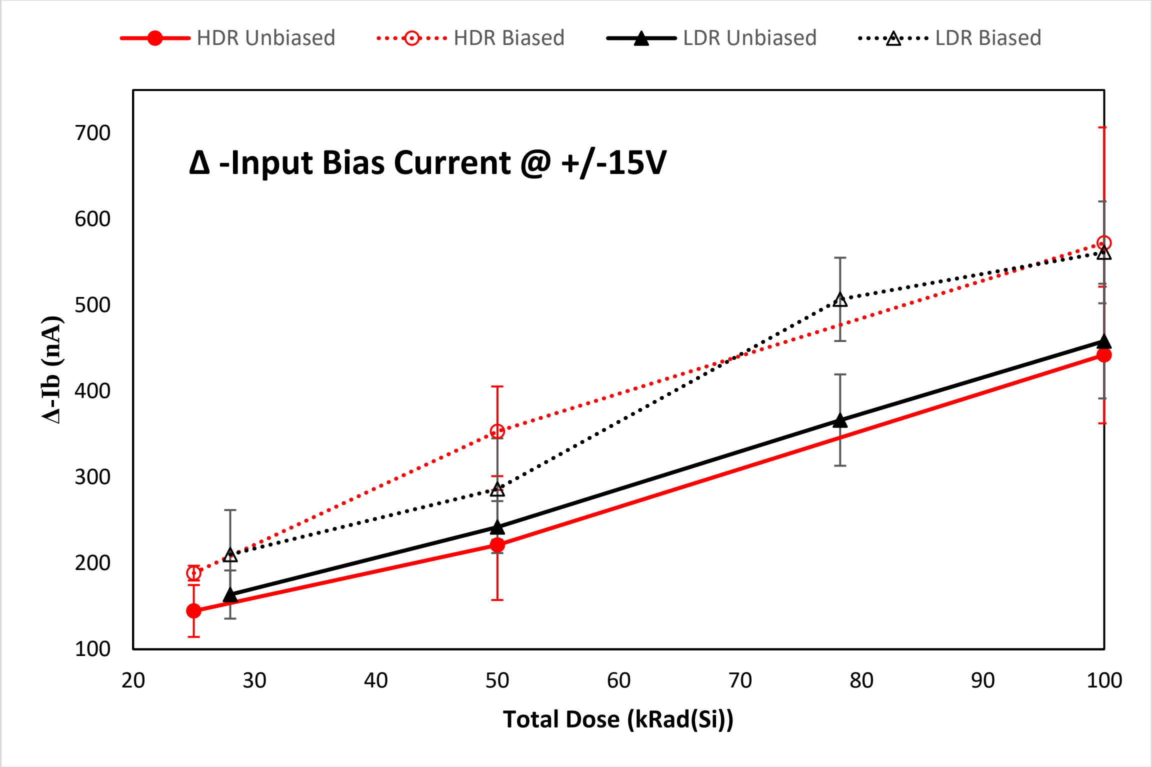

Figure 7. Δ-I_B vs. TID for the RH1028M irradiated at low dose rate and high dose rate.

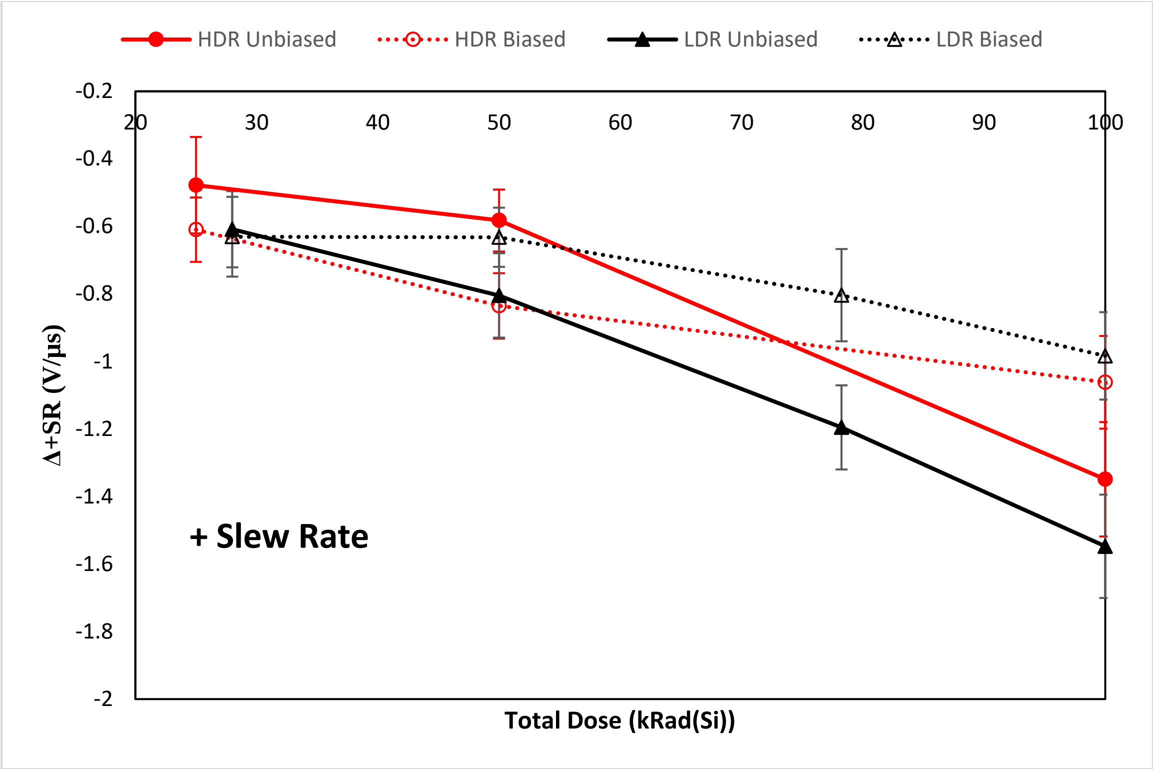

Figure 8. Δ+SR vs. TID for the RH1028M irradiated at low dose rate and high dose rate.

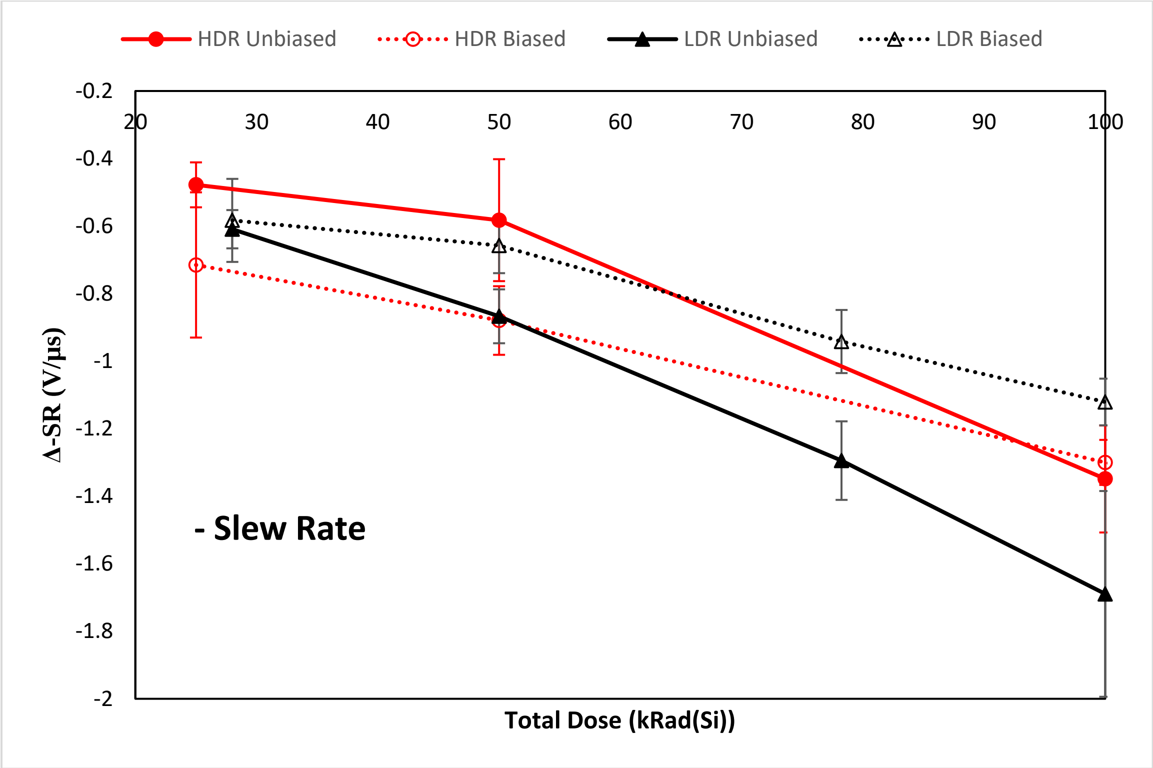

Figure 9. Δ-SR vs. TID for the RH1028M irradiated at low dose rate and high dose rate.

V. REFERENCE

1. MIL-STD-883-K, Test Method 1019.9, Ionizing Radiation (Total Dose) Test Procedure Feb. 22, 2017.
2. Analog Devices, Inc. (2018) "*RH1028M - Ultralow Noise Precision High Speed Op Amps*" [Online]. Available: http://cds.linear.com/docs/en/datasheet/rh10281128fe.pdf, Accessed on: March 16, 2018.

Appendix-A

Appendix-A includes the low dose rate irradiation data.

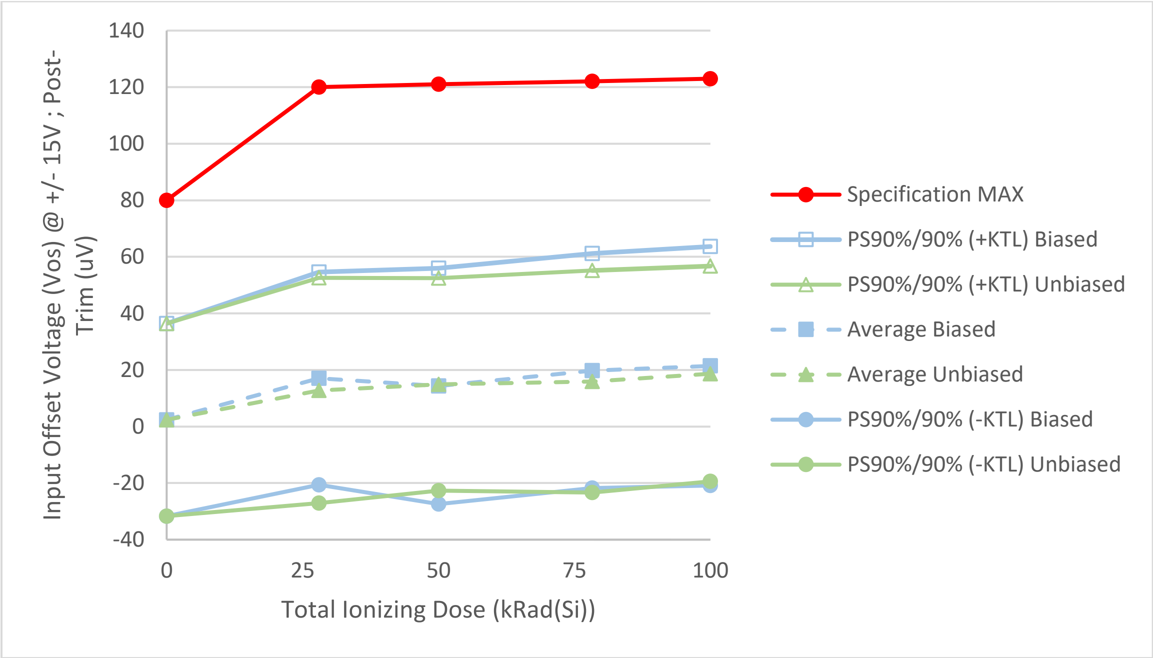

Figure A-1. Input Offset Voltage (Vos) @ +/- 15V vs. TID for the RH1028M irradiated at low dose rate.

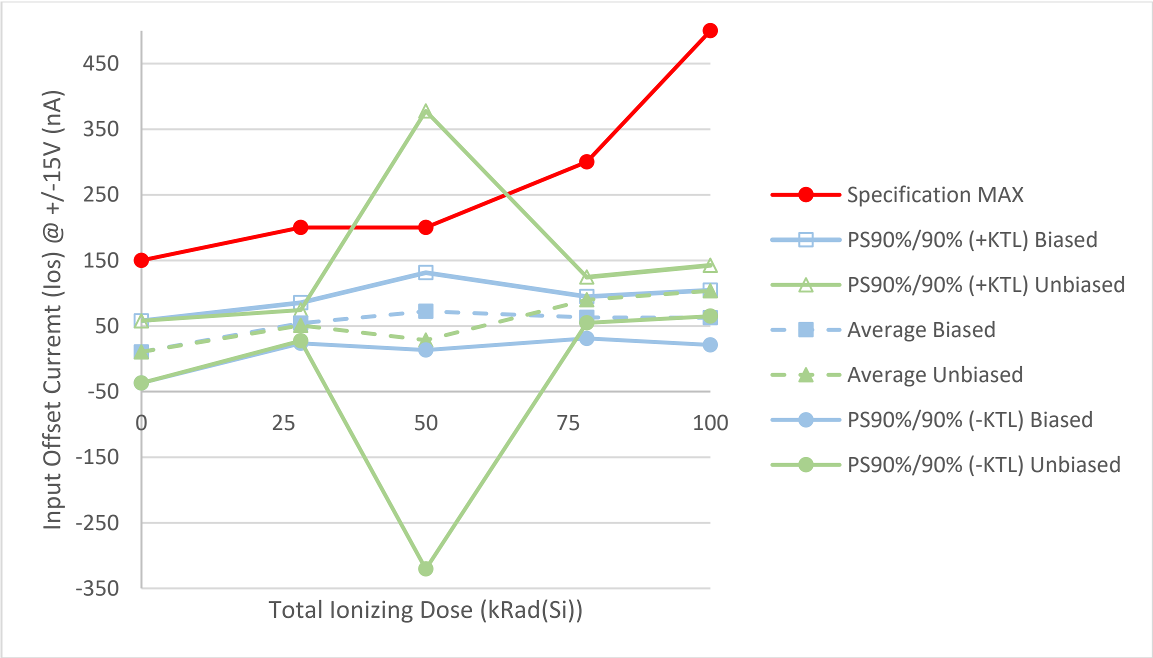

Figure A-2. Input Offset Current with erroneous reading vs. TID for the RH1028M irradiated at low dose rate. Increase in 50 krad(Si) Unbiased KTL values due to single unit tester error. Measurement was not a failed parameter. Corrected chart with anomaly removed in Figure A-3.

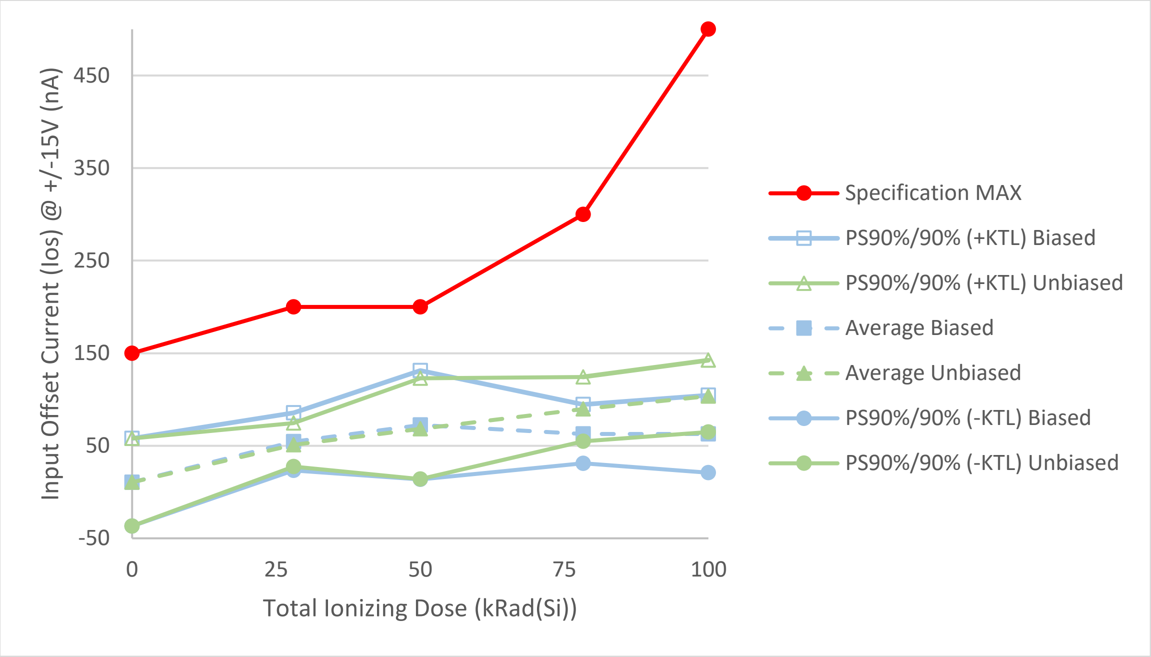

Figure A-3. Input Offset Current without erroneous reading vs. TID for the RH1028M irradiated at low dose rate.

Figure A-4. + Input Bias Current @ +/-15V vs. TID for the RH1028M irradiated at low dose rate.

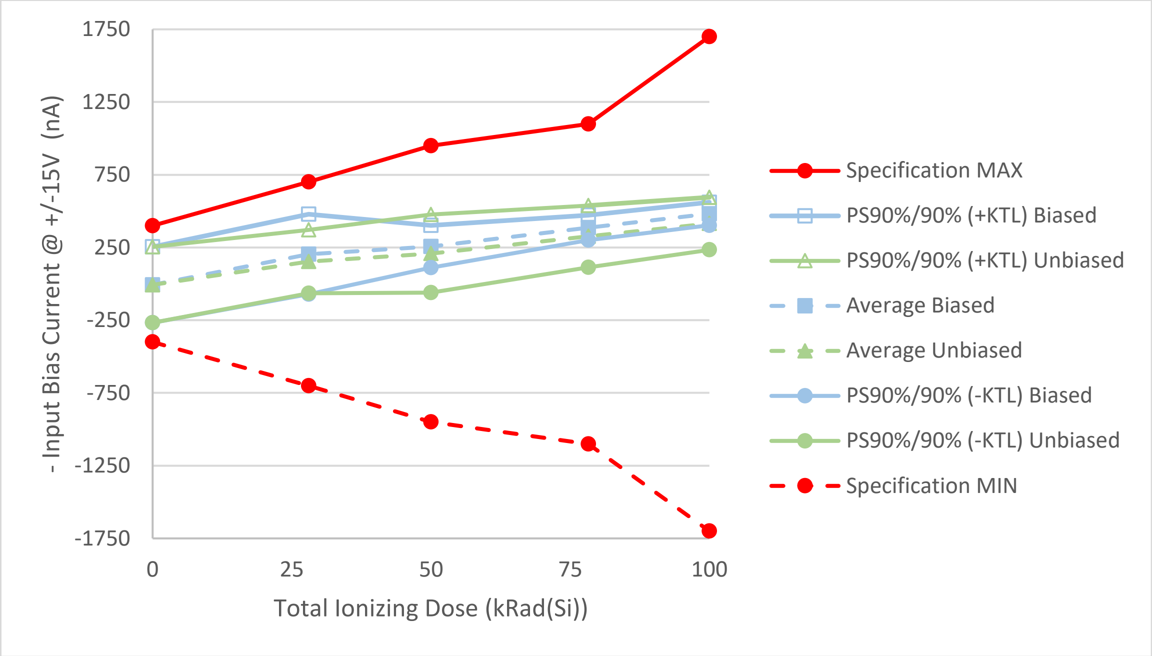

Figure A-5. - Input Bias Current @ +/-15V vs. TID for the RH1028M irradiated at low dose rate.

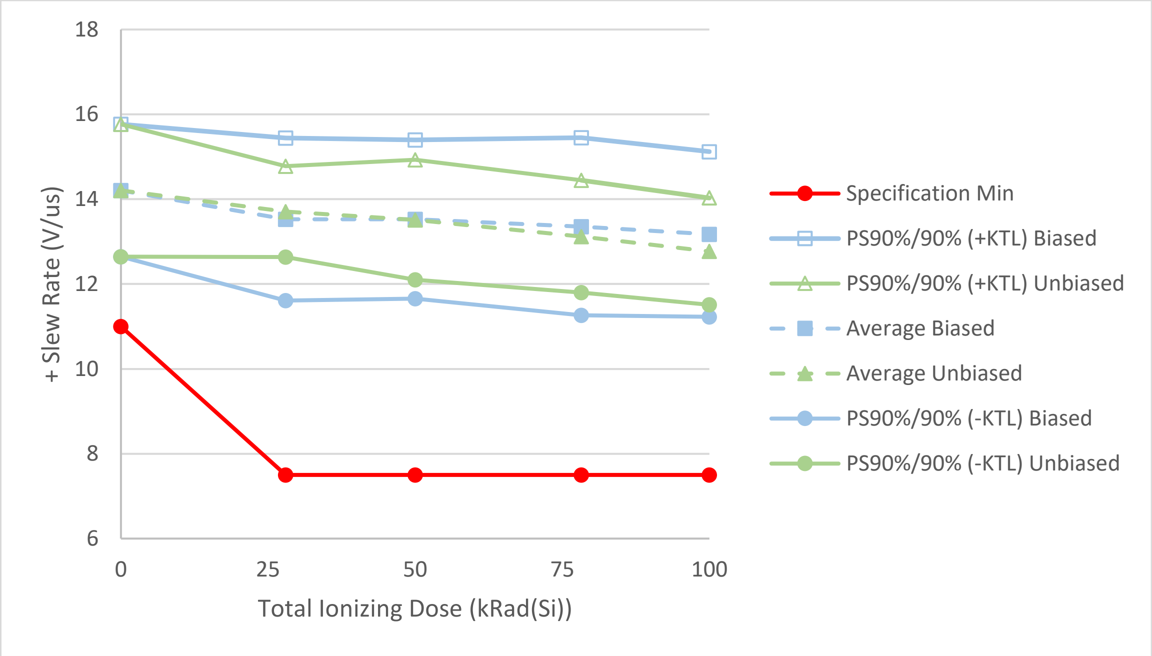

Figure A-6. + Slew Rate vs. TID for the RH1028M irradiated at low dose rate.

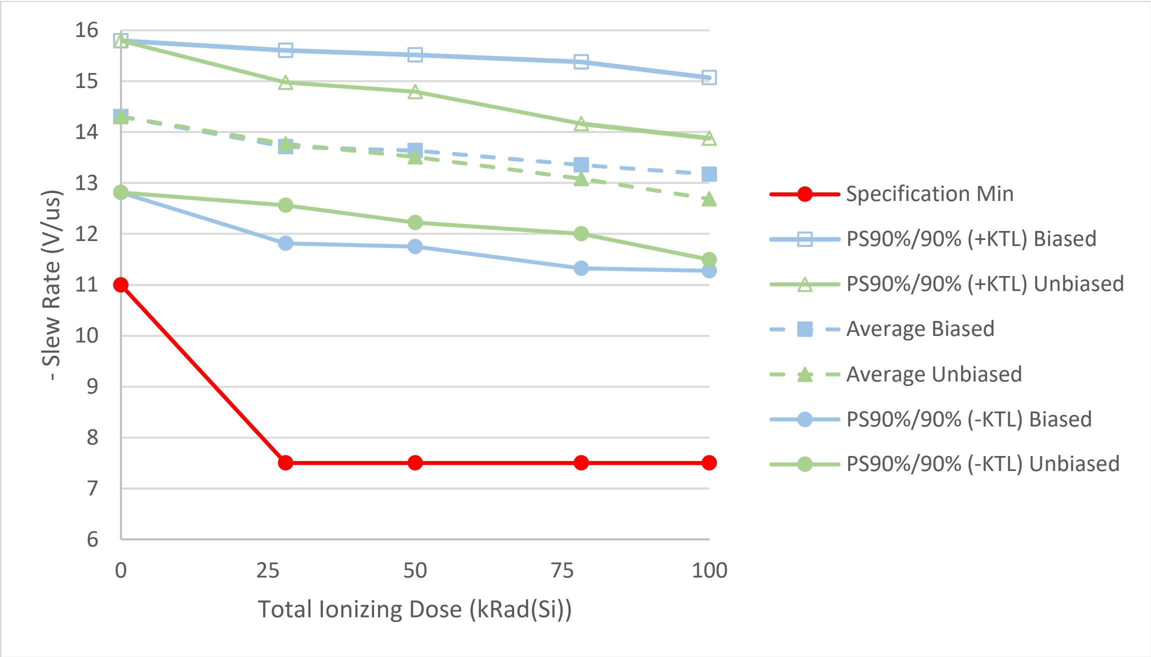

Figure A-7. - Slew Rate vs. TID for the RH1028M irradiated at low dose rate.

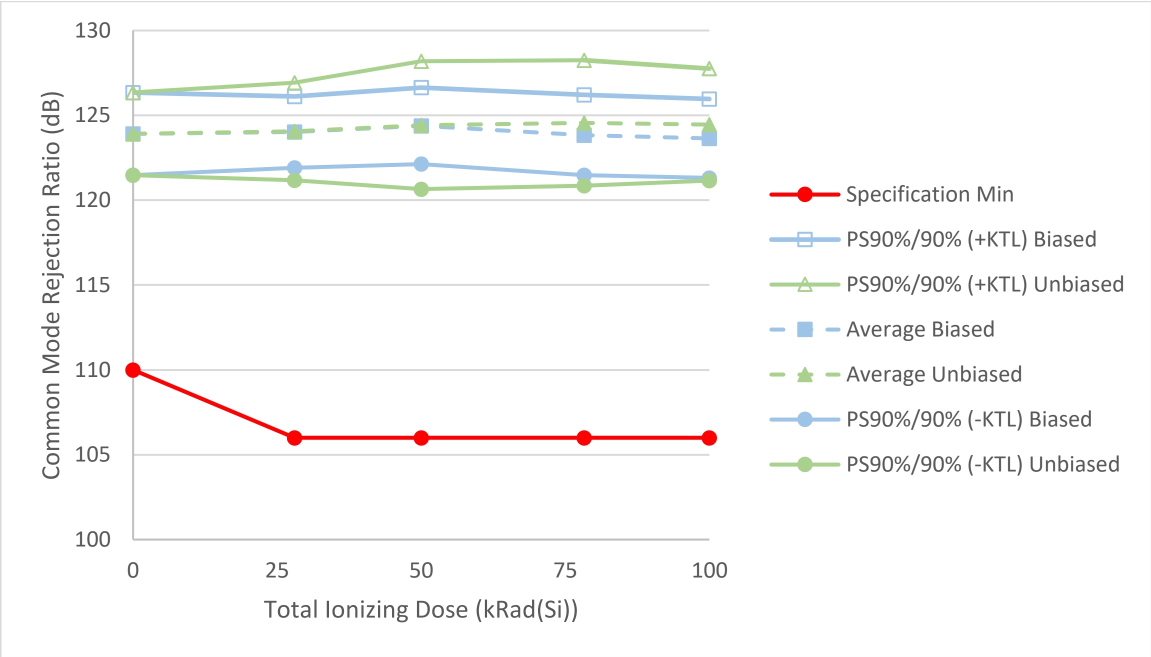

Figure A-8. Common Mode Rejection Ratio vs. TID for the RH1028M irradiated at low dose rate.

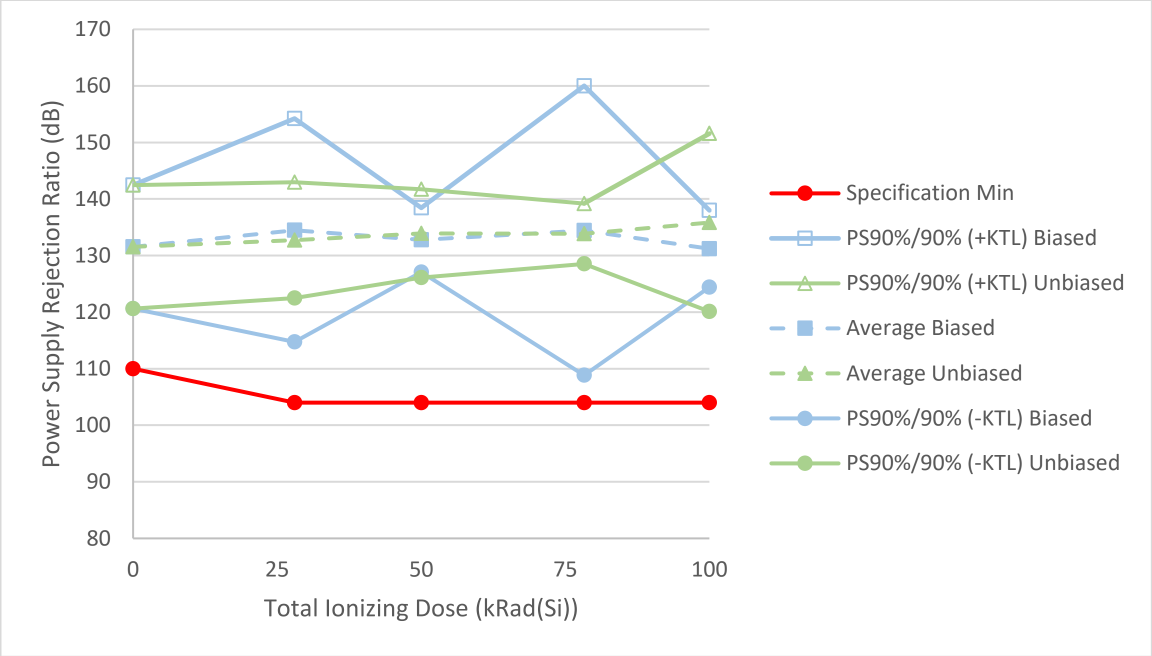

Figure A-9. Power Supply Rejection Ratio vs. TID for the RH1028M irradiated at low dose rate.

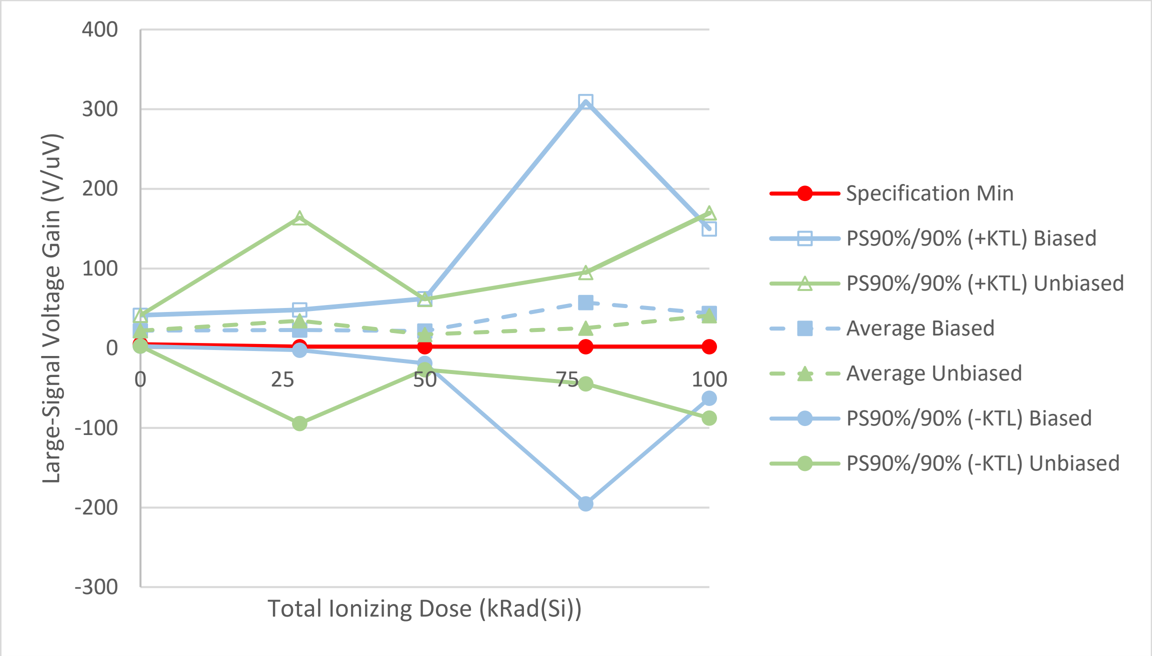

Figure A-10. Large-Signal Voltage Gain vs. TID for the RH1028M irradiated at low dose rate.

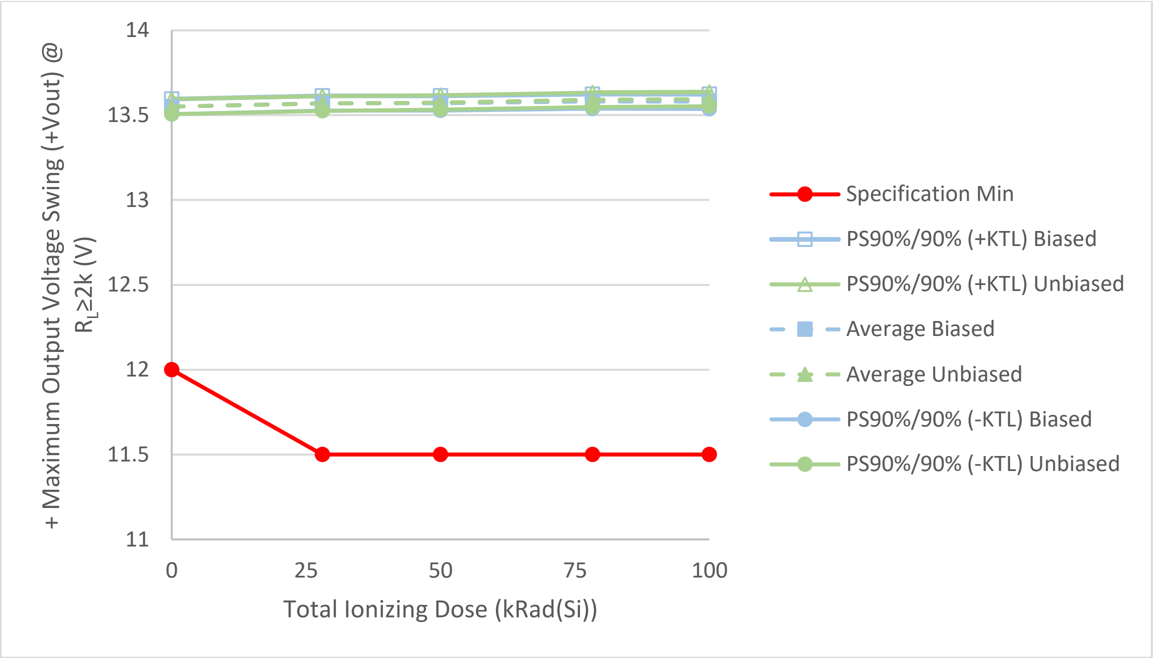

Figure A-11. + Maximum Output Voltage Swing @ R_L>2kΩ vs. TID for the RH1028M irradiated at low dose rate.

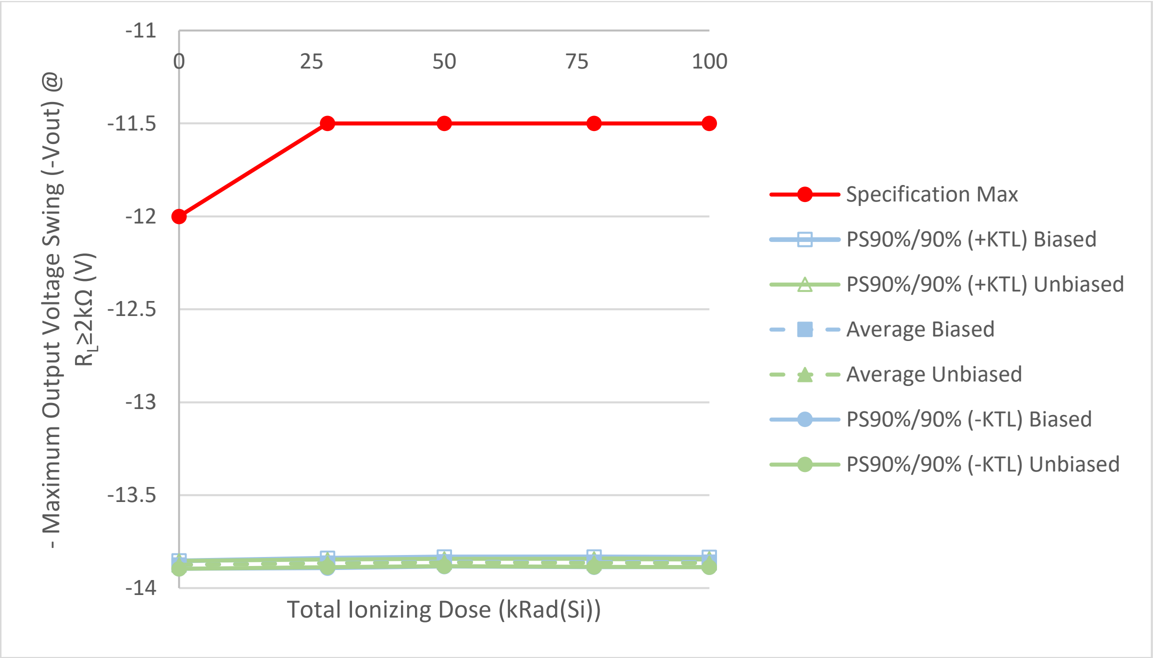

Figure A-12. - Maximum Output Voltage Swing @ R_L≥2kΩ vs. TID for the RH1028M irradiated at low dose rate.

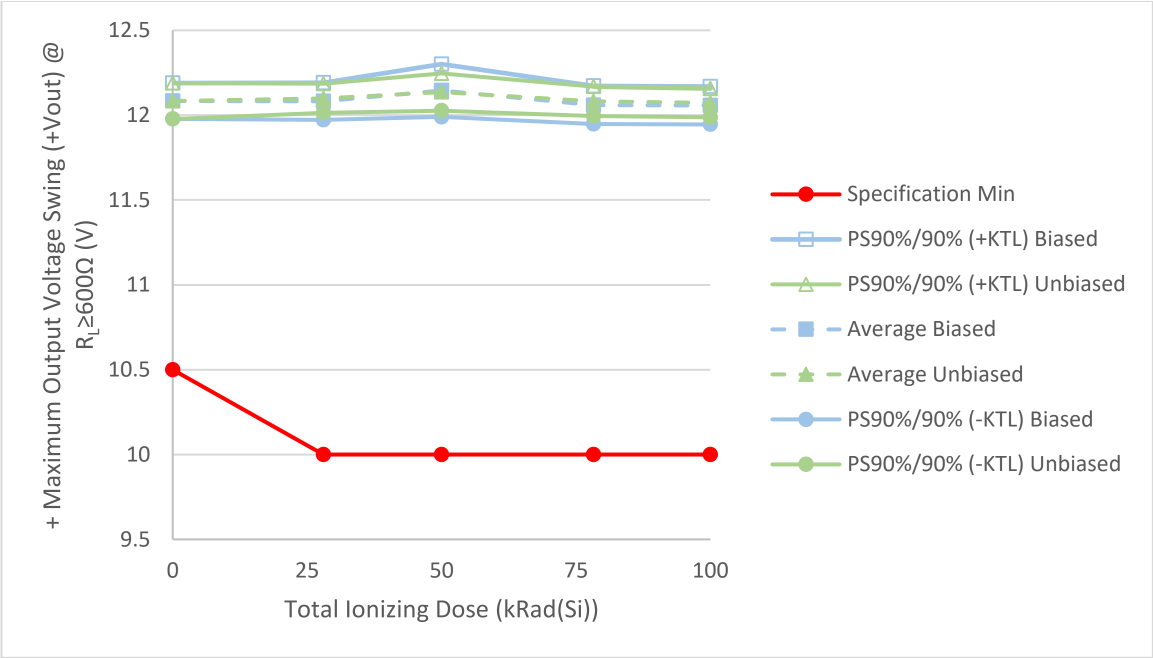

Figure A-13. + Maximum Output Voltage Swing @ R_L≥600Ω vs. TID for the RH1028M irradiated at low dose rate.

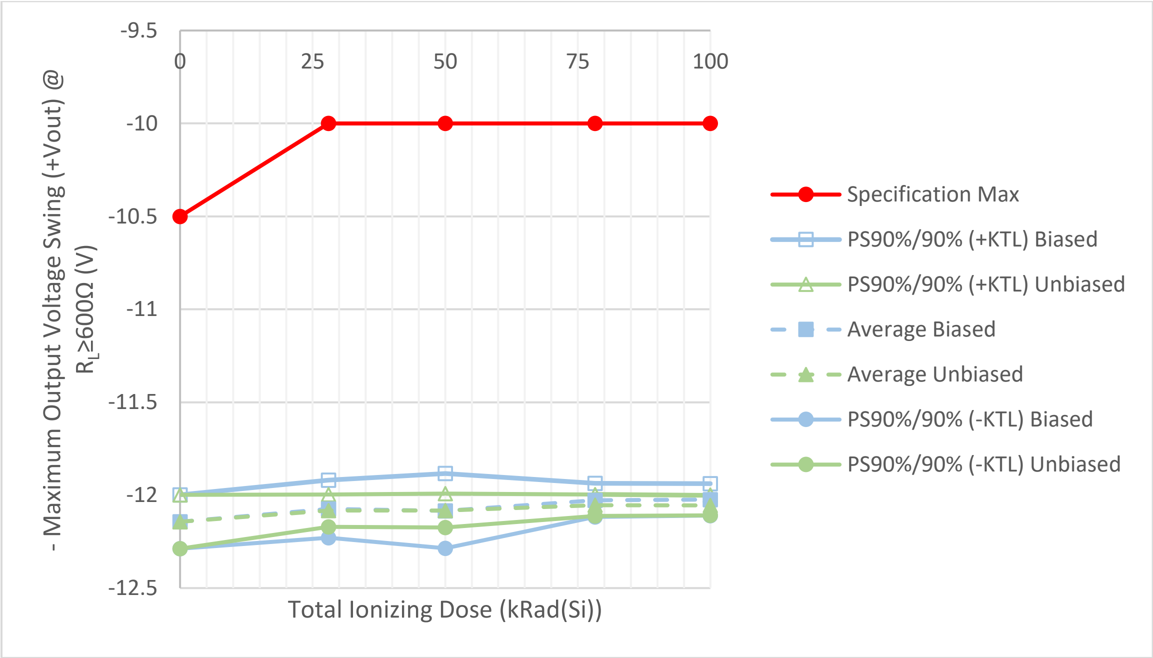

Figure A-14. - Maximum Output Voltage Swing @ R_L≥600Ω vs. TID for the RH1028M irradiated at low dose rate.

Appendix-B

Appendix-B includes the high dose rate irradiation data.

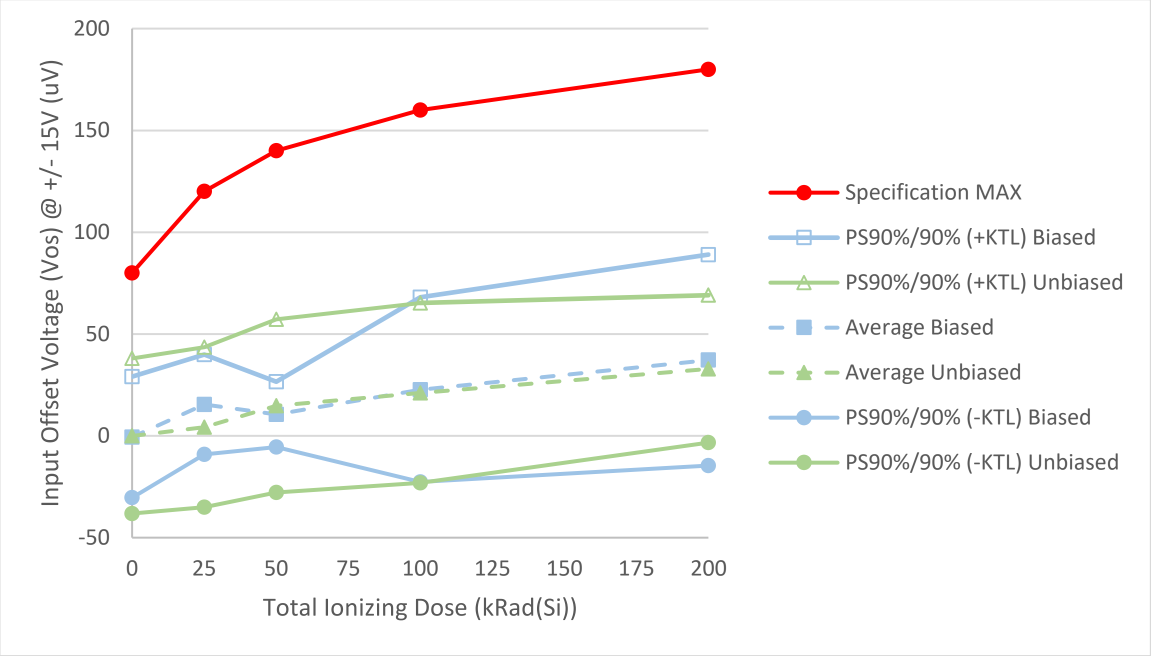

Figure B-1. Input Offset Voltage (Vos) @ +/- 15V vs. TID for the RH1028M irradiated at high dose rate.

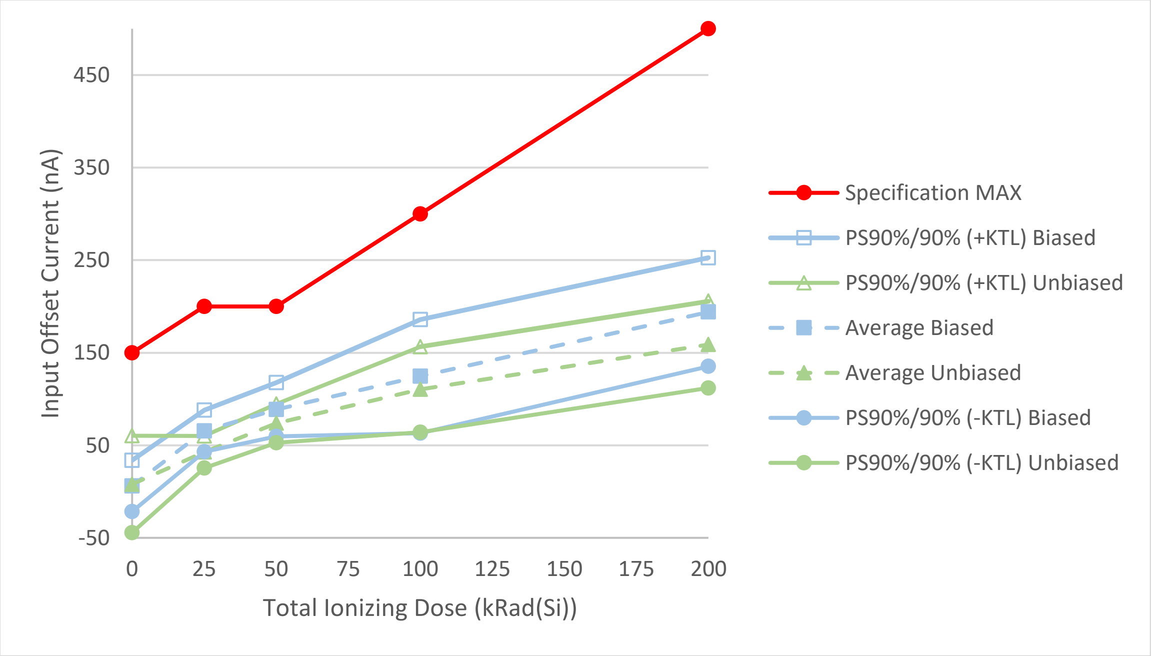

Figure B-2. Input Offset Current vs. TID for the RH1028M irradiated at high dose rate.

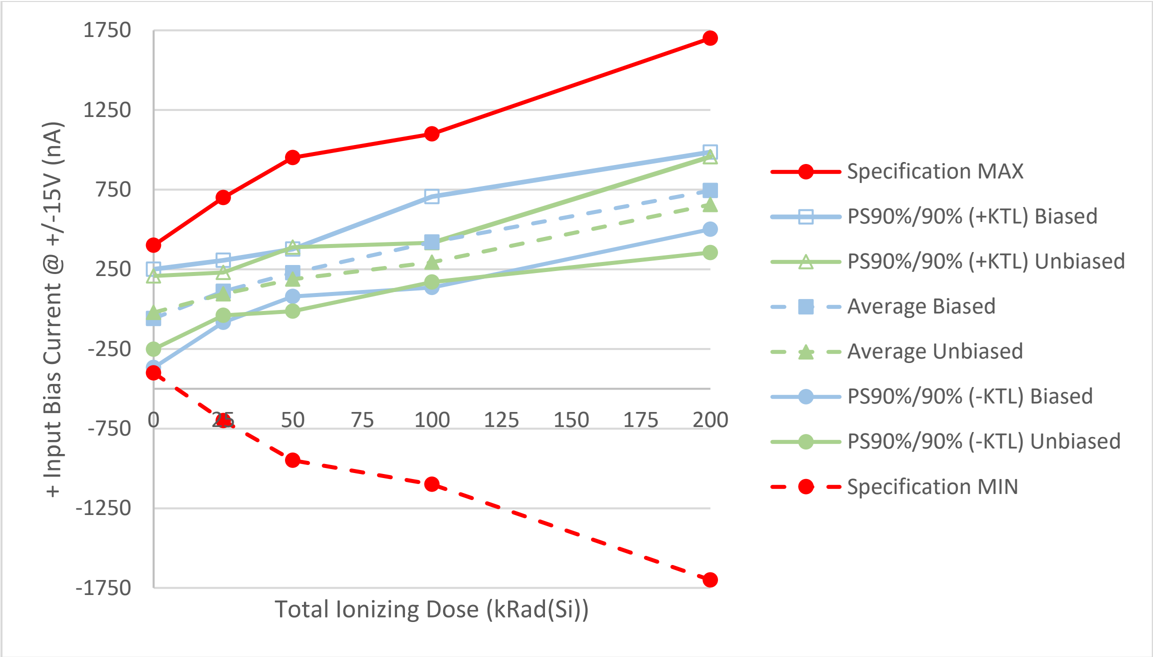

Figure B-3. + Input Bias Current @ +/-15V vs. TID for the RH1028M irradiated at high dose rate.

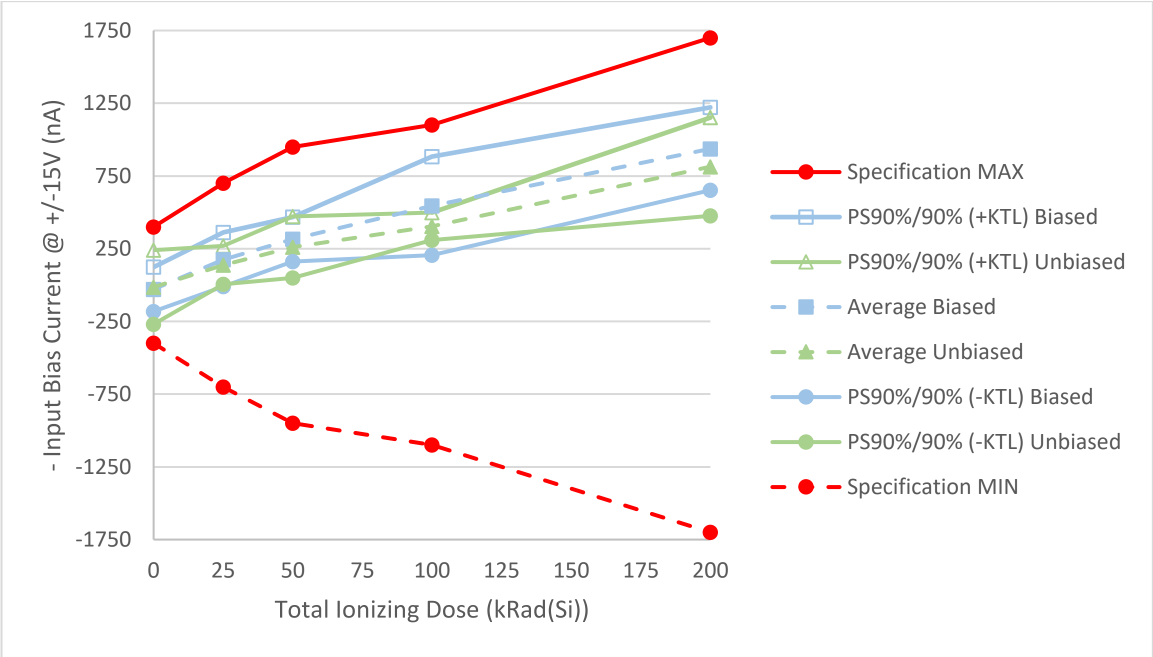

Figure B-4. - Input Bias Current @ +/-15V vs. TID for the RH1028M irradiated at high dose rate.

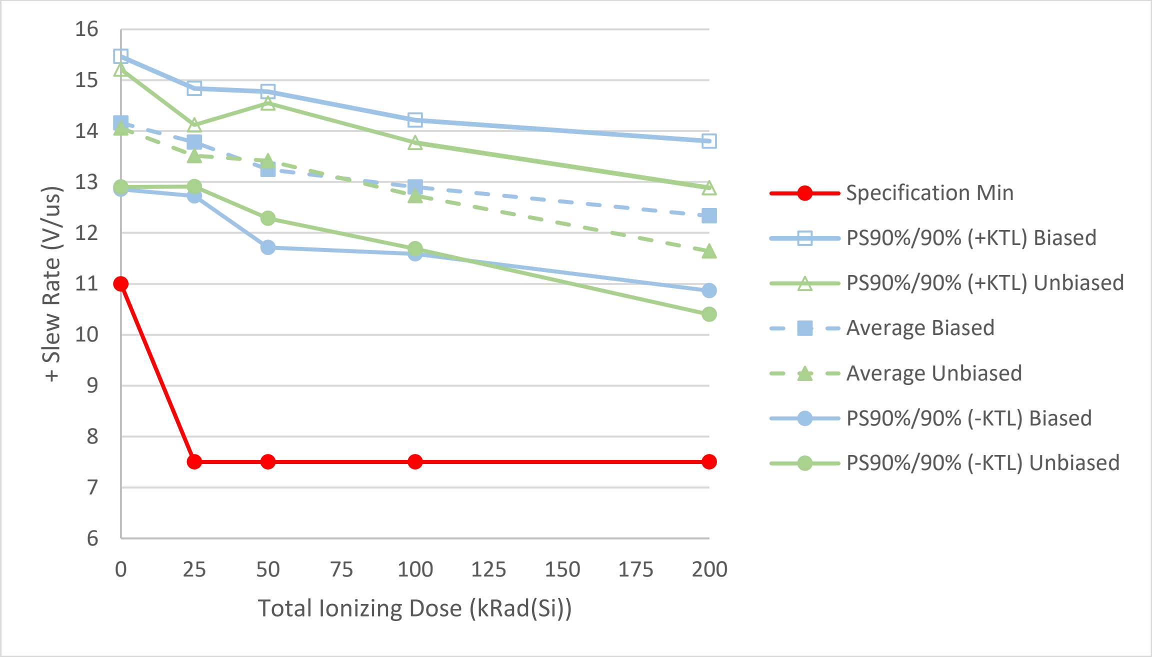

Figure B-5. + Slew Rate vs. TID for the RH1028M irradiated at high dose rate.

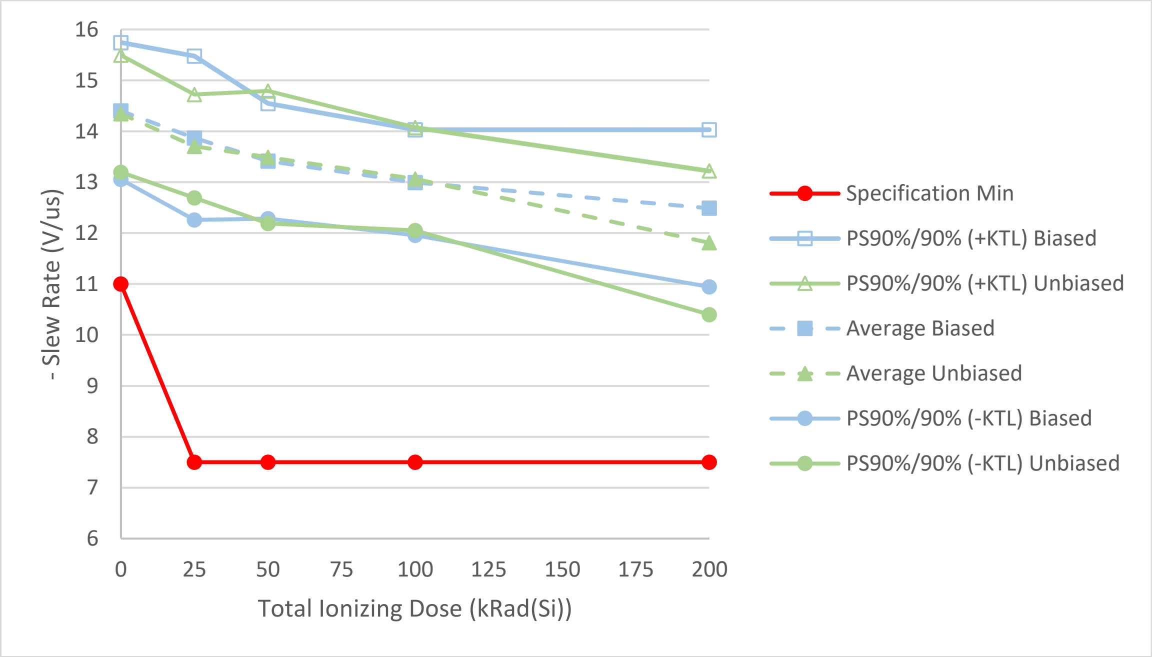

Figure B-6. - Slew Rate vs. TID for the RH1028M irradiated at high dose rate.

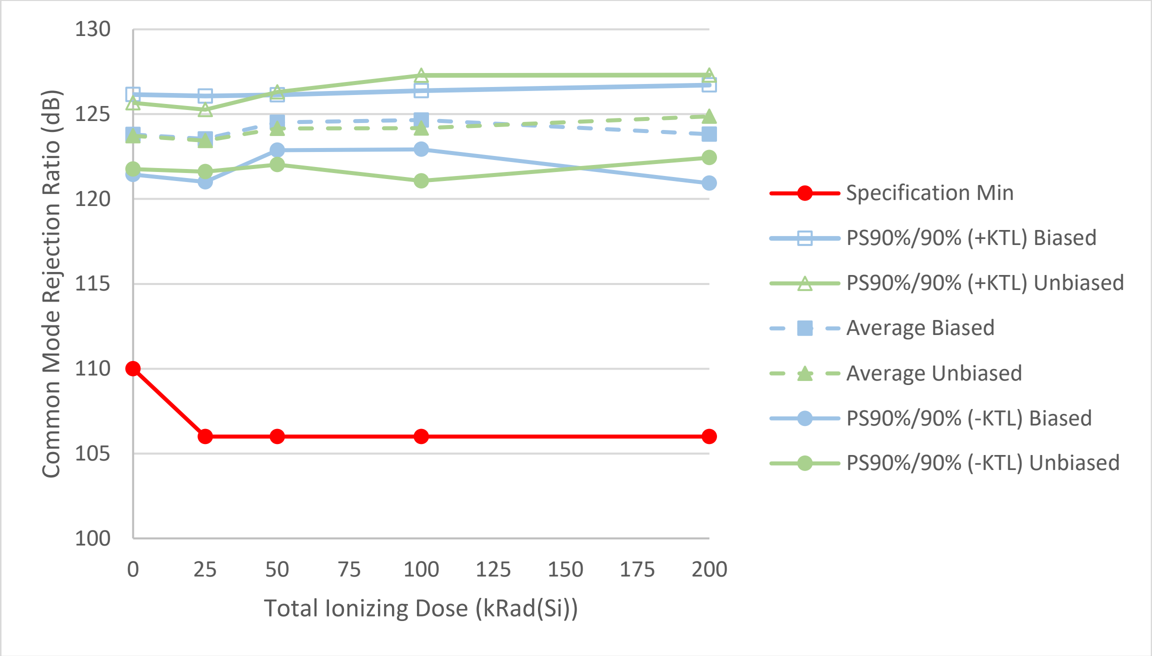

Figure B-7. Common Mode Rejection Ratio vs. TID for the RH1028M irradiated at high dose rate.

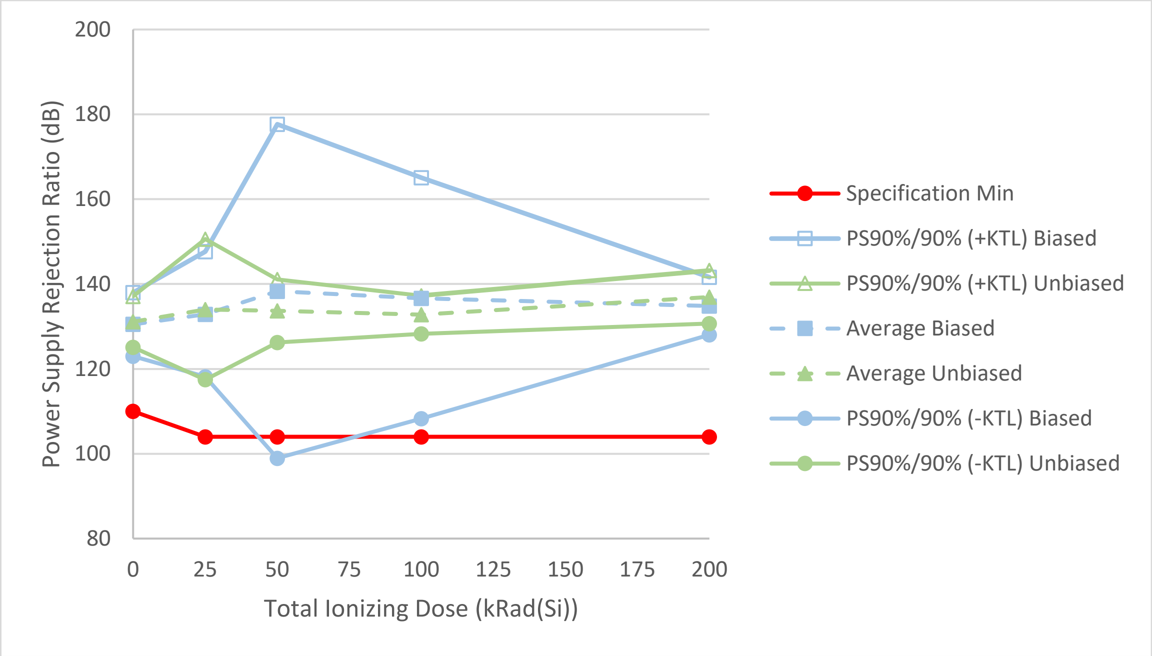

Figure B-8. Power Supply Rejection Ratio vs. TID for the RH1028M irradiated at high dose rate.

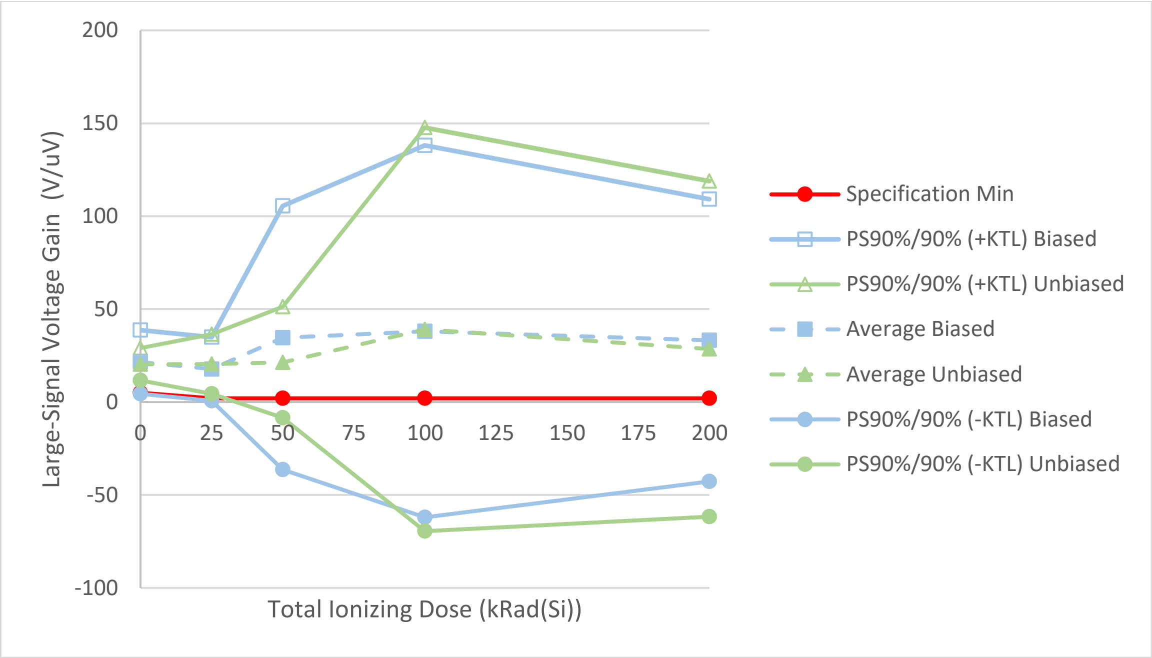

Figure B-9. Large-Signal Voltage Gain vs. TID for the RH1028M irradiated at high dose rate.

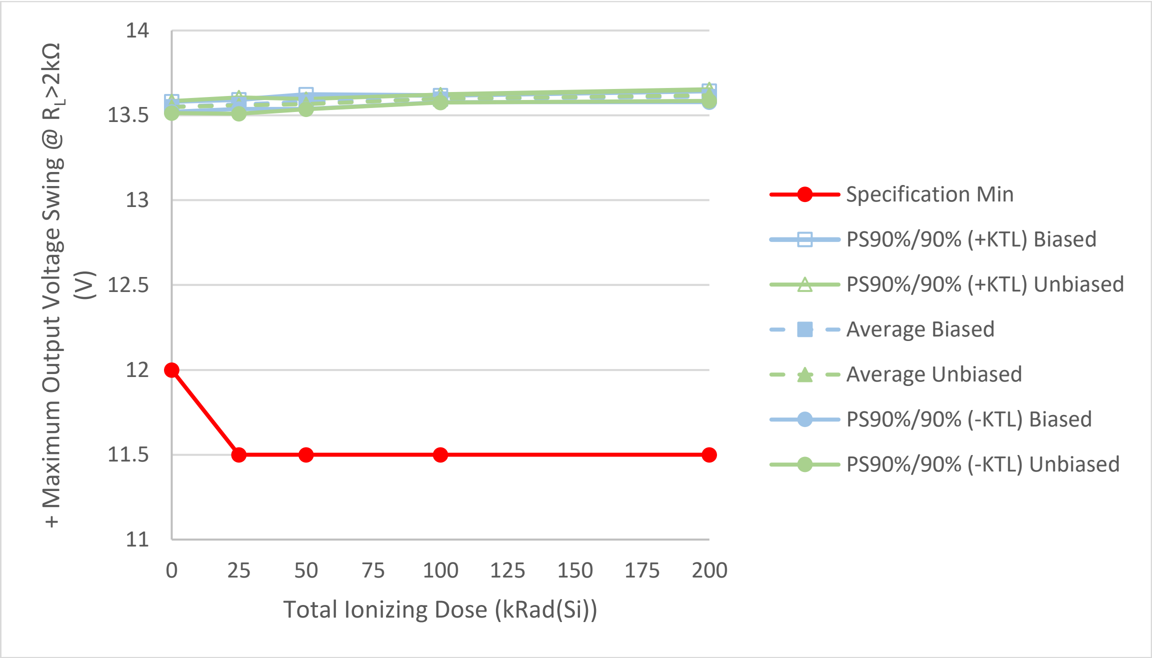

Figure B-10. + Maximum Output Voltage Swing @ R_L>2kΩ vs. TID for the RH1028M irradiated at high dose rate.

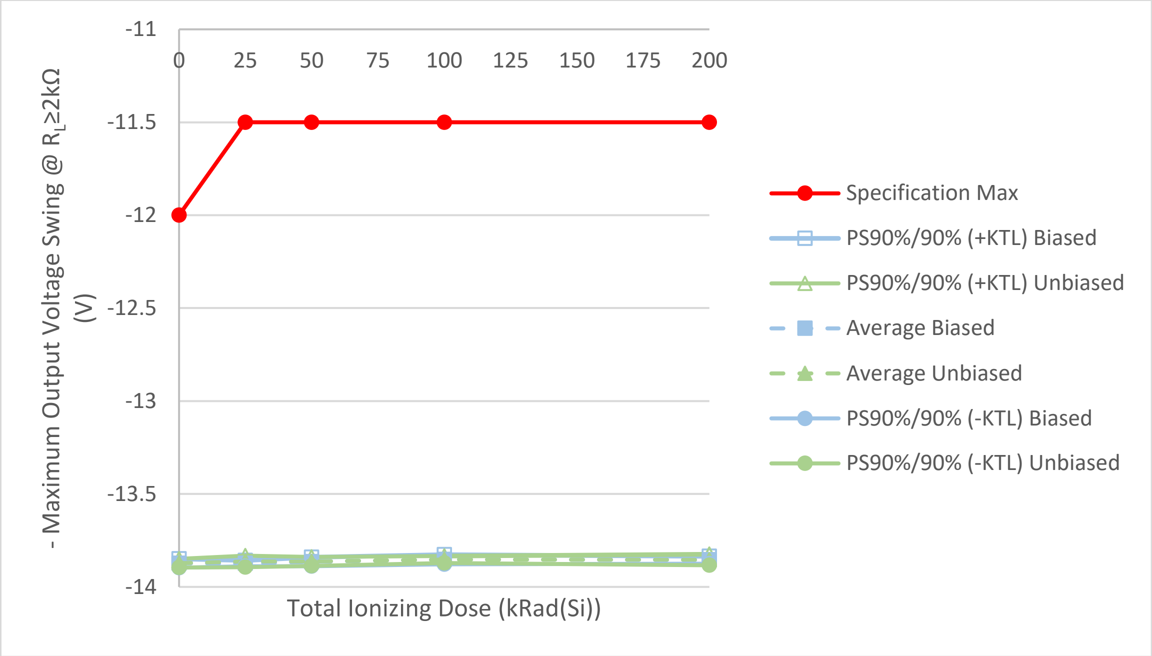

Figure B-11. - Maximum Output Voltage Swing @ R_L≥2kΩ vs. TID for the RH1028M irradiated at high dose rate.

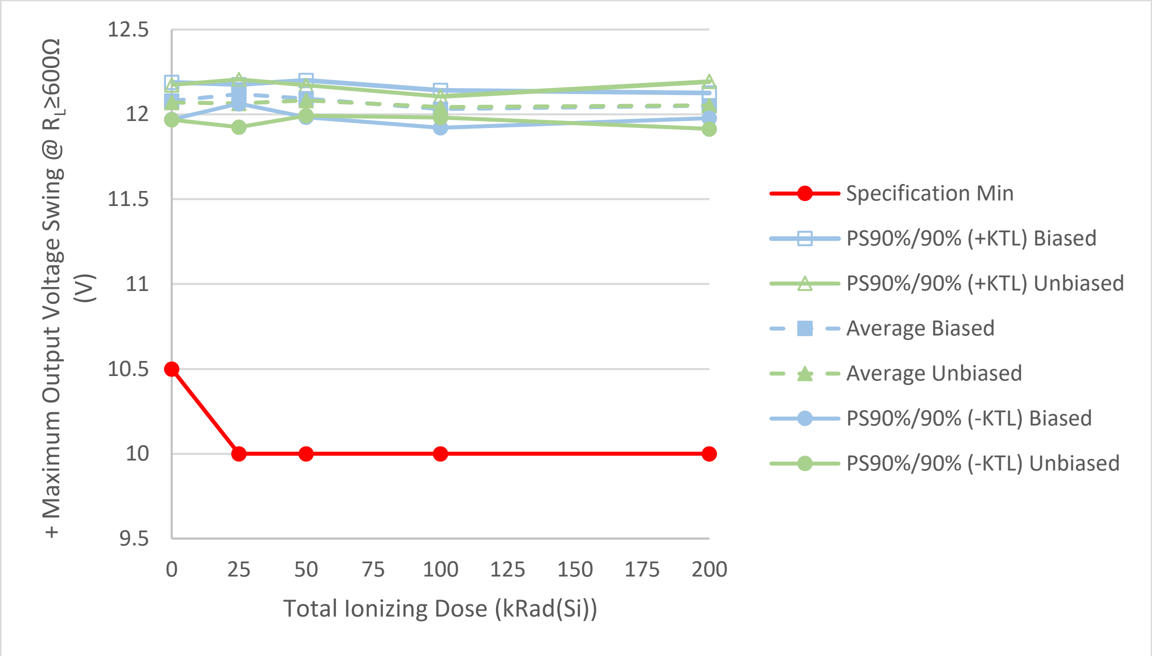

Figure B-12. + Maximum Output Voltage Swing @ R_L≥600Ω vs. TID for the RH1028M irradiated at high dose rate.

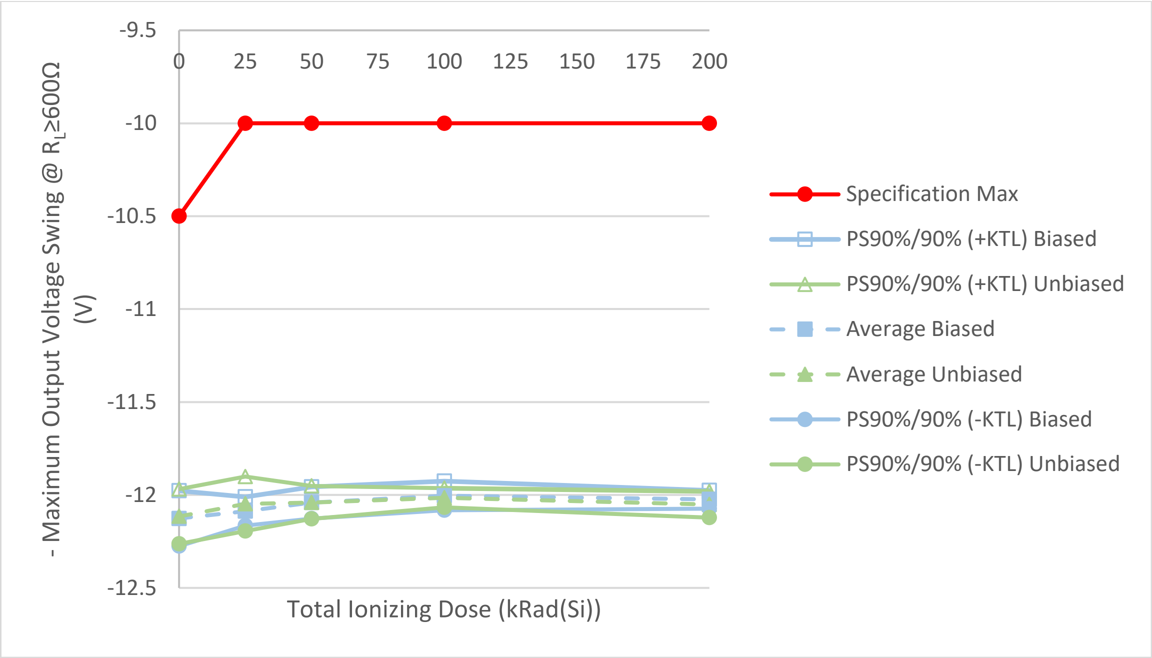

Figure B-13. - Maximum Output Voltage Swing @ R_L≥600Ω vs. TID for the RH1028M irradiated at high dose rate.