

Total Ionization Dose (TID) Test Results of the RH1028MW Ultralow Noise Precision High Speed Operational Amplifiers @ Low Dose Rate (LDR)

LDR = 10 mrads(Si)/s

20 February 2015

Duc Nguyen, Sana Rezgui

Acknowledgements

The authors would like to thank the Signal Conditioning Product Engineering Group from Linear Technology for their help with the board design and assembly as well as the data collection pre- and post-irradiations. Special thanks are also for Thomas Shepherd from Defense Microelectronics Activity (DMEA) for the extensive work for board setup and continuous dosimetry monitoring throughout the ELDRS tests.

TID LDR Test Results of the RH1028MW Ultralow Noise Precision High Speed Operational Amplifiers

Part Type Tested: RH1028MW Ultralow Noise Precision High Speed Operational Amplifier

Traceability Information: Fab Lot # 1117814.1; Wafer # 5; Assembly Lot # 675617.1; Date Code 1228A. See photograph of unit under test in Appendix A.

Quantity of Units: 12 units received, 2 units for control, 5 units for biased irradiation, and 5 units for All GND'd irradiation. Serial numbers 432, 433, and 435-437 had all pins tied to ground during irradiation. Serial numbers 451-455 were biased during irradiation. Serial numbers 438 and 439 were used as control. See Appendix B for the radiation bias connection tables.

Radiation and Electrical Test Increments: Ionizing radiation with the following electrical test increments: 25 Krads(Si), 50 Krads(Si), 78 Krads(Si), 100 Krads(Si).

Radiation dose: 10 mrads(Si)/sec.

Radiation Test Standard: MIL-STD-883 TM1019.9 Condition D.

Test Hardware and Software: LTX pre-irradiation test program EQBRH1028.02; LTX post-irradiation test program EQBRH1028.02; Test Board LT1028.

Facility and Radiation Source: Defense Micro Electronic Activity (DMEA) and Cobalt-60.

Irradiation and Test Temperature: Room temperature controlled to $24^{\circ}\text{C} \pm 6^{\circ}\text{C}$ per MIL-STD-883 and MIL-STD-750.

SUMMARY

ALL 12 PARTS PASSED THE ELECTRICAL TEST LIMITS AS SPECIFIED IN THE DATASHEET AFTER EACH IRRADIATION INCREMENT. ADDITIONAL INFORMATION CAN BE PROVIDED PER REQUEST.

1.0 Overview and Background

Among other radiation effects, Total Ionizing Dose (TID) may affect electrical characteristics, causing parametric and/or functional failures in integrated circuits. During gamma-irradiations, TID-induced and transported electron-hole pairs may result in charge trapping in a transistor's dielectrics and interface regions, affecting the device's basic features. Such effects warrant testing and monitoring of circuits to TID, after which annealing and/or Time Dependent Effects (TDE) may take place, depending on the circuit's design and process technology. Hence the requirement per Condition D (for low-dose rates ranging from less than or equal to 10 mrads(Si)/sec) in TM1019, MIL-STD-883 is to not exceed the allowed time from the end of an incremented irradiation and an electrical test to more than one hour. Additionally, the total time from the end of one incremental irradiation to the start of the next incremental step should be less than two hours.

2.0 Radiation Facility and Test Equipment

The samples were irradiated at Defense Micro-Electronics Activity (DMEA) facility in Sacramento, California. DMEA utilizes J.L. Shepherd model 81-22/484 to provide the dose-rate of 10 mrads(Si)/s. A special design screw-driven automatic cart inside the exposure tunnel positions the Device-Under-Test (DUT) precisely and repeatedly from the source to attain optimal rate verified by ion chamber detectors. See Appendix C for the certificate of dosimetry.

3.0 Test Conditions

The 10 samples were placed in a lead/aluminum container and aligned with the radiation source, Cobalt-60, at DMEA facility in Sacramento, California. During irradiation, five units were biased at +/- 15V, +8V and other five had all pads grounded. The devices were irradiated up to 100 Krad(Si) with increments of 25, 50, 78 Krads(Si). After each irradiation, the samples were transported in dry ice to Linear Technology testing facility. Testing was performed on the two control units to confirm the operation of the test system prior to the electrical testing of the 12 units (10 irradiated and 2 control).

The criteria to pass the low dose-rate test is that five samples irradiated under electrical bias must pass the datasheet limits. If any of the measured parameters of these five units do not meet the required limits then a failure-analysis of the part should be conducted and if valid the lot will be scrapped.

4.0 Tested Parameters

The following parameters were measured pre- and post-irradiations at $V_S = \pm 15V$, $V_{CM} = 0V$ unless otherwise noted:

- Input Offset Voltage V_{OS} (uV)
- Input Offset Current I_{OS} (nA)
- Positive Bias Current $+I_B$ (nA)
- Negative Bias Current $-I_B$ (nA)
- Positive Slew Rate $+SR$ (V/uS)
- Negative Slew Rate $-SR$ (V/uS)
- Common Mode Rejection Ratio CMRR (dB)
- Power Supply Rejection Ratio PSRR (dB)
- Large-Signal Voltage Gain A_{VOL} (V/mV)
- Positive Output Voltage Swing (V) at $R_L = 2K\Omega$
- Negative Output Voltage Swing (V) at $R_L = 2K\Omega$
- Positive Output Voltage Swing (V) at $R_L = 600\Omega$
- Negative Output Voltage Swing (V) at $R_L = 600\Omega$

Appendix D details the test conditions, minimum and maximum values at different accumulated doses.

5.0 Test Results

All ten samples passed the post-irradiation electrical tests. All measurements of the thirteen listed parameters in section 4.0 are within the specification limits.

The used statistics in this report are based on the tolerance limits, which are bounds to gage the quality of the manufactured products. It assumes that if the quality of the items is normally distributed with known mean and known standard deviation, the two-sided tolerance limits can be calculated as follows:

$$+K_{TL} = \text{mean} + (K_{TL}) (\text{standard deviation})$$

$$-K_{TL} = \text{mean} - (K_{TL}) (\text{standard deviation})$$

Where $+K_{TL}$ is the upper tolerance limit and $-K_{TL}$ is the lower tolerance limit. These tolerance limits are defined in a table of inverse normal probability distribution.

However, in most cases, mean and standard deviation are unknown and therefore it is practical to estimate both of them from a sample. Hence the tolerance limit depends greatly on the sample size. The $Ps90\%/90\%$ K_{TL} factor for a lot quality P of 0.9, confidence C of 0.9 with a sample size of 5, can be found from the tabulated table (MIL-HDBK-814, page 94, table IX-B). The K_{TL} factor in this report is 2.742.

In the plots, the dotted lines with diamond markers are the average of the measured data points of five samples irradiated under electrical bias while the dashed lines with X-markers are the average of measured data points of five units irradiated with all pins tied to ground. The solid lines with triangle markers are the average of the data points after the calculation of the K_{TL} statistics on the sample irradiated in the biased setup. The solid lines with square symbols are the average of the measured points after the application of the K_{TL} statistics on the five samples irradiated with all pins grounded. The orange solid lines with circle markers are the specification limits.

The 25 Krads(Si) test limits are using Linear Technology datasheet 20 Krads(Si) specification limits.

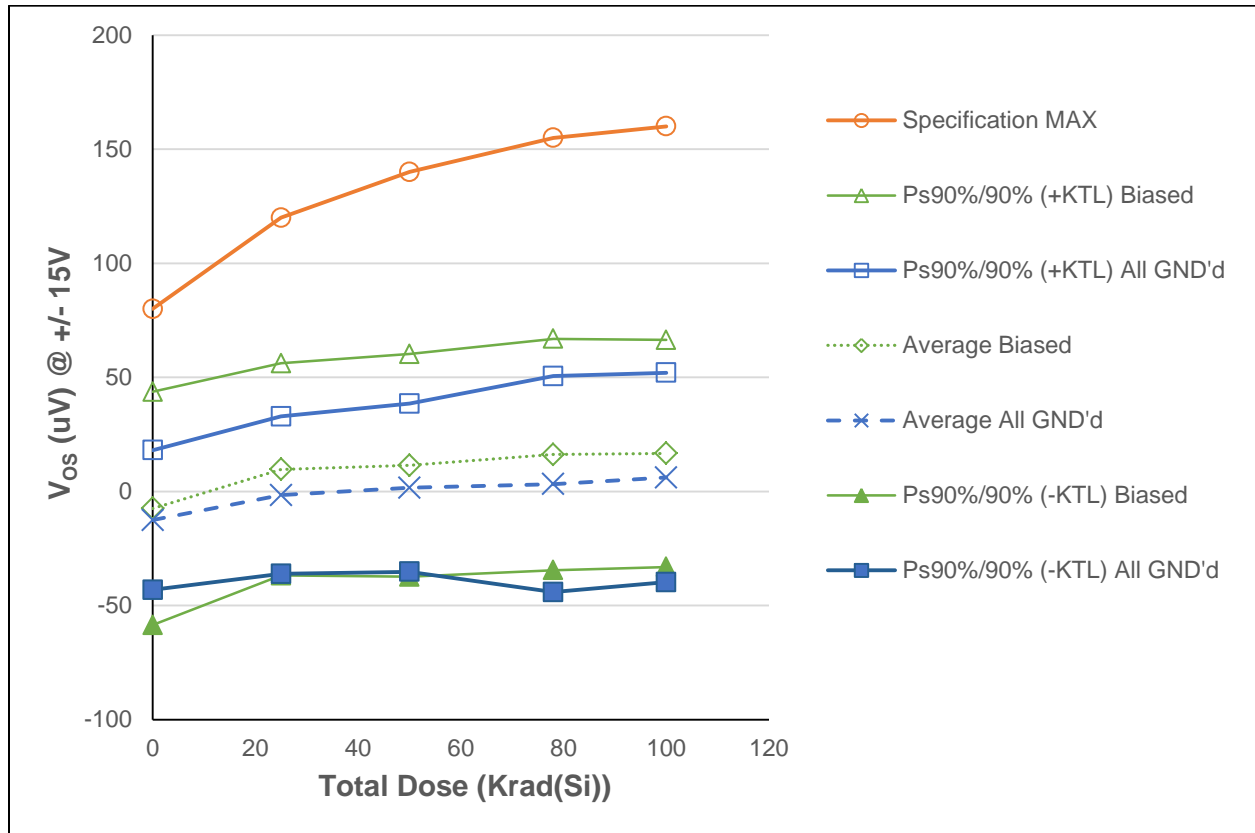


Figure 5.1 Plot of Input Voltage Offset V_{OS} versus Total Dose

All ten samples passed the post-irradiation input voltage offset test.

Table 5.1: Raw data for input voltage offset versus total dose including the statistical calculations, maximum specification, and the status of the test (PASS/FAIL) under the orange headers)

Parameter	V _{OS} @ +/- 15V	Total Dose (Krad(Si)) @ 10 mrads(Si)/second				
Units	(uV)	0	25	50	78	100
432	All GND'd Irradiation	-27.29	-14.80	-11.70	-12.50	-9.79
433	All GND'd Irradiation	-4.59	7.43	14.10	15.10	15.70
435	All GND'd Irradiation	-6.62	5.40	5.52	8.02	9.44
436	All GND'd Irradiation	-21.67	-15.80	-13.50	-17.10	-11.90
437	All GND'd Irradiation	-2.60	9.64	13.70	22.40	27.10
451	Biased-Irradiation	10.17	23.80	26.90	33.70	34.50
452	Biased-Irradiation	-13.62	2.93	1.63	9.74	8.10
453	Biased-Irradiation	-33.04	-14.20	-12.00	-10.10	-8.29
454	Biased-Irradiation	11.57	27.90	30.90	34.10	34.00
455	Biased-Irradiation	-12.46	7.86	9.64	13.40	14.90
438	Control Unit	-24.01	-18.50	-18.20	-19.00	-17.70
439	Control Unit	13.63	20.10	18.40	17.80	17.30
All GND'd Irradiation Statistics						
	Average All GND'd	-12.55	-1.63	1.62	3.18	6.11
	Std Dev All GND'd	11.16	12.58	13.44	17.26	16.74
	Ps90%/90% (+KTL) All GND'd	18.04	32.86	38.49	50.52	52.01
	Ps90%/90% (-KTL) All GND'd	-43.15	-36.11	-35.24	-44.15	-39.79
Biased-Irradiation Statistics						
	Average Biased	-7.48	9.66	11.41	16.17	16.64
	Std Dev Biased	18.64	16.96	17.79	18.49	18.15
	Ps90%/90% (+KTL) Biased	43.64	56.16	60.21	66.87	66.41
	Ps90%/90% (-KTL) Biased	-58.59	-36.84	-37.38	-34.54	-33.13
	Specifications MIN					
	Status (Measurements) All GND'd					
	Status (Measurements) Biased					
	Specification MAX	80	120	140		160
	Status (Measurements) All GND'd	PASS	PASS	PASS		PASS
	Status (Measurements) Biased	PASS	PASS	PASS		PASS
	Status (-KTL) All GND'd					
	Status (+KTL) All GND'd	PASS	PASS	PASS		PASS
	Status (-KTL) Biased					
	Status (+KTL) Biased	PASS	PASS	PASS		PASS

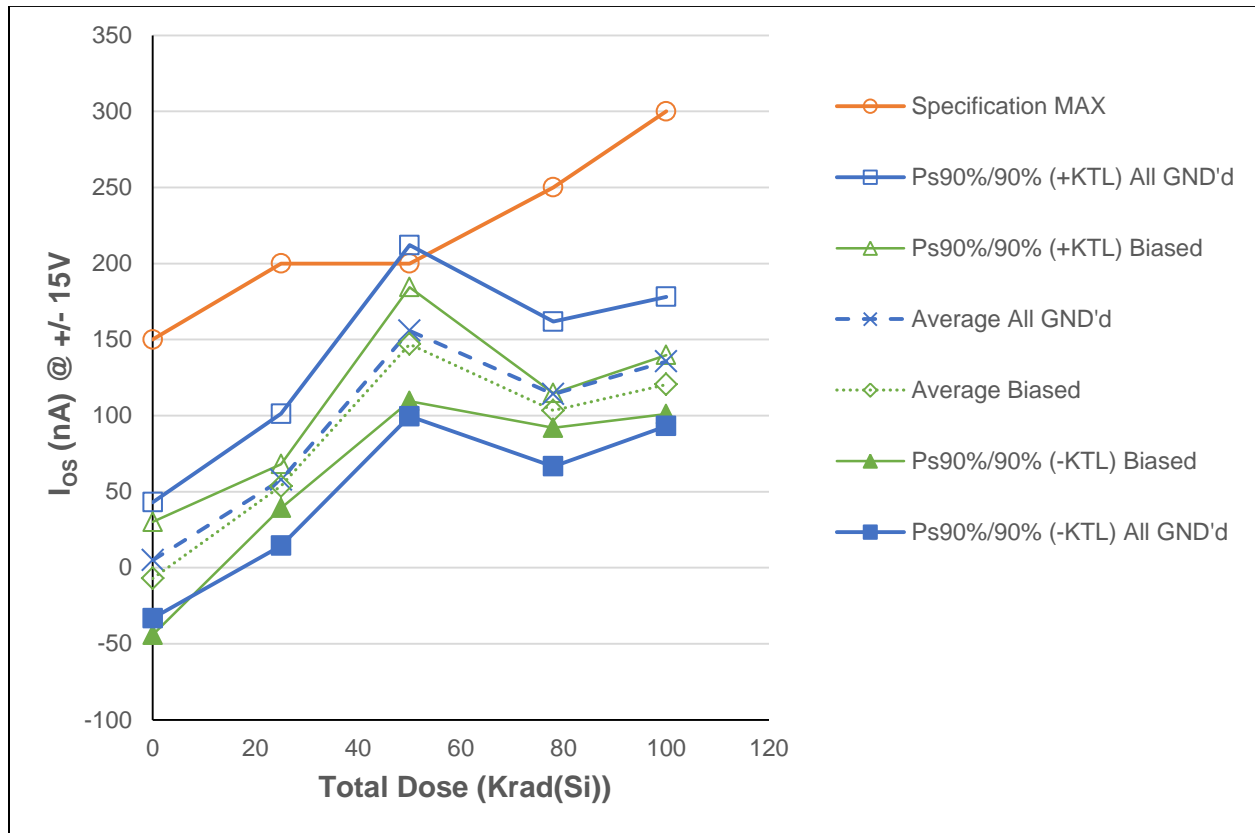


Figure 5.2: Plot of Input Offset Current I_{OS} versus Total Dose

The measured values of 10 samples are under datasheet maximum values. Note the +KTL Biased of All GND'd average is higher than the maximum limit at 50 Krads(Si), due to the small 5-piece sample size.

Table 5.2: Raw data for input offset current versus total dose including the statistical calculations, maximum specification, and the status of the test (PASS/FAIL under the second orange header)

Parameter	I_{OS} @ +/- 15V	Total Dose (Krad(Si)) @ 10 mrads(Si)/second				
Units	(nA)	0	25	50	78	100
432	All GND'd Irradiation	23.44	79.10	180.00	136.00	154.00
433	All GND'd Irradiation	13.92	68.10	168.00	129.00	151.00
435	All GND'd Irradiation	-1.83	49.10	157.00	103.00	124.00
436	All GND'd Irradiation	-12.08	39.20	126.00	95.90	123.00
437	All GND'd Irradiation	1.10	53.50	148.00	107.00	126.00
451	Biased-Irradiation	12.82	53.50	129.00	106.00	128.00
452	Biased-Irradiation	-25.27	45.10	149.00	96.70	110.00
453	Biased-Irradiation	-6.96	55.70	138.00	102.00	119.00
454	Biased-Irradiation	-6.23	54.60	163.00	107.00	126.00
455	Biased-Irradiation	-9.52	59.30	156.00	105.00	119.00
438	Control Unit	9.52	9.16	44.90	11.00	9.15
439	Control Unit	17.21	18.70	73.80	19.50	17.90
All GND'd Irradiation Statistics						
	Average All GND'd	4.91	57.80	155.80	114.18	135.60
	Std Dev All GND'd	13.90	15.81	20.52	17.37	15.50
	Ps90%/90% (+KTL) All GND'd	43.03	101.15	212.07	161.80	178.11
	Ps90%/90% (-KTL) All GND'd	-33.21	14.45	99.53	66.56	93.09
Biased-Irradiation Statistics						
	Average Biased	-7.03	53.64	147.00	103.34	120.40
	Std Dev Biased	13.54	5.25	13.66	4.16	7.09
	Ps90%/90% (+KTL) Biased	30.10	68.03	184.45	114.74	139.85
	Ps90%/90% (-KTL) Biased	-44.16	39.25	109.55	91.94	100.95
	Specification MIN					
	Status (Measurements) All GND'd					
	Status (Measurements) Biased					
	Specification MAX	150	200	200		300
	Status (Measurements) All GND'd	PASS	PASS	PASS		PASS
	Status (Measurements) Biased	PASS	PASS	PASS		PASS
	Status (-KTL) All GND'd					
	Status (+KTL) All GND'd	PASS	PASS	FAIL		PASS
	Status (-KTL) Biased					
	Status (+KTL) Biased	PASS	PASS	PASS		PASS

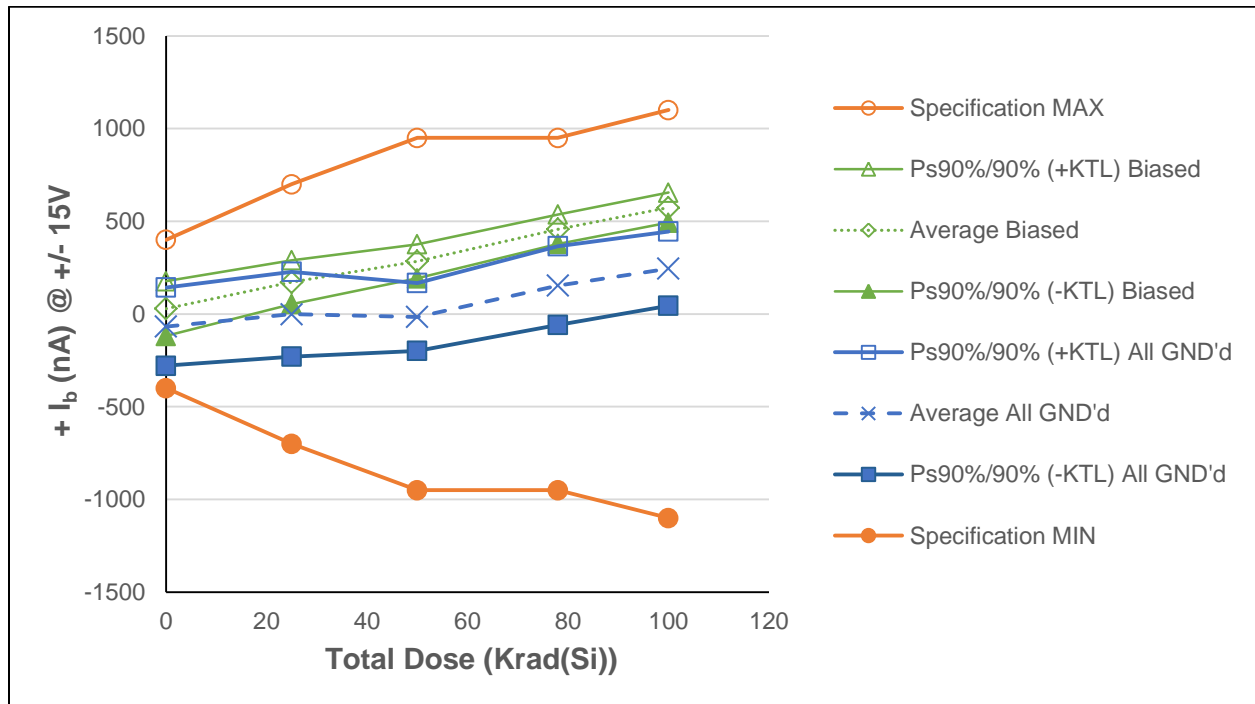


Figure 5.3: Plot of Positive Bias Current $+I_B$ versus Total Dose

All measured data points are within the datasheet specification limits.

Table 5.3: Raw data for positive bias current versus total dose including the statistical calculations, minimum specification, maximum specification, and the status of the test (PASS/FAIL).

Parameter	Positive I_b @ +/- 15V	Total Dose (Krad(Si)) @ 10 mrads(Si)/second				
Units	(nA)	0	25	50	78	100
432	All GND'd Irradiation	-18.87	49.70	13.50	194.00	272.00
433	All GND'd Irradiation	-199.32	-141.00	-132.00	31.80	139.00
435	All GND'd Irradiation	-6.23	73.30	36.10	238.00	339.00
436	All GND'd Irradiation	-55.14	13.20	6.57	166.00	251.00
437	All GND'd Irradiation	-58.62	0.55	-2.19	137.00	223.00
451	Biased-Irradiation	-58.62	183.00	252.00	439.00	551.00
452	Biased-Irradiation	23.08	113.00	263.00	419.00	536.00
453	Biased-Irradiation	37.56	232.00	314.00	481.00	588.00
454	Biased-Irradiation	78.77	172.00	327.00	489.00	609.00
455	Biased-Irradiation	65.95	158.00	267.00	459.00	585.00
438	Control Unit	108.09	45.10	33.00	110.00	105.00
439	Control Unit	-74.93	-81.40	-131.00	-27.40	-83.50
All GND'd Irradiation Statistics						
	Average All GND'd	-67.64	-0.85	-15.60	153.36	244.80
	Std Dev All GND'd	77.02	83.51	66.60	77.49	73.01
	Ps90%/90% (+KTL) All GND'd	143.54	228.13	167.00	365.84	444.99
	Ps90%/90% (-KTL) All GND'd	-278.82	-229.83	-198.21	-59.12	44.61
Biased-Irradiation Statistics						
	Average Biased	29.35	171.60	284.60	457.40	573.80
	Std Dev Biased	53.92	43.00	33.55	29.03	29.64
	Ps90%/90% (+KTL) Biased	177.19	289.52	376.58	537.00	655.08
	Ps90%/90% (-KTL) Biased	-118.49	53.68	192.62	377.80	492.52
	Specification MIN	-400	-700	-950		-1100
	Status (Measurements) All GND'd	PASS	PASS	PASS		PASS
	Status (Measurements) Biased	PASS	PASS	PASS		PASS
	Specification MAX	400	700	950		1100
	Status (Measurements) All GND'd	PASS	PASS	PASS		PASS
	Status (Measurements) Biased	PASS	PASS	PASS		PASS
	Status (-KTL) All GND'd	PASS	PASS	PASS		PASS
	Status (+KTL) All GND'd	PASS	PASS	PASS		PASS
	Status (-KTL) Biased	PASS	PASS	PASS		PASS
	Status (+KTL) Biased	PASS	PASS	PASS		PASS

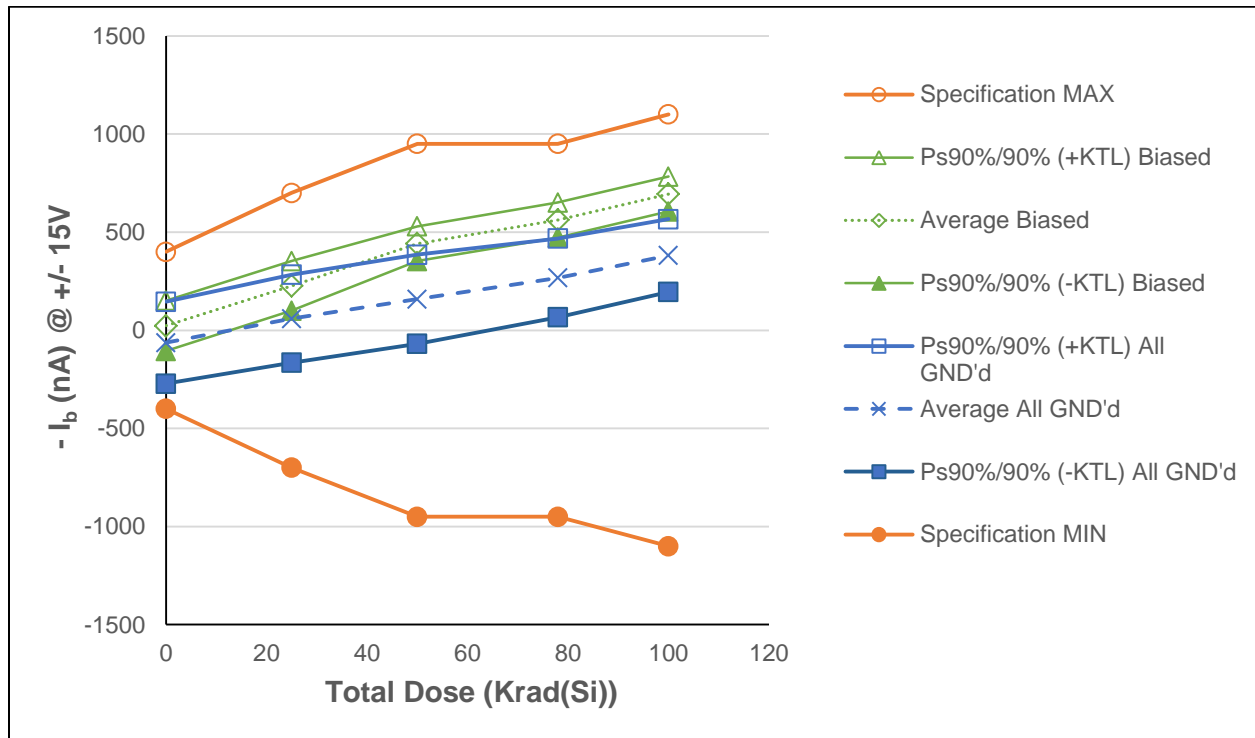


Figure 5.4: Plot of Negative Bias Current $-I_b$ versus Total Dose

All measured data points are within datasheet specification limits.

Table 5.4: Raw data for negative input bias current versus total dose including the statistical calculations, minimum specification, maximum specification, and the status of the test (PASS/FAIL).

Parameter	Negative I_B +/- 15V	Total Dose (Krad(Si)) @ 10 mrads(Si)/second				
Units	(nA)	0	25	50	78	100
432	All GND'd Irradiation	4.58	131.00	229.00	326.00	427.00
433	All GND'd Irradiation	-187.59	-71.80	29.40	159.00	291.00
435	All GND'd Irradiation	-7.69	126.00	233.00	343.00	465.00
436	All GND'd Irradiation	-65.95	56.10	153.00	263.00	372.00
437	All GND'd Irradiation	-59.17	54.20	147.00	245.00	350.00
451	Biased-Irradiation	-42.50	235.00	422.00	545.00	679.00
452	Biased-Irradiation	-3.30	159.00	397.00	516.00	648.00
453	Biased-Irradiation	30.23	288.00	464.00	585.00	708.00
454	Biased-Irradiation	73.28	232.00	477.00	598.00	734.00
455	Biased-Irradiation	57.34	218.00	447.00	566.00	703.00
438	Control Unit	117.25	120.00	113.00	121.00	114.00
439	Control Unit	-58.44	-58.60	-70.10	-55.90	-64.50
All GND'd Irradiation Statistics						
	Average All GND'd	-63.17	59.10	158.28	267.20	381.00
	Std Dev All GND'd	76.11	81.87	82.69	73.18	67.66
	Ps90%/90% (+KTL) All GND'd	145.53	283.60	385.01	467.86	566.54
	Ps90%/90% (-KTL) All GND'd	-271.87	-165.40	-68.45	66.54	195.46
Biased-Irradiation Statistics						
	Average Biased	23.01	226.40	441.40	562.00	694.40
	Std Dev Biased	46.75	46.13	32.24	32.58	32.47
	Ps90%/90% (+KTL) Biased	151.19	352.90	529.80	651.34	783.43
	Ps90%/90% (-KTL) Biased	-105.17	99.90	353.00	472.66	605.37
	Specification MIN	-400	-700	-950		-1100
	Status (Measurements) All GND'd	PASS	PASS	PASS		PASS
	Status (Measurements) Biased	PASS	PASS	PASS		PASS
	Specification MAX	400	700	950		1100
	Status (Measurements) All GND'd	PASS	PASS	PASS		PASS
	Status (Measurements) Biased	PASS	PASS	PASS		PASS
	Status (-KTL) All GND'd	PASS	PASS	PASS		PASS
	Status (+KTL) All GND'd	PASS	PASS	PASS		PASS
	Status (-KTL) Biased	PASS	PASS	PASS		PASS
	Status (+KTL) Biased	PASS	PASS	PASS		PASS

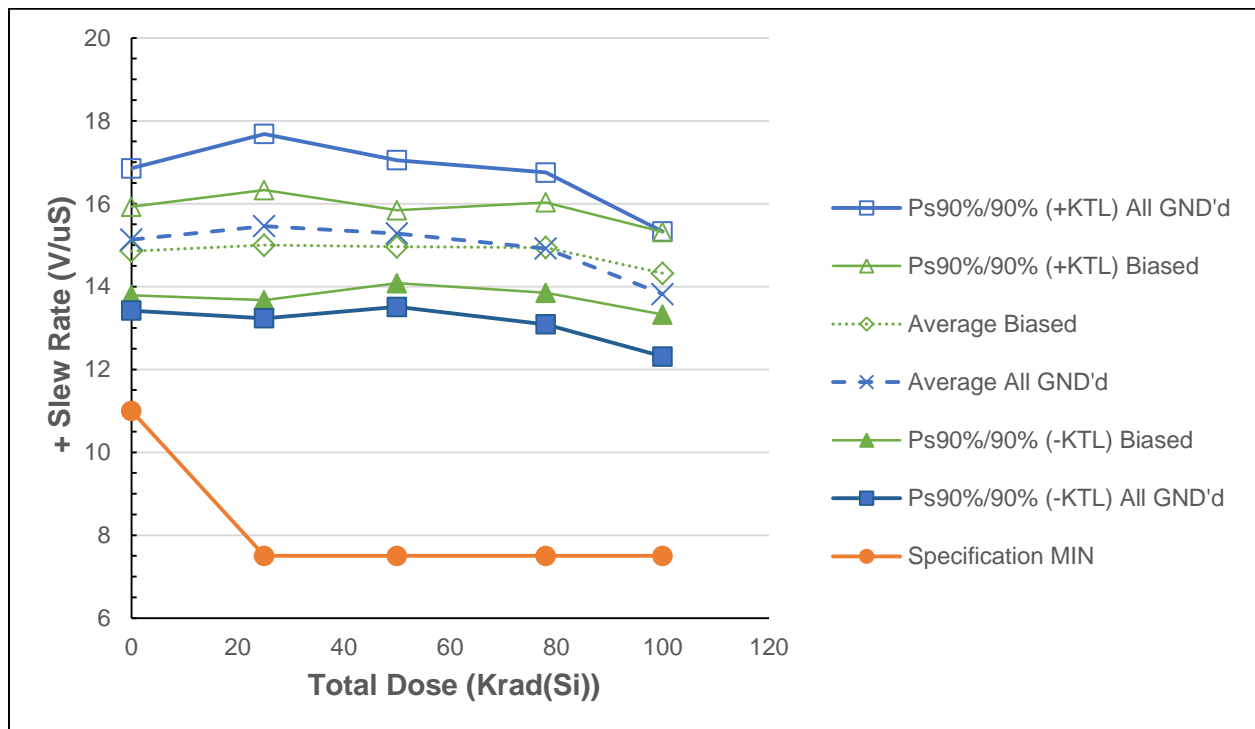


Figure 5.5: Plot of Positive Slew Rate versus Total Dose

The measured parameters are over the specification minimum limits.

Table 5.5: Raw data for positive slew rate versus total dose including the statistical calculations, minimum specification, and the status of the test (PASS/FAIL)

Parameter	Positive Slew Rate	Total Dose (Krad(Si)) @ 10 mrads(Si)/second				
Units	(V/us)	0	25	50	78	100
432	All GND'd Irradiation	15.72	16.20	16.00	15.50	14.40
433	All GND'd Irradiation	14.59	14.60	14.60	14.20	13.10
435	All GND'd Irradiation	15.72	16.20	15.70	15.50	14.20
436	All GND'd Irradiation	15.25	15.70	15.50	15.20	14.00
437	All GND'd Irradiation	14.39	14.60	14.60	14.20	13.40
451	Biased-Irradiation	14.39	14.40	14.60	14.60	14.00
452	Biased-Irradiation	14.59	14.80	14.80	14.80	14.00
453	Biased-Irradiation	15.25	15.50	15.30	15.50	14.80
454	Biased-Irradiation	15.25	15.50	15.30	15.20	14.60
455	Biased-Irradiation	14.81	14.80	14.80	14.60	14.20
438	Control Unit	15.03	15.50	15.70	15.70	14.60
439	Control Unit	15.48	16.20	16.20	16.20	15.30
All GND'd Irradiation Statistics						
	Average All GND'd	15.14	15.46	15.28	14.92	13.82
	Std Dev All GND'd	0.63	0.81	0.65	0.67	0.55
	Ps90%/90% (+KTL) All GND'd	16.85	17.68	17.05	16.75	15.33
	Ps90%/90% (-KTL) All GND'd	13.42	13.24	13.51	13.09	12.31
Biased-Irradiation Statistics						
	Average Biased	14.86	15.00	14.96	14.94	14.32
	Std Dev Biased	0.39	0.48	0.32	0.40	0.36
	Ps90%/90% (+KTL) Biased	15.92	16.33	15.84	16.03	15.32
	Ps90%/90% (-KTL) Biased	13.79	13.67	14.08	13.85	13.32
	Specification MIN	11.0	7.5	7.5		7.5
	Status (Measurements) All GND'd	PASS	PASS	PASS		PASS
	Status (Measurements) Biased	PASS	PASS	PASS		PASS
	Specification MAX					
	Status (Measurements) All GND'd					
	Status (Measurements) Biased					
	Status (-KTL) All GND'd	PASS	PASS	PASS		PASS
	Status (+KTL) All GND'd					
	Status (-KTL) Biased	PASS	PASS	PASS		PASS
	Status (+KTL) Biased					

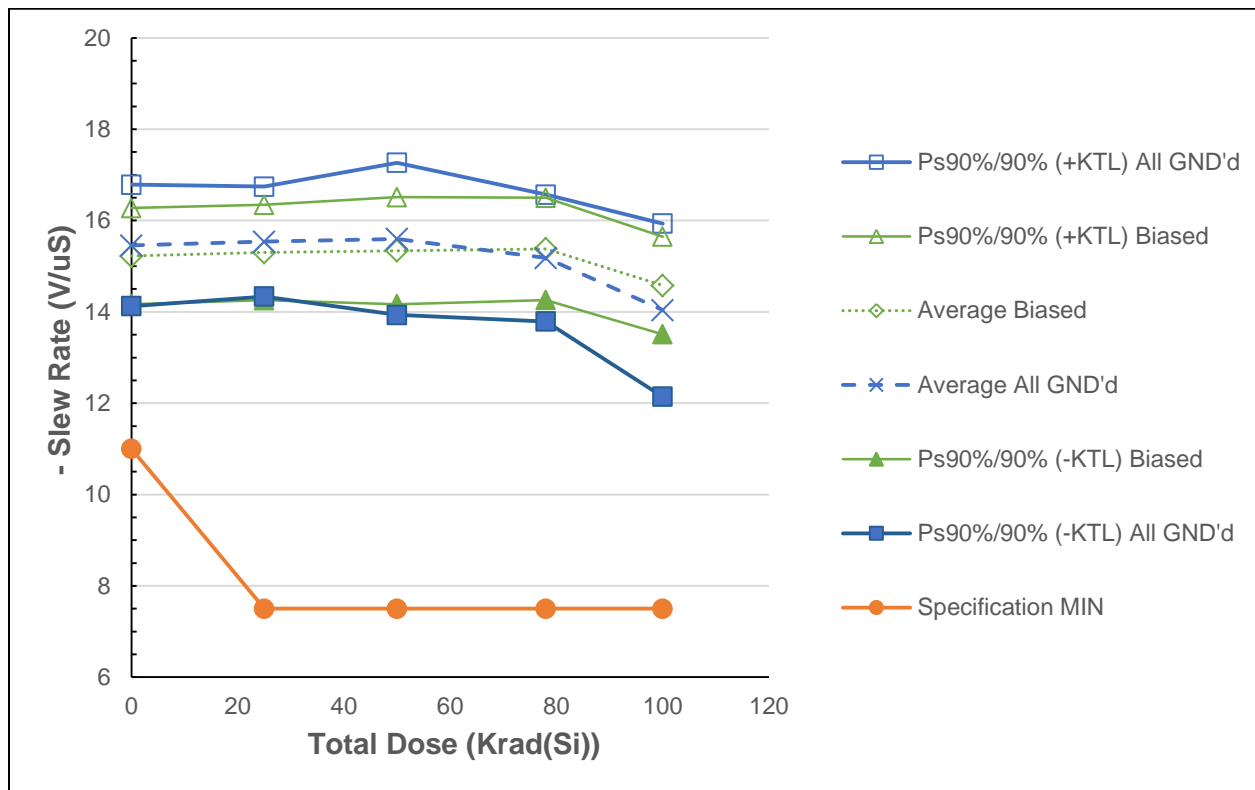


Figure 5.6: Plot of Negative Slew Rate versus Total Dose

All measured data are higher than specification minimum limits.

Table 5.6: Raw data for negative slew rate versus total dose including the statistical calculations, minimum specification, and the status of the test (PASS/FAIL)

Parameter	Negative Slew Rate	Total Dose (Krad(Si)) @ 10 mrad(Si)/second				
Units	(V/us)	0	25	50	78	100
432	All GND'd Irradiation	16.07	16.10	16.30	15.80	14.70
433	All GND'd Irradiation	14.91	15.10	14.90	14.70	13.00
435	All GND'd Irradiation	15.82	15.80	16.10	15.60	14.50
436	All GND'd Irradiation	15.35	15.60	15.60	15.10	14.30
437	All GND'd Irradiation	15.13	15.10	15.10	14.70	13.70
451	Biased-Irradiation	15.13	15.10	14.90	15.10	14.30
452	Biased-Irradiation	14.91	15.10	15.10	15.10	14.30
453	Biased-Irradiation	15.35	15.60	15.80	15.60	14.90
454	Biased-Irradiation	15.82	15.80	15.80	16.00	15.10
455	Biased-Irradiation	14.91	14.90	15.10	15.10	14.30
438	Control Unit	15.13	15.80	16.10	16.00	15.10
439	Control Unit	15.82	16.30	16.60	16.50	15.60
All GND'd Irradiation Statistics						
	Average All GND'd	15.46	15.54	15.60	15.18	14.04
	Std Dev All GND'd	0.48	0.44	0.61	0.51	0.69
	Ps90%/90% (+KTL) All GND'd	16.79	16.74	17.27	16.57	15.94
	Ps90%/90% (-KTL) All GND'd	14.13	14.34	13.93	13.79	12.14
Biased-Irradiation Statistics						
	Average Biased	15.22	15.30	15.34	15.38	14.58
	Std Dev Biased	0.38	0.38	0.43	0.41	0.39
	Ps90%/90% (+KTL) Biased	16.28	16.34	16.51	16.50	15.65
	Ps90%/90% (-KTL) Biased	14.17	14.26	14.17	14.26	13.51
	Specification MIN	11.0	7.5	7.5		7.5
	Status (Measurements) All GND'd	PASS	PASS	PASS		PASS
	Status (Measurements) Biased	PASS	PASS	PASS		PASS
	Specification MAX					
	Status (Measurements) All GND'd					
	Status (Measurements) Biased					
	Status (-KTL) All GND'd	PASS	PASS	PASS		PASS
	Status (+KTL) All GND'd					
	Status (-KTL) Biased	PASS	PASS	PASS		PASS
	Status (+KTL) Biased					

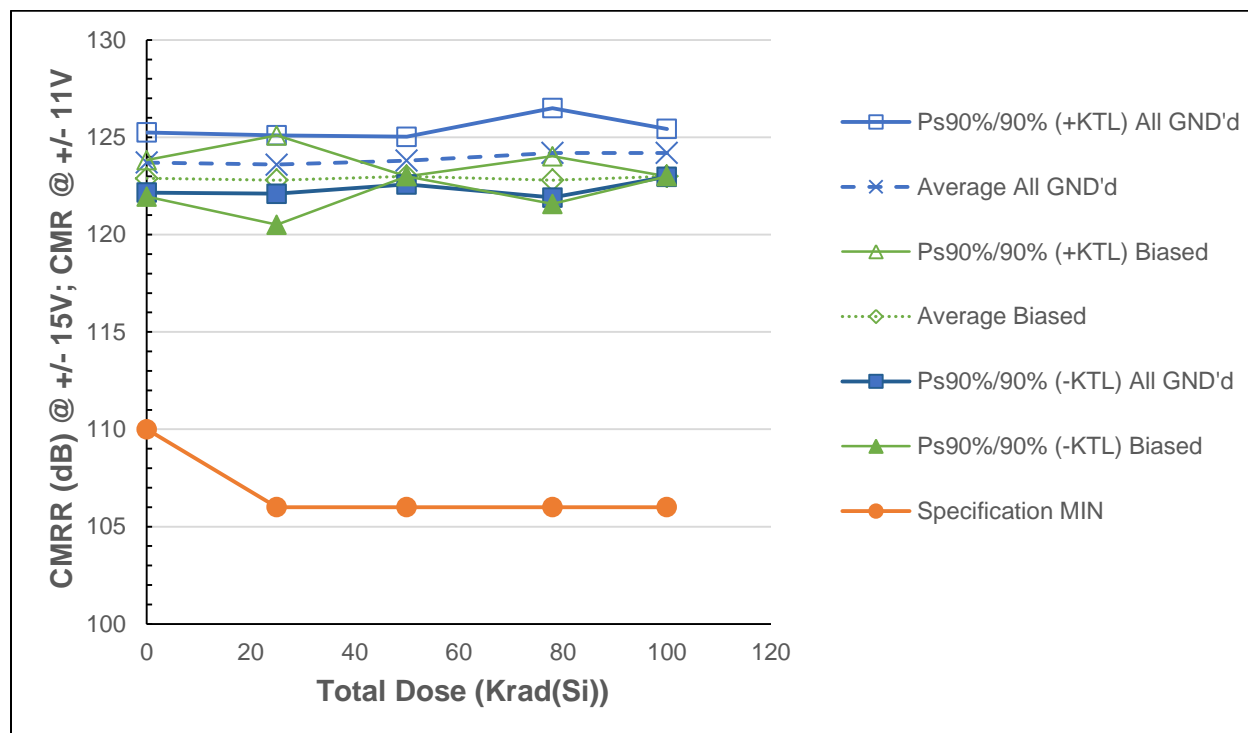


Figure 5.7: Plot of Common Mode Rejection Rate (CMRR) versus Total Dose

The average measured values of 10 samples pass the datasheet specification minimum limit.

Table 5.7: Raw data table for common mode rejection ratio (CMRR) versus total dose including the statistical calculations, minimum specification, and the status of the test (PASS/FAIL)

Parameter	CMRR @ +/- 15V; CMR @ +/- 11V	Total Dose (Krad(Si)) @ 10 mrads(Si)/second				
Units	(dB)	0	25	50	78	100
432	All GND'd Irradiation	124	124	124	125	124
433	All GND'd Irradiation	124	123	124	124	124
435	All GND'd Irradiation	124	124	124	124	124
436	All GND'd Irradiation	124	123	124	125	125
437	All GND'd Irradiation	123	124	123	123	124
451	Biased-Irradiation	123	123	123	122	123
452	Biased-Irradiation	123	123	123	123	123
453	Biased-Irradiation	123	122	123	123	123
454	Biased-Irradiation	123	122	123	123	123
455	Biased-Irradiation	123	124	123	123	123
438	Control Unit	122	121	122	121	122
439	Control Unit	123	124	124	123	123
All GND'd Irradiation Statistics						
	Average All GND'd	124	124	124	124	124
	Std Dev All GND'd	1	1	0	1	0
	Ps90%/90% (+KTL) All GND'd	125	125	125	126	125
	Ps90%/90% (-KTL) All GND'd	122	122	123	122	123
Biased-Irradiation Statistics						
	Average Biased	123	123	123	123	123
	Std Dev Biased	0	1	0	0	0
	Ps90%/90% (+KTL) Biased	124	125	123	124	123
	Ps90%/90% (-KTL) Biased	122	121	123	122	123
	Specification MIN	110	106	106		106
	Status (Measurements) All GND'd	PASS	PASS	PASS		PASS
	Status (Measurements) Biased	PASS	PASS	PASS		PASS
	Specification MAX					
	Status (Measurements) All GND'd					
	Status (Measurements) Biased					
	Status (-KTL) All GND'd	PASS	PASS	PASS		PASS
	Status (+KTL) All GND'd					
	Status (-KTL) Biased	PASS	PASS	PASS		PASS
	Status (+KTL) Biased					

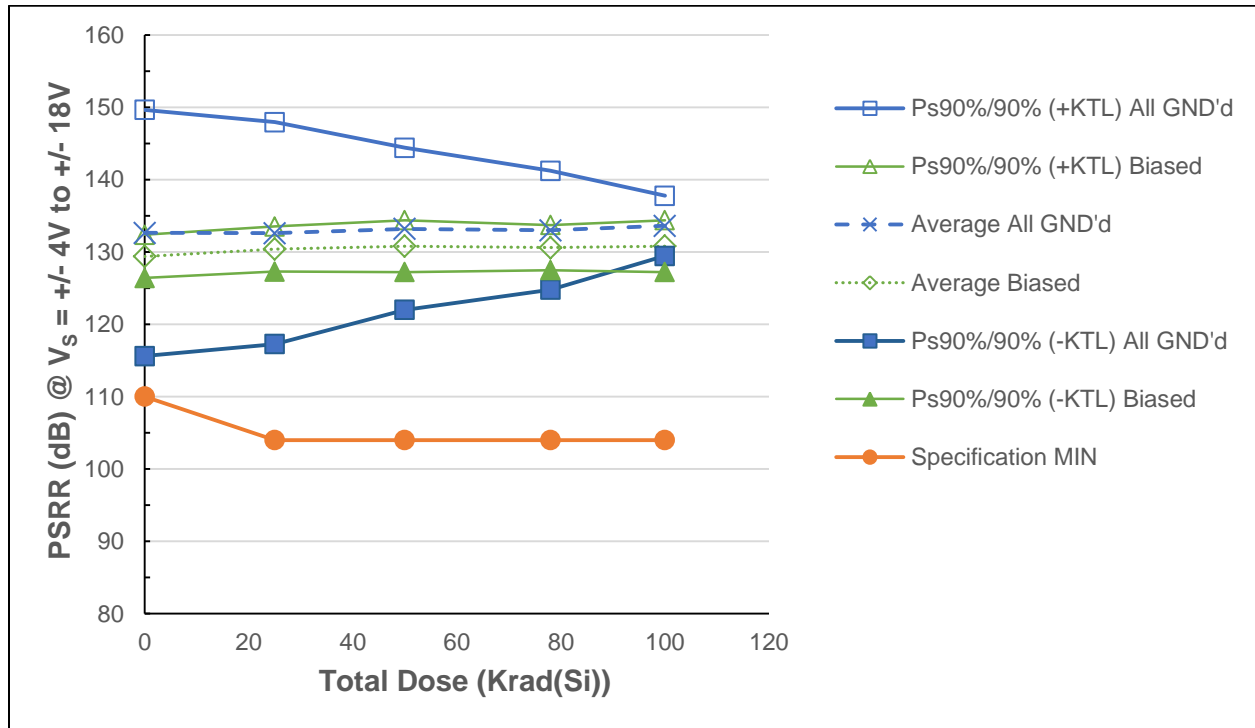


Figure 5.8: Plot of Power Supply Rejection Rate (PSRR) versus Total Dose

The average measured values of 10 samples pass the datasheet specification minimum limit.

Table 5.8: Raw data table for power supply rejection ratio (PSRR) versus total dose including the statistical calculations, minimum specification, and the status of the test (PASS/FAIL)

Parameter	PSRR @ $V_S = \pm 4V$ to $\pm 18V$	Total Dose (Krad(Si)) @ 10 mrad(Si)/second				
Units	(dB)	0	25	50	78	100
432	All GND'd Irradiation	131	132	132	132	133
433	All GND'd Irradiation	131	131	133	133	134
435	All GND'd Irradiation	132	131	132	132	132
436	All GND'd Irradiation	143	142	140	138	136
437	All GND'd Irradiation	127	127	129	130	133
451	Biased-Irradiation	128	129	130	131	131
452	Biased-Irradiation	131	131	132	131	132
453	Biased-Irradiation	129	130	131	130	130
454	Biased-Irradiation	128	130	129	129	129
455	Biased-Irradiation	130	132	132	132	132
438	Control Unit	130	131	131	131	131
439	Control Unit	129	130	130	129	129
All GND'd Irradiation Statistics						
	Average All GND'd	133	133	133	133	134
	Std Dev All GND'd	6	6	4	3	2
	Ps90%/90% (+KTL) All GND'd	150	148	144	141	138
	Ps90%/90% (-KTL) All GND'd	116	117	122	125	129
Biased-Irradiation Statistics						
	Average Biased	129	130	131	131	131
	Std Dev Biased	1	1	1	1	1
	Ps90%/90% (+KTL) Biased	132	134	134	134	134
	Ps90%/90% (-KTL) Biased	126	127	127	127	127
	Specification MIN	110	104	104		104
	Status (Measurements) All GND'd	PASS	PASS	PASS		PASS
	Status (Measurements) Biased	PASS	PASS	PASS		PASS
	Specification MAX					
	Status (Measurements) All GND'd					
	Status (Measurements) Biased					
	Status (-KTL) All GND'd	PASS	PASS	PASS		PASS
	Status (+KTL) All GND'd					
	Status (-KTL) Biased	PASS	PASS	PASS		PASS
	Status (+KTL) Biased					

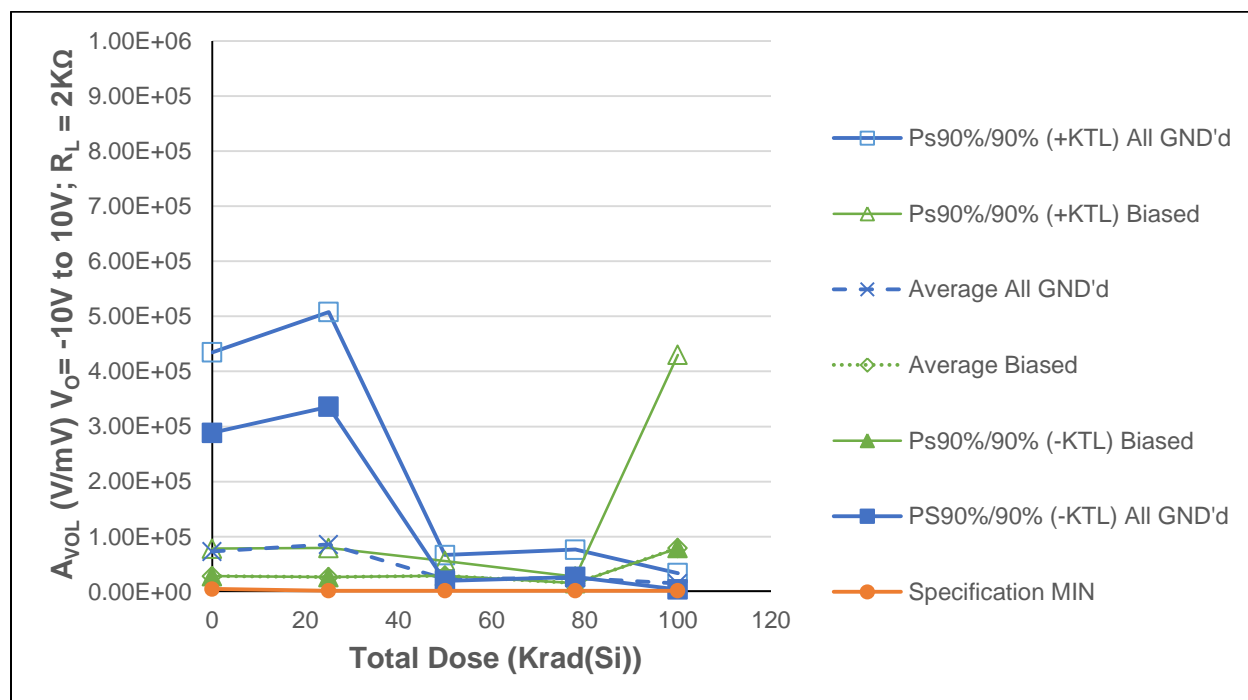


Figure 5.9: Plot of Large Signal Voltage Gain A_{VoL} versus Total Dose

The average measured values of 10 samples pass the datasheet specification minimum limit.

Table 5.9: Raw data table for large voltage signal gain versus total dose including the statistical calculations, minimum specification, and the status of the test (PASS/FAIL)

Parameter	A_{VOL} @ $V_O = -10V$ to $10V$; $R_L = 2K\Omega$	Total Dose (Krad(Si)) @ 10 mrad(Si)/second				
Units	(V/mV)	0	25	50	78	100
432	All GND'd Irradiation	1.42E+04	1.90E+04	1.85E+04	2.02E+04	1.40E+04
433	All GND'd Irradiation	1.70E+04	1.10E+04	2.10E+04	3.66E+04	1.95E+04
435	All GND'd Irradiation	1.46E+04	1.34E+04	1.82E+04	9.99E+03	1.12E+04
436	All GND'd Irradiation	1.06E+04	2.52E+04	8.62E+03	6.48E+03	6.05E+03
437*	All GND'd Irradiation	3.09E+05	3.61E+05	5.03E+04	5.14E+04	2.37E+04
451*	Biased-Irradiation	6.01E+04	5.55E+04	4.24E+04	1.81E+04	3.08E+05
452	Biased-Irradiation	1.76E+04	2.02E+04	2.28E+04	9.26E+03	1.77E+04
453	Biased-Irradiation	1.72E+04	3.55E+04	3.05E+04	1.60E+04	2.54E+04
454	Biased-Irradiation	1.97E+04	1.49E+04	3.28E+04	2.06E+04	2.37E+04
455	Biased-Irradiation	2.67E+04	6.80E+03	1.69E+04	1.41E+04	2.16E+04
438	Control Unit	2.64E+04	5.41E+04	2.35E+04	6.96E+04	2.57E+04
439	Control Unit	1.91E+04	4.70E+04	1.79E+04	1.18E+04	2.14E+04
	All GND'd Irradiation Statistics					
	Average All GND'd	7.31E+04	8.59E+04	2.33E+04	2.49E+04	1.49E+04
	Std Dev All GND'd	1.32E+05	1.54E+05	1.58E+04	1.89E+04	6.92E+03
	Ps90%/90% (+KTL) All GND'd	4.35E+05	5.08E+05	6.67E+04	7.66E+04	3.39E+04
	PS90%/90% (-KTL) All GND'd	2.89E+05	3.36E+05	2.00E+04	2.68E+04	4.08E+03
	Biased-Irradiation Statistics					
	Average Biased	2.82E+04	2.66E+04	2.91E+04	1.56E+04	7.93E+04
	Std Dev Biased	1.82E+04	1.93E+04	9.76E+03	4.30E+03	1.28E+05
	Ps90%/90% (+KTL) Biased	7.82E+04	7.94E+04	5.58E+04	2.74E+04	4.30E+05
	Ps90%/90% (-KTL) Biased	2.82E+04	2.65E+04	2.90E+04	1.55E+04	7.92E+04
	Specification MIN	5.00E+03	2.00E+03	2.00E+03		2.00E+03
	Status (Measurements) All GND'd	PASS	PASS	PASS		PASS
	Status (Measurements) Biased	PASS	PASS	PASS		PASS
	Specification MAX					
	Status (Measurements) All GND'd					
	Status (Measurements) Biased					
	Status (-KTL) All GND'd	PASS	PASS	PASS		PASS
	Status (+KTL) All GND'd					
	Status (-KTL) Biased	PASS	PASS	PASS		PASS
	Status (+KTL) Biased					

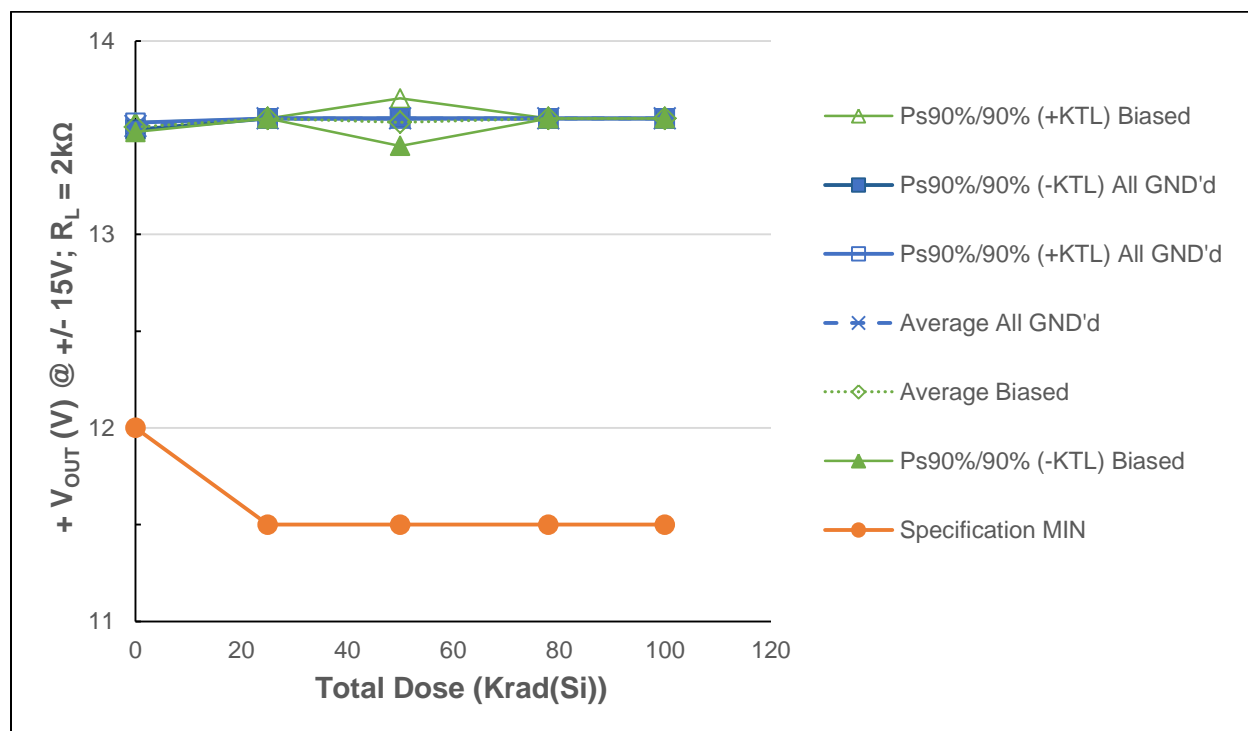


Figure 5.10: Plot of Positive Output Swing Voltage V_{OUT} with $R_L = 2K\Omega$ versus Total Dose

The average measured values of 10 samples pass the datasheet specification minimum limit.

Table 5.10: Raw data table for positive output voltage swing at $R_L = 2k\Omega$ versus total dose including the statistical calculations, minimum specification, and the status of the test (PASS/FAIL)

Parameter	$V_{OUT} (+)$ @ +/- 15V; $R_L = 2k\Omega$	Total Dose (Krad(Si)) @ 10 mrads(Si)/second				
Units	(V)	0	25	50	78	100
432	All GND'd Irradiation	13.57	13.60	13.60	13.60	13.60
433	All GND'd Irradiation	13.55	13.60	13.60	13.60	13.60
435	All GND'd Irradiation	13.56	13.60	13.60	13.60	13.60
436	All GND'd Irradiation	13.56	13.60	13.60	13.60	13.60
437	All GND'd Irradiation	13.56	13.60	13.60	13.60	13.60
451	Biased-Irradiation	13.57	13.60	13.60	13.60	13.60
452	Biased-Irradiation	13.54	13.60	13.50	13.60	13.60
453	Biased-Irradiation	13.55	13.60	13.60	13.60	13.60
454	Biased-Irradiation	13.56	13.60	13.60	13.60	13.60
455	Biased-Irradiation	13.55	13.60	13.60	13.60	13.60
438	Control Unit	13.54	13.50	13.50	13.50	13.50
439	Control Unit	13.57	13.60	13.60	13.60	13.60
All GND'd Irradiation Statistics						
	Average All GND'd	13.56	13.60	13.60	13.60	13.60
	Std Dev All GND'd	0.01	0.00	0.00	0.00	0.00
	Ps90%/90% (+KTL) All GND'd	13.58	13.60	13.60	13.60	13.60
	Ps90%/90% (-KTL) All GND'd	13.54	13.60	13.60	13.60	13.60
Biased-Irradiation Statistics						
	Average Biased	13.55	13.60	13.58	13.60	13.60
	Std Dev Biased	0.01	0.00	0.04	0.00	0.00
	Ps90%/90% (+KTL) Biased	13.58	13.60	13.70	13.60	13.60
	Ps90%/90% (-KTL) Biased	13.53	13.60	13.46	13.60	13.60
	Specification MIN	12.0	11.5	11.5		11.5
	Status (Measurements) All GND'd	PASS	PASS	PASS		PASS
	Status (Measurements) Biased	PASS	PASS	PASS		PASS
	Specification MAX					
	Status (Measurements) All GND'd					
	Status (Measurements) Biased					
	Status (-KTL) All GND'd	PASS	PASS	PASS		PASS
	Status (+KTL) All GND'd					
	Status (-KTL) Biased	PASS	PASS	PASS		PASS
	Status (+KTL) Biased					

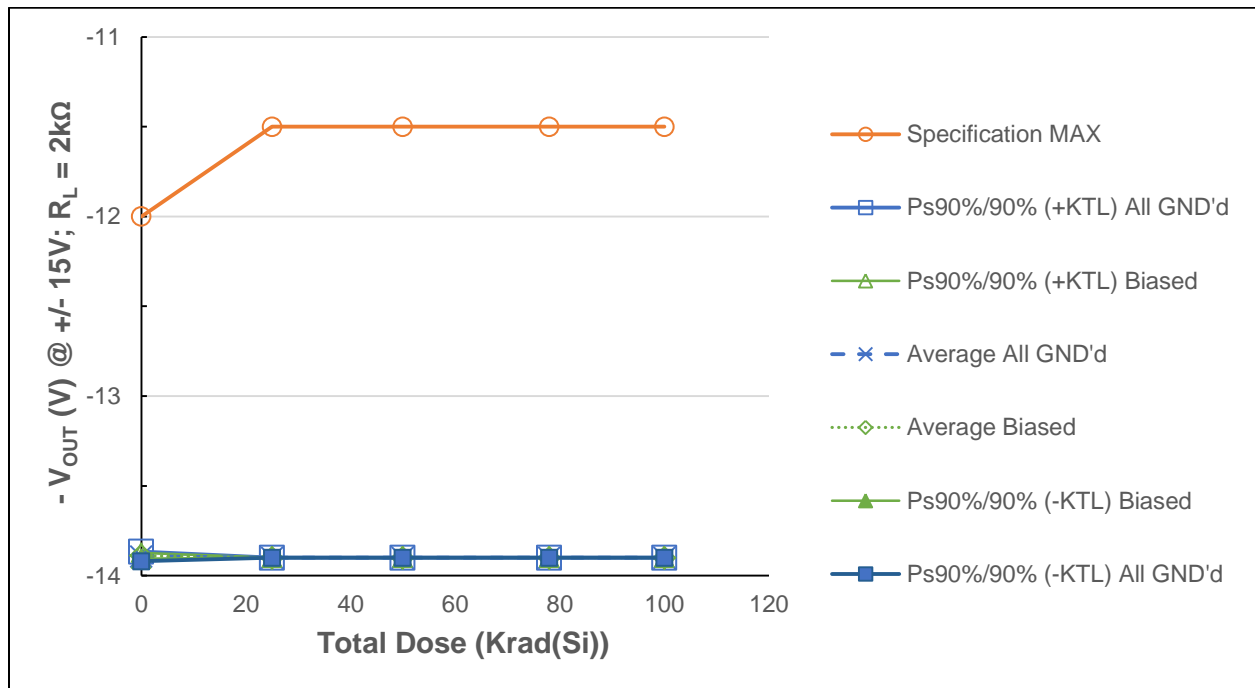


Figure 5.11: Plot of Negative Output Swing Voltage V_{OUT} with $R_L = 2K\Omega$ versus Total Dose

The average measured values of 10 samples pass the datasheet specification maximum limit.

Table 5.11: Raw data table for negative output voltage swing at $R_L = 2K\Omega$ versus total dose including the statistical calculations, maximum specifications, and the status of the test (PASS/FAIL)

Parameter	$V_{OUT} (-) @ +/- 15V; R_L = 2k\Omega$	Total Dose (Krad(Si)) @ 10 mrads(Si)/second				
Units	(V)	0	25	50	78	100
432	All GND'd Irradiation	-13.90	-13.90	-13.90	-13.90	-13.90
433	All GND'd Irradiation	-13.88	-13.90	-13.90	-13.90	-13.90
435	All GND'd Irradiation	-13.90	-13.90	-13.90	-13.90	-13.90
436	All GND'd Irradiation	-13.90	-13.90	-13.90	-13.90	-13.90
437	All GND'd Irradiation	-13.88	-13.90	-13.90	-13.90	-13.90
451	Biased-Irradiation	-13.90	-13.90	-13.90	-13.90	-13.90
452	Biased-Irradiation	-13.88	-13.90	-13.90	-13.90	-13.90
453	Biased-Irradiation	-13.89	-13.90	-13.90	-13.90	-13.90
454	Biased-Irradiation	-13.89	-13.90	-13.90	-13.90	-13.90
455	Biased-Irradiation	-13.89	-13.90	-13.90	-13.90	-13.90
438	Control Unit	-13.89	-13.90	-13.90	-13.90	-13.90
439	Control Unit	-13.90	-13.90	-13.90	-13.90	-13.90
All GND'd Irradiation Statistics						
	Average All GND'd	-13.89	-13.90	-13.90	-13.90	-13.90
	Std Dev All GND'd	0.01	0.00	0.00	0.00	0.00
	Ps90%/90% (+KTL) All GND'd	-13.87	-13.90	-13.90	-13.90	-13.90
	Ps90%/90% (-KTL) All GND'd	-13.92	-13.90	-13.90	-13.90	-13.90
Biased-Irradiation Statistics						
	Average Biased	-13.89	-13.90	-13.90	-13.90	-13.90
	Std Dev Biased	0.01	0.00	0.00	0.00	0.00
	Ps90%/90% (+KTL) Biased	-13.87	-13.90	-13.90	-13.90	-13.90
	Ps90%/90% (-KTL) Biased	-13.91	-13.90	-13.90	-13.90	-13.90
Specification MIN						
	Status (Measurements) All GND'd					
	Status (Measurements) Biased					
Specification MAX						
	Status (Measurements) All GND'd	PASS	PASS	PASS		PASS
	Status (Measurements) Biased	PASS	PASS	PASS		PASS
	Status (-KTL) All GND'd					
	Status (+KTL) All GND'd	PASS	PASS	PASS		PASS
	Status (-KTL) Biased					
	Status (+KTL) Biased	PASS	PASS	PASS		PASS

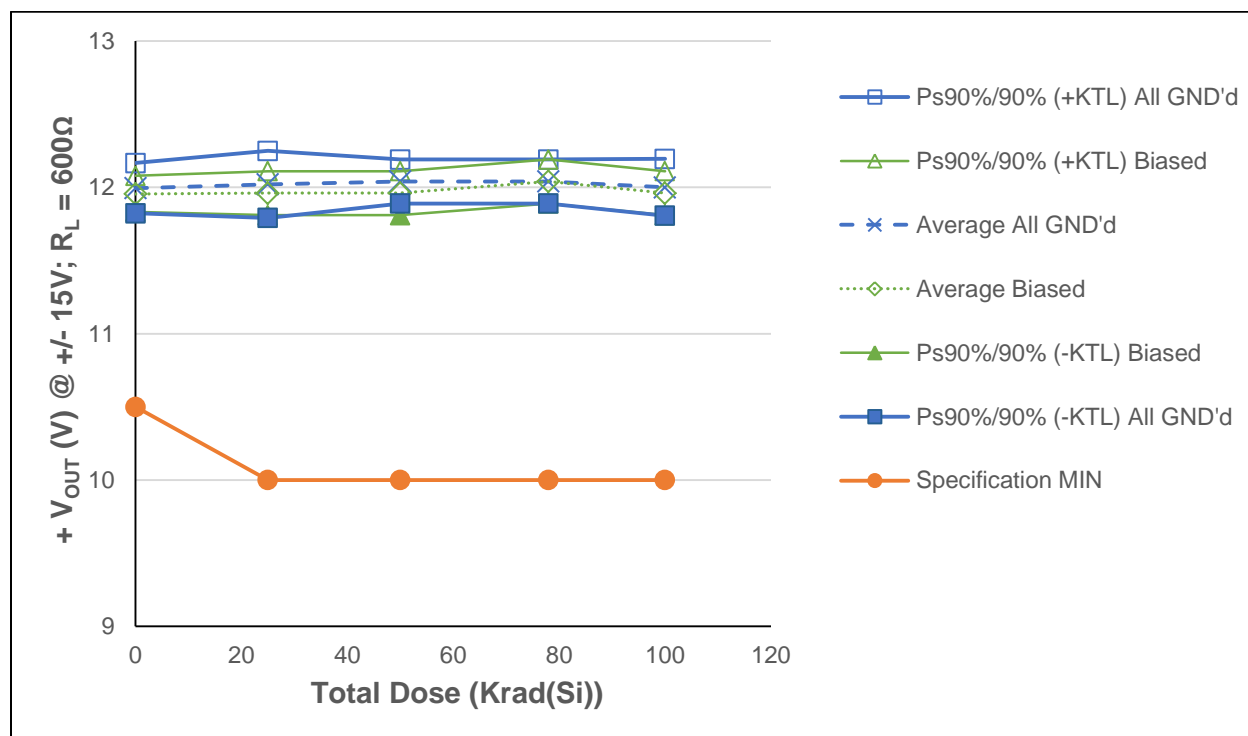


Figure 5.12: Plot of Positive Output Swing Voltage V_{OUT} with $R_L = 600\Omega$ versus Total Dose

The average measured values of 10 samples pass the datasheet specification minimum limit.

Table 5.12: Raw data table for positive output voltage swing at $R_L = 600\Omega$ versus total dose including the statistical calculations, minimum specification, and the status of the test (PASS/FAIL)

Parameter	$V_{OUT} (+) @ +/- 15V; R_L = 600\Omega$	Total Dose (Krad(Si)) @ 10 mrads(Si)/second				
Units	(V)	0	25	50	78	100
432	All GND'd Irradiation	12.08	12.10	12.10	12.10	12.10
433	All GND'd Irradiation	11.92	11.90	12.00	12.00	11.90
435	All GND'd Irradiation	12.04	12.10	12.10	12.10	12.00
436	All GND'd Irradiation	11.98	12.00	12.00	12.00	12.00
437	All GND'd Irradiation	11.95	12.00	12.00	12.00	12.00
451	Biased-Irradiation	11.98	12.00	12.00	12.10	12.00
452	Biased-Irradiation	11.89	11.90	11.90	12.00	11.90
453	Biased-Irradiation	11.99	12.00	12.00	12.10	12.00
454	Biased-Irradiation	11.98	12.00	12.00	12.00	12.00
455	Biased-Irradiation	11.93	11.90	11.90	12.00	11.90
438	Control Unit	11.98	12.00	12.00	12.00	12.10
439	Control Unit	12.04	12.10	12.10	12.10	12.10
All GND'd Irradiation Statistics						
	Average All GND'd	11.99	12.02	12.04	12.04	12.00
	Std Dev All GND'd	0.06	0.08	0.05	0.05	0.07
	Ps90%/90% (+KTL) All GND'd	12.17	12.25	12.19	12.19	12.19
	Ps90%/90% (-KTL) All GND'd	11.82	11.79	11.89	11.89	11.81
Biased-Irradiation Statistics						
	Average Biased	11.96	11.96	11.96	12.04	11.96
	Std Dev Biased	0.04	0.05	0.05	0.05	0.05
	Ps90%/90% (+KTL) Biased	12.08	12.11	12.11	12.19	12.11
	Ps90%/90% (-KTL) Biased	11.83	11.81	11.81	11.89	11.81
	Specification MIN	10.5	10.0	10.0		10.0
	Status (Measurements) All GND'd	PASS	PASS	PASS		PASS
	Status (Measurements) Biased	PASS	PASS	PASS		PASS
	Specification MAX					
	Status (Measurements) All GND'd					
	Status (Measurements) Biased					
	Status (-KTL) All GND'd	PASS	PASS	PASS		PASS
	Status (+KTL) All GND'd					
	Status (-KTL) Biased	PASS	PASS	PASS		PASS
	Status (+KTL) Biased					

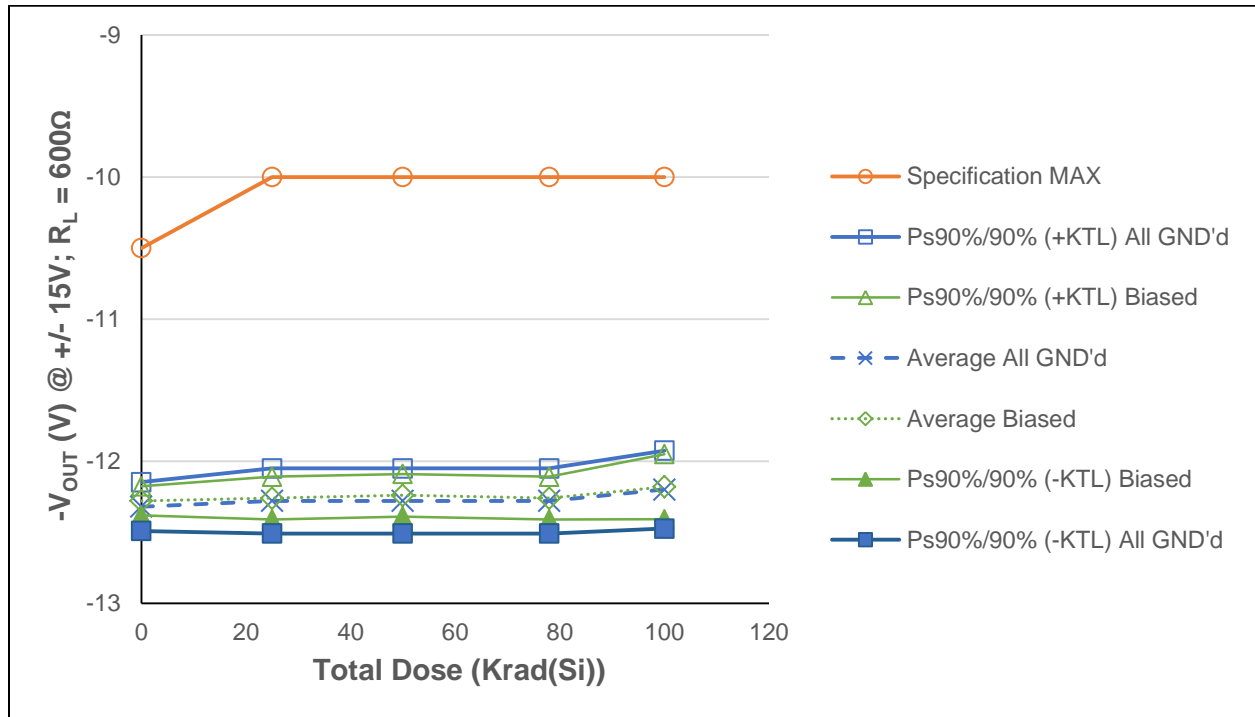


Figure 5.13: Plot of Negative Output Swing Voltage V_{OUT} with $R_L = 600\Omega$ versus Total Dose

The average measured values of 10 samples pass the datasheet specification maximum limit.

Table 5.13: Raw data table for negative output voltage swing at $R_L = 600\Omega$ versus total dose including the statistical calculations, maximum specification, and the status of the test (PASS/FAIL)

Parameter	$V_{OUT} (-) @ +/- 15V; R_L = 600\Omega$	Total Dose (Krad(Si)) @ 10 mrads(Si)/second				
Units	(V)	0	25	50	78	100
432	All GND'd Irradiation	-12.39	-12.40	-12.40	-12.40	-12.30
433	All GND'd Irradiation	-12.26	-12.20	-12.20	-12.20	-12.10
435	All GND'd Irradiation	-12.36	-12.30	-12.30	-12.30	-12.30
436	All GND'd Irradiation	-12.33	-12.30	-12.30	-12.30	-12.20
437	All GND'd Irradiation	-12.25	-12.20	-12.20	-12.20	-12.10
451	Biased-Irradiation	-12.30	-12.30	-12.30	-12.30	-12.20
452	Biased-Irradiation	-12.24	-12.20	-12.20	-12.20	-12.10
453	Biased-Irradiation	-12.33	-12.30	-12.30	-12.30	-12.30
454	Biased-Irradiation	-12.28	-12.30	-12.20	-12.30	-12.20
455	Biased-Irradiation	-12.24	-12.20	-12.20	-12.20	-12.10
438	Control Unit	-12.32	-12.30	-12.40	-12.40	-12.40
439	Control Unit	-12.36	-12.40	-12.50	-12.40	-12.40
All GND'd Irradiation Statistics						
	Average All GND'd	-12.32	-12.28	-12.28	-12.28	-12.20
	Std Dev All GND'd	0.06	0.08	0.08	0.08	0.10
	Ps90%/90% (+KTL) All GND'd	-12.15	-12.05	-12.05	-12.05	-11.93
	Ps90%/90% (-KTL) All GND'd	-12.49	-12.51	-12.51	-12.51	-12.47
Biased-Irradiation Statistics						
	Average Biased	-12.28	-12.26	-12.24	-12.26	-12.18
	Std Dev Biased	0.04	0.05	0.05	0.05	0.08
	Ps90%/90% (+KTL) Biased	-12.18	-12.11	-12.09	-12.11	-11.95
	Ps90%/90% (-KTL) Biased	-12.38	-12.41	-12.39	-12.41	-12.41
Specification MIN						
	Status (Measurements) All GND'd					
	Status (Measurements) Biased					
Specification MAX						
	Status (Measurements) All GND'd	PASS	PASS	PASS		PASS
	Status (Measurements) Biased	PASS	PASS	PASS		PASS
	Status (-KTL) All GND'd					
	Status (+KTL) All GND'd	PASS	PASS	PASS		PASS
	Status (-KTL) Biased					
	Status (+KTL) Biased	PASS	PASS	PASS		PASS

Appendix A

Picture of one among ten samples used in the test. The date code and related identification numbers should be correlated with the provided information in the second page of this report.

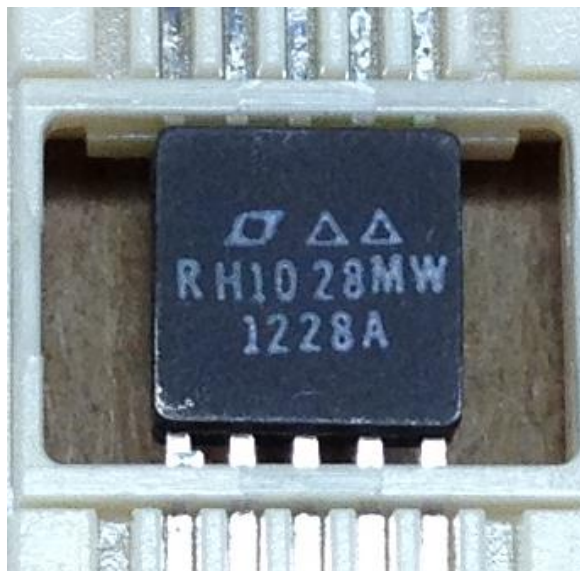


Figure A1: Top View showing date code



Figure A2: Bottom View showing serial number

Appendix B

Radiation Bias Connection Tables

Table B1: Biased Conditions

Pin	Function	Connection / Bias
1	NC	NC
2	V _{OS} TRIM	NC
3	- IN	To 10 KΩ resistor to pin 7
4	+ IN	To 10 KΩ resistor to +8V
5	V ⁻	To - 15V to bypass capacitor
6	Overcomp	NC
7	V _{OUT}	To 10 KΩ resistor to pin 3
8	V ⁺	To + 15V to bypass capacitor
9	V _{OS} TRIM	NC
10	NC	NC

Table B2: All GND'd

Pin	Function	Connection / Bias
1	NC	GND
2	V _{OS} TRIM	GND
3	- IN	GND
4	+ IN	GND
5	V ⁻	GND
6	Overcomp	GND
7	V _{OUT}	GND
8	V ⁺	GND
9	V _{OS} TRIM	GND
10	NC	GND

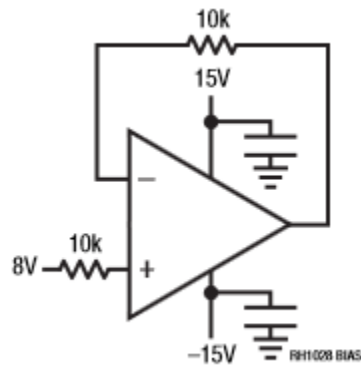


Figure B1: Total Dose Bias Circuit

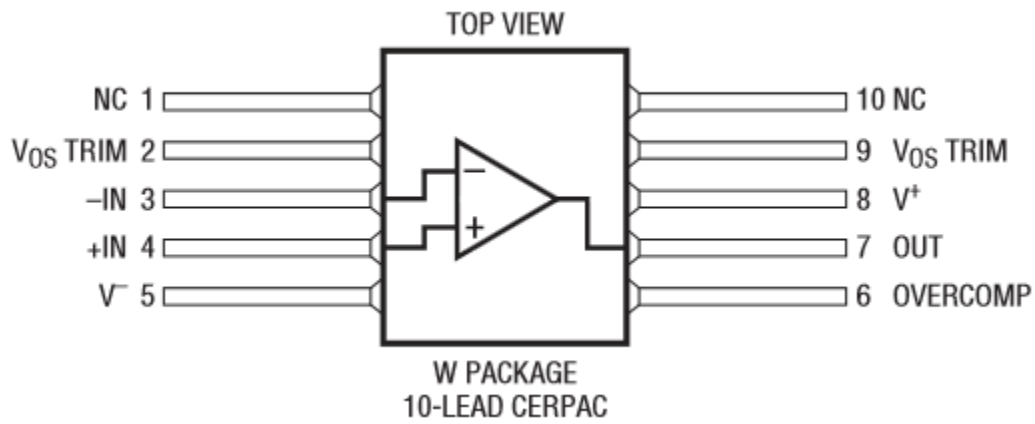


Figure B2: Pin-Out

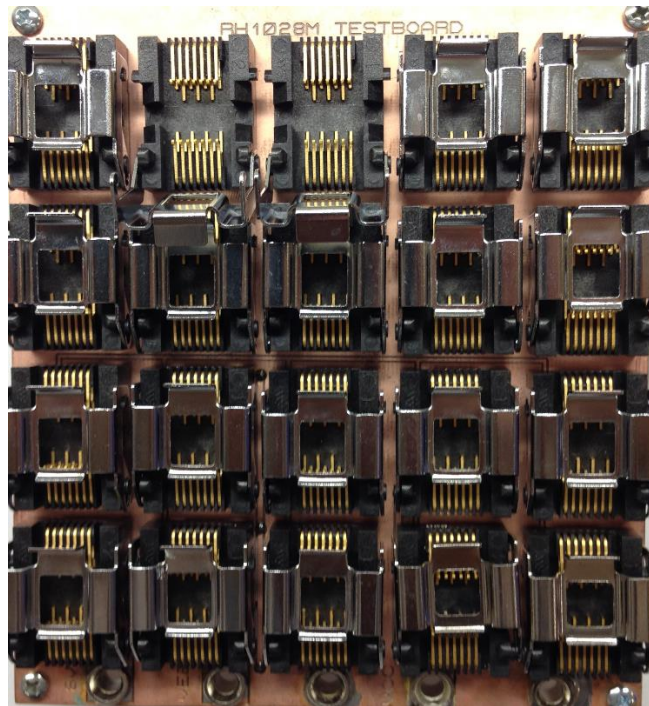


Figure B3: Bias Board (top view)

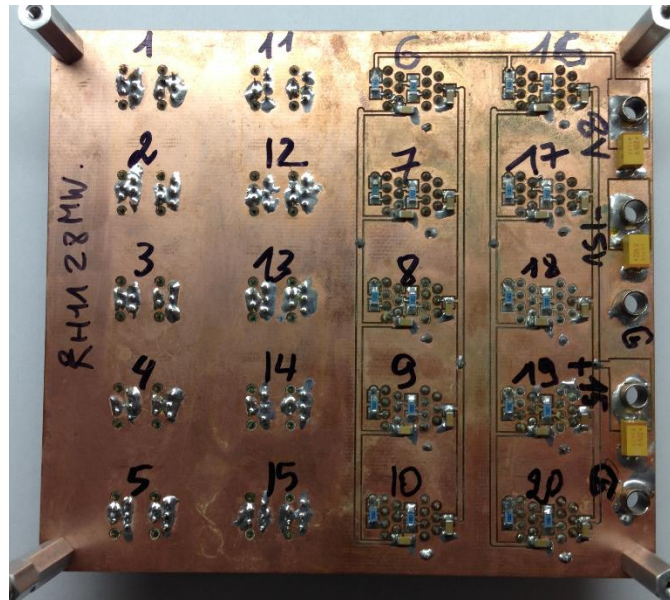


Figure B4: Bias Board (bottom view)

Appendix C

TEST CERTIFICATE

**Defense Microelectronics Activity
Science and Engineering Gamma Irradiation Test Facility
DMEA/MEBC
4234 54th Street
McClellan, CA 95652**



Testing Certificate Number: 1691.01

This laboratory is accredited by the American Association for Laboratory Accreditation (A2LA) and the dosimetry reported in this test certificate has been determined in accordance with the laboratory's terms of accreditation. The results contained herein relate only to the items tested. This certificate may not be reproduced, except in full, without the approval of this laboratory.

Date: 2013-12-05

Test Certificate #: 2014-NRC-005

Total Pages (except cover): 3

WARNING - This document contains technical data whose export is restricted by the Arms Export Control Act (Title 22, U.S.C., Sec 2751, et seq.) or the Export Administration Act of 1979 (Title 50, U.S.C., App. 2401 et seq.), as amended. Violations of these export laws are subject to severe criminal penalties. Disseminate in accordance with provisions of DoD Directive 5230.25.

DD FORM 1222, FEB 62 (EF)

Continuation of DD Form 1222

4.	Test Performed	Results of Test	Experiment #:	2014-NRC-005	Page 2 of 3	Step No.
				Sample Result	Requirements	
	20131204 09:38:00 to 20131204 09:54:13	5.000E+04 rad(SiO ₂) at 3.084E+03 rad(SiO ₂)/min	WQRH1498MW, WFR #19, S/Ns 1-5:	50 krad TD		1
	20131204 09:38:00 to 20131204 09:54:13	5.000E+04 rad(SiO ₂) at 3.084E+03 rad(SiO ₂)/min	WQRH1498MW, WFR #13, S/Ns 1-5:	50 krad TD		1
	20131204 09:38:00 to 20131204 09:54:13	5.000E+04 rad(SiO ₂) at 3.084E+03 rad(SiO ₂)/min	WQRH1498MW, WFR #10, S/Ns 1-5:	50 krad TD		1
	20131204 09:38:00 to 20131204 09:54:13	5.000E+04 rad(SiO ₂) at 3.084E+03 rad(SiO ₂)/min	WQRH1498MW, WFR #7, S/Ns 37-41:	50 krad TD		1
	20131204 10:04:30 to 20131204 11:09:21	2.000E+05 rad(SiO ₂) at 3.084E+03 rad(SiO ₂)/min	WQRH1498MW, WFR #19, S/Ns 6-10:	200 krad TD		2
	20131204 10:04:30 to 20131204 11:09:21	2.000E+05 rad(SiO ₂) at 3.084E+03 rad(SiO ₂)/min	WQRH1498MW, WFR #13, S/Ns 6-10:	200 krad TD		2
	20131204 10:04:30 to 20131204 11:09:21	2.000E+05 rad(SiO ₂) at 3.084E+03 rad(SiO ₂)/min	WQRH1498MW, WFR #10, S/Ns 6-10:	200 krad TD		2
	20131204 10:04:30 to 20131204 11:09:21	2.000E+05 rad(SiO ₂) at 3.084E+03 rad(SiO ₂)/min	WQRH1498MW, WFR #7, S/Ns 42-46:	200 krad TD		2
	20131204 11:21:30 to 20131204 11:36:49	5.000E+04 rad(SiO ₂) at 3.266E+03 rad(SiO ₂)/min	WQRH1498MW, WFR #6, S/Ns 29-38:	50 krad SD, 50 krad TD		3
	20131204 11:42:00 to 20131204 12:27:56	1.500E+05 rad(SiO ₂) at 3.266E+03 rad(SiO ₂)/min	WQRH1498MW, WFR #6, S/Ns 34-38:	150 krad SD, 200 krad TD		4
	20131204 12:55:00 to 20131204 13:11:13	5.000E+04 rad(SiO ₂) at 3.084E+03 rad(SiO ₂)/min	WQRH1014MW, WFR #11, S/Ns 3-7:	50 krad TD		5
	20131204 12:55:00 to 20131204 13:11:13	5.000E+04 rad(SiO ₂) at 3.084E+03 rad(SiO ₂)/min	WQRH1014MW, WFR #12, S/Ns 15-19:	50 krad TD		5
	20131204 12:55:00 to 20131204 13:11:13	5.000E+04 rad(SiO ₂) at 3.084E+03 rad(SiO ₂)/min	WQRH1014MW, WFR #13, S/Ns 27-31:	50 krad TD		5
	20131204 12:55:00 to 20131204 13:11:13	5.000E+04 rad(SiO ₂) at 3.084E+03 rad(SiO ₂)/min	WQRH1014MW, WFR #14, S/Ns 38-42:	50 krad TD		5
	20131204 13:21:35 to 20131204 14:26:26	2.000E+05 rad(SiO ₂) at 3.084E+03 rad(SiO ₂)/min	WQRH1014MW, WFR #11, S/Ns 8-12:	200 krad TD		6
	20131204 13:21:35 to 20131204 14:26:26	2.000E+05 rad(SiO ₂) at 3.084E+03 rad(SiO ₂)/min	WQRH1014MW, WFR #12, S/Ns 20-24:	200 krad TD		6
	20131204 13:21:35 to 20131204 14:26:26	2.000E+05 rad(SiO ₂) at 3.084E+03 rad(SiO ₂)/min	WQRH1014MW, WFR #13, S/Ns 32-36:	200 krad TD		6
	20131204 13:21:35 to 20131204 14:26:26	2.000E+05 rad(SiO ₂) at 3.084E+03 rad(SiO ₂)/min	WQRH1014MW, WFR #14, S/Ns 43-47:	200 krad TD		6

Uncertainty: Total Doses reported are \pm 14.80% (Step Nos. 1-2, 5-6)
 \pm 8.76% (Step Nos. 3-4)

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$.

NOTES:

- ASTM = American Society for Testing and Materials.
- DUT = Device Under Test.
- S/N = Serial Number.
- SD = Step Dose.
- TD = Total Dose.
- Dose rate uniformity across target area: \pm 8.56% (Step Nos. 1-2, 5-6)
 \pm 2.52% (Step Nos. 3-4)
- All irradiation steps met the requirements of MIL-STD-883H, Test Method 1019.8, Condition A.
- After the original Test Request (DD Form 1222) was approved, the following changes were made:
 - Total number of irradiation steps was 15 instead of 13 per customer request.
 - Latitude to change test parameters to suit customer requirements was included in the original Test Request; no Customer Order Change Request (SEGIT Form QP03-4, Rev. 5) was required/issued.
- Source information:
 - Irradiator = J.L. Shepherd & Associates Model 81-22/484 self-contained irradiation facility, S/Ns 7125/50016.
 - Source selection = two large Co-60 sources.
- Dosimeter system:
 - Radcal Model No. 9010 Radiation Monitor Controller, S/N 90-1286.
 - Radcal Model No. 90X5-0.18 Electrometer/Ion Chamber, S/Ns 95-0476/9770.
 - This dosimeter system was calibrated per ISO/IEC 17025:2005 by University of Wisconsin Medical Radiation Research Center on 11 Oct 2012 (Report No. ION13910). This calibration is effective for two years.
- Irradiation geometry: in accordance with section 7.3.2 of ASTM E1249-00 (2005), the DUT's semiconductor chip plane was perpendicular to the incident radiation beam.
- Filter box: a DMEA Dose Enhancement Chamber (DEC) was used for all testing/dosimetry involved with this experiment.
 The DEC's Pb and Al layers are compliant with section 7.2.2 of ASTM E1249-00 (2005) with respect to thickness and geometry.

Continuation of DD Form 1222				Experiment #:	2014-NRC-005	Page 3 of 3	
4.	Test Performed	Results of Test		Sample Result	Requirements		Step No.
	20131204 15:06:00 to 20131204 15:09:07	1.000E+04	rad(SiO ₂) at	3.212E+03	rad(SiO ₂)/min WQRH1028MW, WFR #5, S/Ns 352-362 (no 354), 363-375 (no 367,369,372); 10 krad SD, 10 krad TD		7
	20131204 15:14:20 to 20131204 15:20:34	2.000E+04	rad(SiO ₂) at	3.212E+03	rad(SiO ₂)/min WQRH1028MW, WFR #5, S/Ns 363-366, 368, 370-371, 373-375; 20 krad SD, 30 krad TD		8
	20131204 15:30:15 to 20131204 15:45:49	5.000E+04	rad(SiO ₂) at	3.212E+03	rad(SiO ₂)/min WQRH1028MW, WFR #5, S/Ns 380-382, 384-386, 388, 391-394, 396-406 (no 401); 50 krad SD, 50 krad TD		9
	20131204 15:53:00 to 20131204 16:08:34	5.000E+04	rad(SiO ₂) at	3.212E+03	rad(SiO ₂)/min WQRH1028MW, WFR #5, S/Ns 396-406 (no 401); 50 krad SD, 100 krad TD		10
	20131204 16:17:35 to 20131204 17:04:17	1.500E+05	rad(SiO ₂) at	3.212E+03	rad(SiO ₂)/min WQRH1028MW, WFR #5, S/Ns 407-414, 416-418, 425-428-430; 150 krad SD, 150 krad TD		11
	20131204 17:08:50 to 20131204 17:24:24	5.000E+04	rad(SiO ₂) at	3.212E+03	rad(SiO ₂)/min WQRH1028MW, WFR #5, S/Ns 419-425, 428-430; 50 krad SD, 200 krad TD		12
	20131204 17:47:30 to 20131204 18:03:46	5.000E+04	rad(SiO ₂) at	3.073E+03	rad(SiO ₂)/min BIPC150 Devices E, G, J, N, WFR #2, S/Ns E1-E3, G1-G3, J1-J3, N1-N3; 50 krad SD, 50 krad TD		13
	20131204 18:09:30 to 20131204 18:25:46	5.000E+04	rad(SiO ₂) at	3.073E+03	rad(SiO ₂)/min BIPC150 Devices E, G, J, N, WFR #2, S/Ns E2-E3, G2-G3, J2-J3, N2-N3; 50 krad SD, 100 krad TD		14
	20131204 18:29:30 to 20131204 19:02:03	1.000E+05	rad(SiO ₂) at	3.073E+03	rad(SiO ₂)/min BIPC150 Devices E, G, J, N, WFR #2, S/Ns E3, G3, J3, N3; 100 krad SD, 200 krad TD		15

Uncertainty: Total Doses reported are ±
10.46% (Step Nos. 7-12)
15.18% (Step Nos. 13-15)

Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$.

NOTES:

- ASTM = American Society for Testing and Materials.
- DUT = Device Under Test.
- S/N = Serial Number.
- SD = Step Dose.
- TD = Total Dose.
- Dose rate uniformity across target area:
 - ± 4.22% (Step Nos. 7-12)
 - ± 8.95% (Step Nos. 13-15)
- All irradiation steps met the requirements of MIL-STD-883H, Test Method 1019.8, Condition A.
- After the original Test Request (DD Form 1222) was approved, the following changes were made:
 - BIPC device quantity per dose level was 4 each (was TBD).
 - Total number of irradiation steps was 15 instead of 13 per customer request.
Latitude to change test parameters to suit customer requirements was included in the original Test Request; no Customer Order Change Request (SEGIT Form QP03-4, Rev. 5) was required/issued.
- Source information:
 - Irradiator = J.L. Shepherd & Associates Model 81-22/484 self-contained irradiation facility, S/Ns 7125/50016.
 - Source selection = two large Co-60 sources.
- Dosimeter system:
 - Radcal Model No. 9010 Radiation Monitor Controller, S/N 90-1286.
 - Radcal Model No. 90XS-0.18 Electrometer/Ion Chamber, S/Ns 95-0476/9770.
 - This dosimeter system was calibrated per ISO/IEC 17025:2005 by University of Wisconsin Medical Radiation Research Center on 11 Oct 2012 (Report No. ION13910). This calibration is effective for two years.
- Irradiation geometry: in accordance with section 7.3.2 of ASTM E1249-00 (2005), the DUT's semiconductor chip plane was perpendicular to the incident radiation beam.
- Filter box: a DMEA Dose Enhancement Chamber (DEC) was used for all testing/dosimetry involved with this experiment.
The DEC's Pb and Al layers are compliant with section 7.2.2 of ASTM E1249-00 (2005) with respect to thickness and geometry.

Appendix D

Table D1: Electrical Characteristics of Device-Under-Test

Parameter	Pre-irradiation		10 Krad(Si)		20 Krad(Si)		50 Krad(Si)		100 Krad(Si)		200 Krad(Si)		Units
	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
Input Offset Voltage	80		100		120		140		160		180		μV
Input Offset Current	150		200		200		200		300		500		nA
+ Input Bias Current	+/-400		+/-600		+/-700		+/-950		+/-1100		+/-1700		nA
- Input Bias Current	+/-400		+/-600		+/-700		+/-950		+/-1100		+/-1700		nA
+ Slew Rate	11		7.5		7.5		7.5		7.5		7.5		V/μS
- Slew Rate	11		7.5		7.5		7.5		7.5		7.5		V/μS
CMRR	110		106		106		106		106		106		dB
PSRR	110		104		104		104		104		104		dB
A _{VOL} (R _L = 2 KΩ)	5		2		2		2		2		2		V/μV
V _{OUT} (+) (R _L = 2 KΩ)	12		11.5		11.5		11.5		11.5		11.5		V
V _{OUT} (-) (R _L = 2 KΩ)	-12		-11.5		-11.5		-11.5		-11.5		-11.5		V
V _{OUT} (+) (R _L = 600 Ω)	10.5		10		10		10		10		10		V
V _{OUT} (-) (R _L = 600 Ω)	-10.5		-10		-10		-10		-10		-10		V