Total Ionization Dose (TID) Test Results of the RH1021CMH-5 Precision 5V Reference @ High Dose Rate (HDR)

HDR = 50 rads(Si)/s

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Acknowledgements

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TID HDR Testing of the RH1021CMH-5 Precision 5V Reference

Part Type Tested: RH1021-5 Precision 5V Reference

Traceability Information: Fab Lot# 10214210.1; Wafer # 10; Assembly Lot # 697997.1; Date Code: 1217A. See photograph of unit under test in Appendix A.

Quantity of Units: 42 units received, 2 units for control, 20 units for biased irradiation, and 20 units for unbiased irradiation. Serial numbers 267-271, 277-281, 297-300, and 316 had all pins tied to ground during irradiation. Serial numbers 272-276, 282-286, 292-296, 317, and 319-322 were biased during irradiation. Serial numbers 323 and 324 were used as control. See Appendix B for the radiation bias connection tables.

Radiation and Electrical Test Increments: 40 samples were divided into four groups of 10 each. Group 1 with serial numbers from 267 to 276 were irradiated to 10 Krads(Si). Serial numbers 277-286 were used for the 30 Krads(Si) group. The following serial numbers 287-296 were irradiated to 50 Krads(Si). The last group with serial numbers 297-300, 316-317, and 310-322 were exposed to 100 Krads(Si). All 42 samples were electrically tested pre- and post-irradiaton.

Radiation dose: 50 rads(Si)/sec.

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

Test Hardware and Software: LTX pre-irradiation test program EQCM10215.02; LTX post-irradiation test program ERHC10215.00; Test Board LT1021; Test Setup 04-04-0540.

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

Irradiation and Test Temperature: Room temperature controlled to 24°C±6°C per MIL-STD-883 and MIL-STD-750.

SUMMARY

ALL 40 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 circuits' 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 the transistors' dielectrics and interface regions, affecting hence the devices' 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 is the requirement per Condition A (for high-dose rates ranging from 50 and 300 rads(Si)/sec) in TM1019, MIL-STD-883 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 50 rads(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 40 test samples and two control units were electrically tested at 25°C prior to irradiation. The parts were then placed in a lead/aluminum container and aligned with the radiation source, Cobalt-60, at DMEA facility in Sacramento, California. During irradiation, five units of four separate were biased at +/- 15V and other five of the same four groups had all pads grounded. Ten units of group 1 were irradiated to 10 Krads(Si); group 2 to 30 Krads(Si); group 3 to 50 Krads(Si) and group 4 to 100 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 42 units (40 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:

- Output Voltage (V)
- Output Voltage Temperature Coefficient (ppm/°C)
- Line Regulation with condition 7.2V ≤ V_{IN} ≤ 10V (ppm/V)
- Line Regulation with condition 710V ≤ V_{IN} ≤ 40V (ppm/V)
- Load Regulation (Sourcing Current) (ppm/mA)
- Load Regulation (Sinking Current) (ppm/mA)
- Supply Current (Series Mode) (mA)

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

5.0 Test Results

All 40 samples passed the post-irradiation electrical tests. All measurements of the seven 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 by adding to and subtracting from mean the product of standard deviation and the tolerance limit factor K_{TL} where K_{TL} is tabulated from a table of the inverse normal probability distribution. The upper tolerance limit $+K_{TL}$ and the lower tolerance limit $-K_{TL}$ are

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

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

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

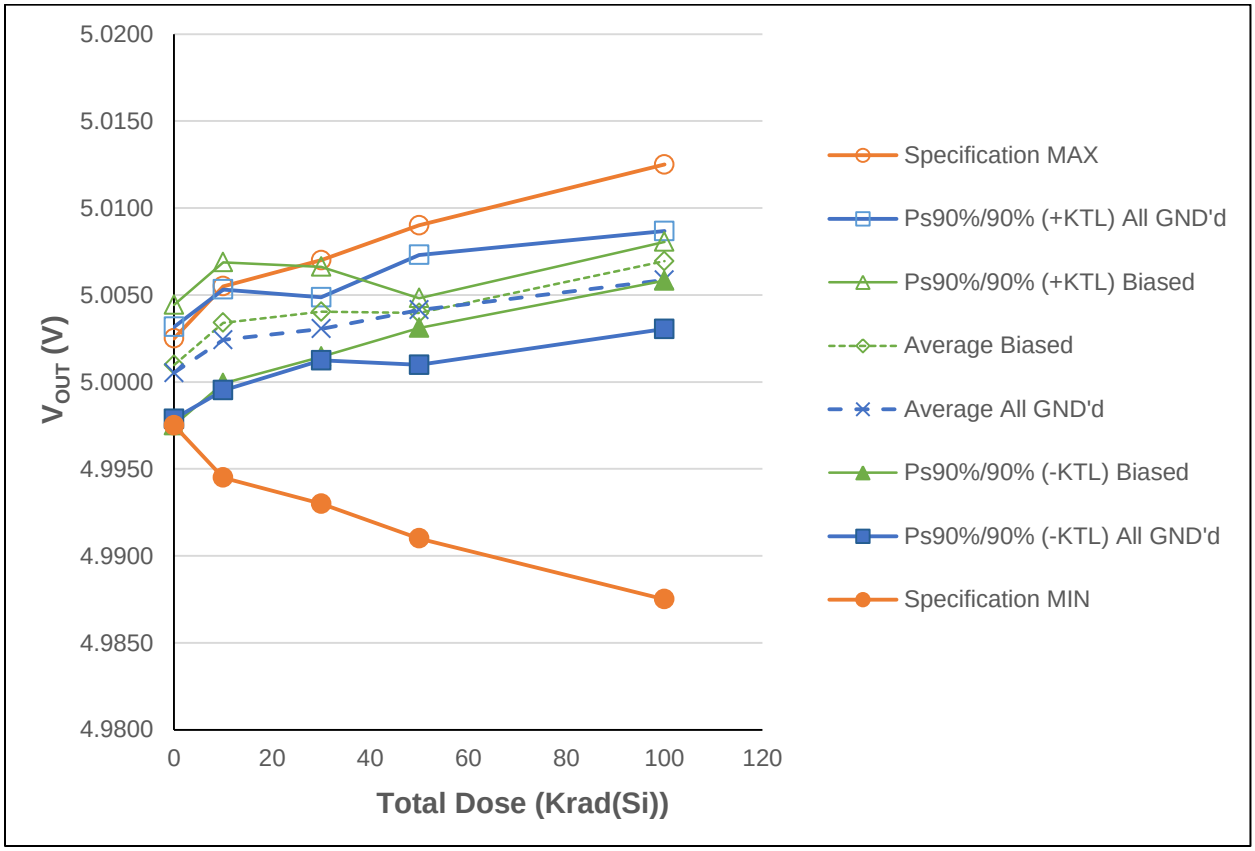

Figure 5.1 Plot of Output Voltage versus Total Dose

All 40 samples passed the output voltage test at each post-irradiation interval. Note the KTL square and triangle markers are slightly above the pre-irradiation and 10 Krads(Si) datasheet limits, due to the small sample population and in this report the sample size is five.

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

Parameter	VOUT	Total Dose (Krad(Si)) @ 50 rads(Si)/s				
Unit #	(V)	0	10	30	50	100
267	All GND'd Irradiation	5.0014	5.0036			
268	All GND'd Irradiation	4.9992	5.0010			
269	All GND'd Irradiation	5.0003	5.0022			
270	All GND'd Irradiation	5.0015	5.0033			
271	All GND'd Irradiation	5.0001	5.0019			
272	Biased Irradiation	4.9999	5.0023			
273	Biased Irradiation	5.0021	5.0044			
274	Biased Irradiation	5.0015	5.0039			
275	Biased Irradiation	5.0020	5.0046			
276	Biased Irradiation	4.9994	5.0018			
277	All GND'd Irradiation	5.0005		5.0035		
278	All GND'd Irradiation	4.9993		5.0021		
279	All GND'd Irradiation	5.0008		5.0038		
280	All GND'd Irradiation	5.0002		5.0031		
281	All GND'd Irradiation	5.0000		5.0027		
282	Biased Irradiation	5.0017		5.0054		
283	Biased Irradiation	5.0000		5.0037		
284	Biased Irradiation	4.9994		5.0031		
285	Biased Irradiation	4.9996		5.0034		
286	Biased Irradiation	5.0010		5.0046		
287	All GND'd Irradiation	4.9993			5.0031	
288	All GND'd Irradiation	4.9993			5.0037	
289	All GND'd Irradiation	5.0016			5.0054	
290	All GND'd Irradiation	5.0023			5.0054	
291	All GND'd Irradiation	4.9993			5.0031	
292	Biased Irradiation	4.9995			5.0039	
293	Biased Irradiation	4.9997			5.0042	
294	Biased Irradiation	4.9995			5.0039	
295	Biased Irradiation	4.9993			5.0036	
296	Biased Irradiation	4.9999			5.0044	
297	All GND'd Irradiation	5.0012				5.0064
298	All GND'd Irradiation	4.9996				5.0044
299	All GND'd Irradiation	5.0004				5.0052
300	All GND'd Irradiation	5.0022				5.0068
316	All GND'd Irradiation	5.0019				5.0065
317	Biased Irradiation	5.0015				5.0068
319	Biased Irradiation	5.0013				5.0070
320	Biased Irradiation	5.0021				5.0076
321	Biased Irradiation	5.0014				5.0065
322	Biased Irradiation	5.0015				5.0068
323	Control Unit	5.0020	5.0020	5.0020	5.0020	5.0020
324	Control Unit	4.9997	4.9997	4.9997	4.9997	4.9997
	All GND'd Irradiation Statistics					
	Average All GND'd	5.0005	5.0024	5.0031	5.0041	5.0059
	Std Dev All GND'd	0.0010	0.0011	0.0007	0.0012	0.0010
	Ps90%/90% (+KTL) All GND'd	5.0032	5.0053	5.0049	5.0073	5.0087
	Ps90%/90% (-KTL) All GND'd	4.9979	4.9995	5.0012	5.0010	5.0030
	Biased Irradiation Statistics					
	Average Biased	5.0010	5.0034	5.0040	5.0040	5.0069
	Std Dev Biased	0.0013	0.0013	0.0009	0.0003	0.0004
	Ps90%/90% (+KTL) Biased	5.0044	5.0069	5.0066	5.0048	5.0081
	Ps90%/90% (-KTL) Biased	4.9975	4.9999	5.0015	5.0031	5.0058
	Specification MIN	4.9975	4.9945	4.993	4.991	4.9875
	Status (Measurements) All GND'd	PASS	PASS	PASS	PASS	PASS
	Status (Measurements) Biased	PASS	PASS	PASS	PASS	PASS
	Specification MAX	5.0025	5.0055	5.007	5.009	5.0125
	Status (Measurements) All GND'd	PASS	PASS	PASS	PASS	PASS
	Status (Measurements) Biased	PASS	PASS	PASS	PASS	PASS
	Status (-KTL) All GND'd	PASS	PASS	PASS	PASS	PASS
	Status (+KTL) All GND'd	FAIL	PASS	PASS	PASS	PASS
	Status (-KTL) Biased	PASS	PASS	PASS	PASS	PASS
	Status (+KTL) Biased	FAIL	FAIL	PASS	PASS	PASS

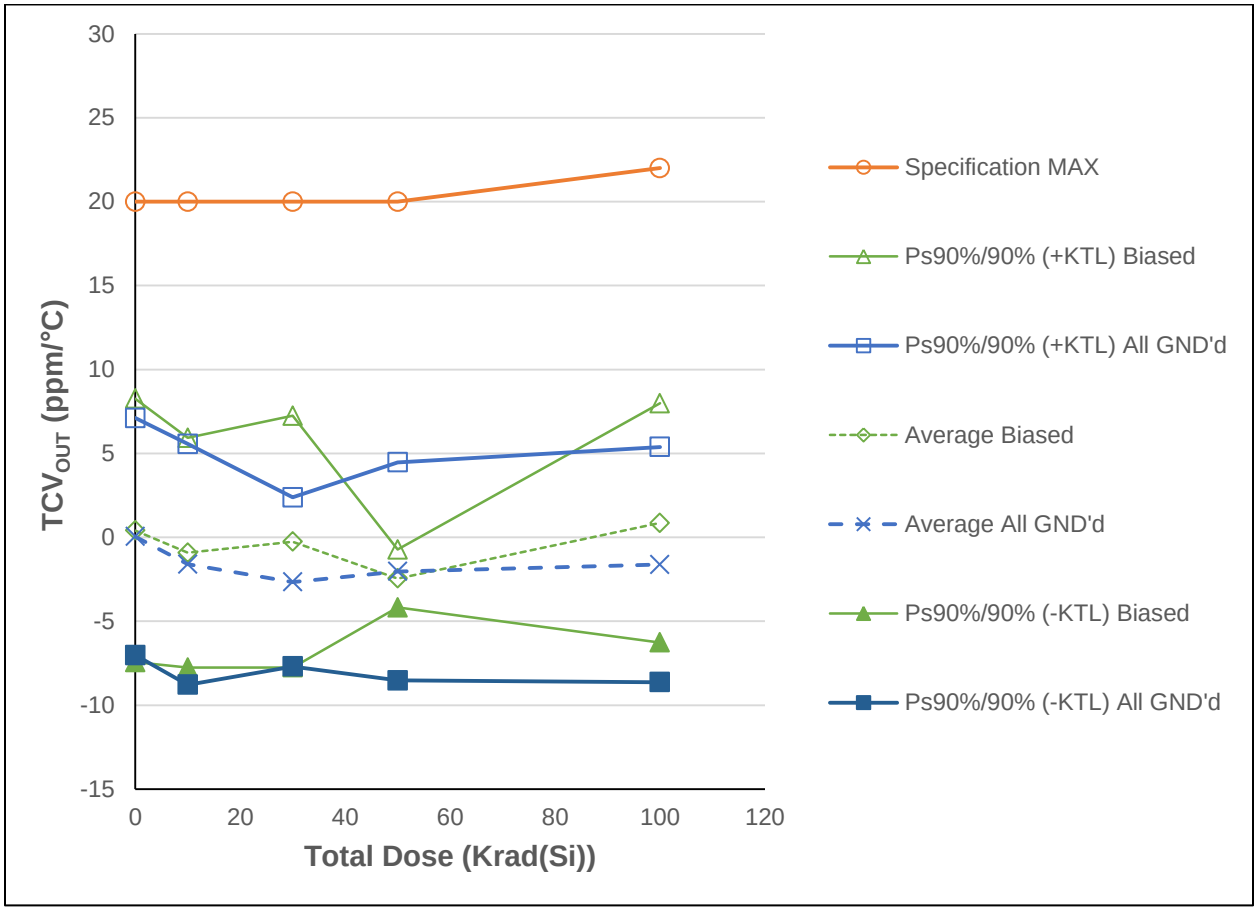

Figure 5.2: Plot of Output Voltage Temperature Coefficient versus Total Dose

The measured values of 40 samples are under datasheet maximum limits.

Table 5.2: Raw data for voltage output temperature coefficient (ppm/°C) versus total dose including the statistical calculations, maximum specification, and the status of the test (PASS/FAIL under the second orange header)

Parameter	TCVOUT	Total Dose (Krad(Si)) @ 50 rads(Si)/s				
Unit #	(ppm/°C)	0	10	30	50	100
267	All GND'd Irradiation	2.1174	0.6310			
268	All GND'd Irradiation	-1.5662	-3.2914			
269	All GND'd Irradiation	-0.7313	-2.9544			
270	All GND'd Irradiation	3.2820	1.7400			
271	All GND'd Irradiation	-2.8780	-4.1635			
272	Biased Irradiation	-2.5449	-3.3035			
273	Biased Irradiation	1.8385	0.8532			
274	Biased Irradiation	2.4986	1.0514			
275	Biased Irradiation	3.0841	0.7932			
276	Biased Irradiation	-2.8311	-3.9678			
277	All GND'd Irradiation	-0.9250		-2.5771		
278	All GND'd Irradiation	-1.1409		-2.8181		
279	All GND'd Irradiation	1.8676		0.2847		
280	All GND'd Irradiation	-2.6635		-4.6808		
281	All GND'd Irradiation	-1.6067		-3.5044		
282	Biased Irradiation	3.8025		3.2043		
283	Biased Irradiation	-0.4499		-1.4550		
284	Biased Irradiation	-1.2728		-2.6209		
285	Biased Irradiation	-1.7655		-2.5392		
286	Biased Irradiation	3.9495		2.1307		
287	All GND'd Irradiation	-2.7148			-3.9902	
288	All GND'd Irradiation	-0.8225			-1.9220	
289	All GND'd Irradiation	-0.3292			-1.6458	
290	All GND'd Irradiation	2.1592			1.6504	
291	All GND'd Irradiation	-2.2171			-4.2475	
292	Biased Irradiation	-1.6561			-3.1467	
293	Biased Irradiation	-0.7808			-1.8549	
294	Biased Irradiation	-1.0879			-1.9982	
295	Biased Irradiation	-2.0311			-3.1229	
296	Biased Irradiation	-0.7220			-2.1441	
297	All GND'd Irradiation	2.9908				2.1781
298	All GND'd Irradiation	-2.8348				-3.8832
299	All GND'd Irradiation	-0.1148				-2.0208
300	All GND'd Irradiation	-2.2721				-3.8911
316	All GND'd Irradiation	1.4085				-0.4904
317	Biased Irradiation	2.0351				1.2340
319	Biased Irradiation	3.1216				2.3799
320	Biased Irradiation	4.2971				4.1319
321	Biased Irradiation	-0.5240				-1.2587
322	Biased Irradiation	-0.4528				-2.2015
323	Control Unit	-0.1213	-0.1213	-0.1213	-0.1213	-0.1213
324	Control Unit	-1.9747	-1.9747	-1.9747	-1.9747	-1.9747
	All GND'd Irradiation Statistics					
	Average All GND'd	0.0448	-1.6076	-2.6592	-2.0310	-1.6215
	Std Dev All GND'd	2.5747	2.6172	1.8371	2.3698	2.5565
	Ps90%/90% (+KTL) All GND'd	7.1045	5.5687	2.3783	4.4670	5.3884
	Ps90%/90% (-KTL) All GND'd	-7.0150	-8.7840	-7.6966	-8.5291	-8.6313
	Biased Irradiation Statistics					
	Average Biased	0.4090	-0.9147	-0.2560	-2.4534	0.8571
	Std Dev Biased	2.8631	2.4968	2.7347	0.6305	2.5989
	Ps90%/90% (+KTL) Biased	8.2597	5.9314	7.2425	-0.7246	7.9833
	Ps90%/90% (-KTL) Biased	-7.4417	-7.7608	-7.7545	-4.1822	-6.2691
	Specificaiton MIN					
	Status (Measurements) All GND'd					
	Status (Measurements) Biased					
	Specification MAX	20	20	20	20	22
	Status (Measurements) All GND'd	PASS	PASS	PASS	PASS	PASS
	Status (Measurements) Biased	PASS	PASS	PASS	PASS	PASS
	Status (-KTL) All GND'd					
	Status (+KTL) All GND'd	PASS	PASS	PASS	PASS	PASS
	Status (-KTL) Biased					
	Status (+KTL) Biased	PASS	PASS	PASS	PASS	PASS

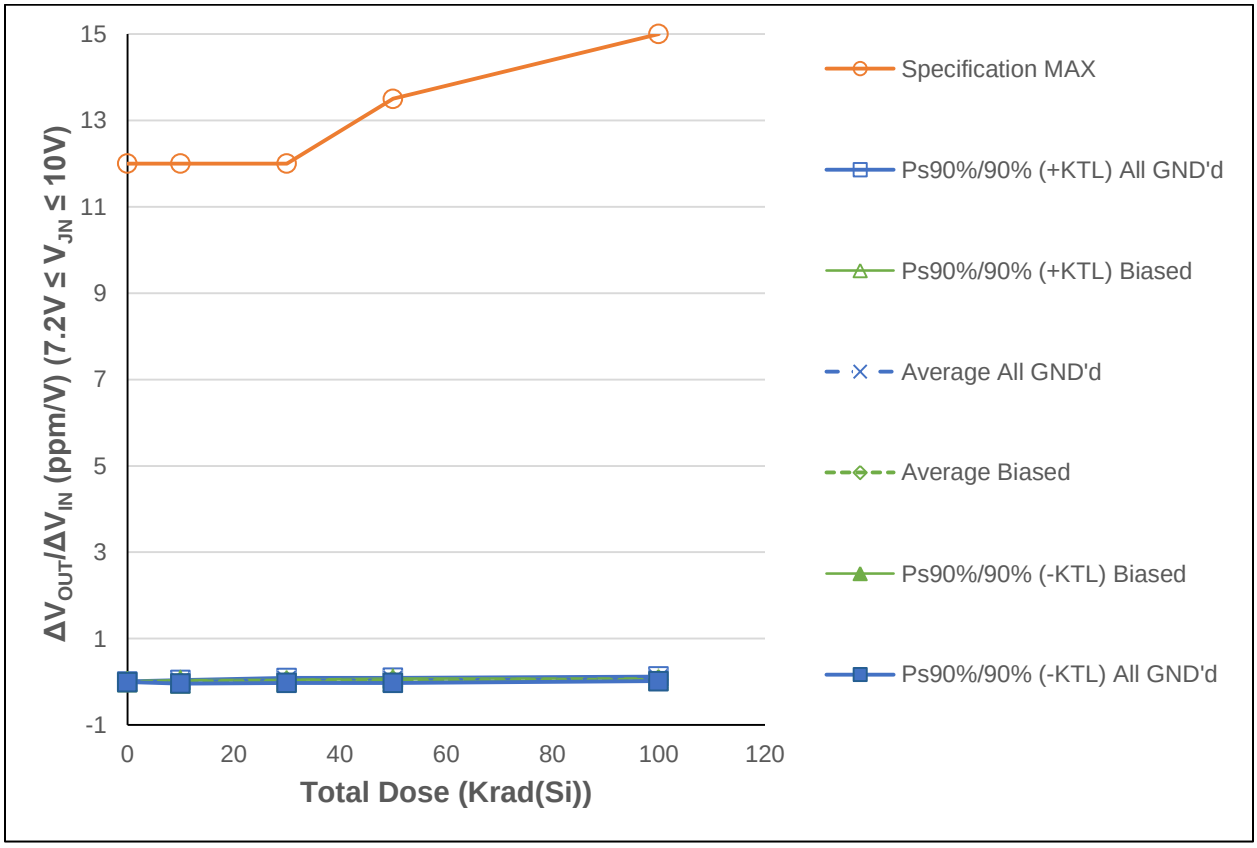

Figure 5.3: Plot of Line Regulation (7.2V ≤ V_{IN} ≤ 10V) versus Total Dose

All measured data points are lower than the datasheet specification maximum.

Table 5.3: Raw data for line regulation (ppm/V) with 7.2V ≤ V_{IN} ≤ 10V versus total dose including the statistical calculations, minimum specification, maximum specification, and the status of the test (PASS/FAIL).

Parameter	VOUT/ΔVIN (7.2V ≤ VIN ≤ 10V)	Total Dose (Krad(Si)) @ 50 rads(Si)/s				
Unit #	(ppm/V)	0	10	30	50	100
267	All GND'd Irradiation	0.0005	-0.0059			
268	All GND'd Irradiation	0.0001	-0.0175			
269	All GND'd Irradiation	0.0055	0.0023			
270	All GND'd Irradiation	0.0009	0.0162			
271	All GND'd Irradiation	-0.0001	0.0163			
272	Biased Irradiation	0.0006	0.0067			
273	Biased Irradiation	0.0008	-0.0143			
274	Biased Irradiation	0.0067	0.0027			
275	Biased Irradiation	0.0021	0.0254			
276	Biased Irradiation	0.0074	0.0017			
277	All GND'd Irradiation	0.0009		0.0075		
278	All GND'd Irradiation	0.0055		0.0344		
279	All GND'd Irradiation	0.0071		0.0237		
280	All GND'd Irradiation	0.0025		0.0354		
281	All GND'd Irradiation	-0.0004		0.0655		
282	Biased Irradiation	-0.0049		0.0134		
283	Biased Irradiation	0.0028		0.0337		
284	Biased Irradiation	-0.0046		0.0213		
285	Biased Irradiation	0.0155		0.0304		
286	Biased Irradiation	0.0037		0.0242		
287	All GND'd Irradiation	-0.0038			0.0328	
288	All GND'd Irradiation	-0.0026			0.0246	
289	All GND'd Irradiation	-0.0004			0.0639	
290	All GND'd Irradiation	-0.0013			0.0055	
291	All GND'd Irradiation	-0.0033			0.0468	
292	Biased Irradiation	0.0012			0.0298	
293	Biased Irradiation	0.0000			0.0511	
294	Biased Irradiation	-0.0007			0.0477	
295	Biased Irradiation	0.0051			0.0196	
296	Biased Irradiation	0.0032			0.0456	
297	All GND'd Irradiation	-0.0102				0.0618
298	All GND'd Irradiation	-0.0050				0.0423
299	All GND'd Irradiation	0.0022				0.0843
300	All GND'd Irradiation	0.0024				0.0731
316	All GND'd Irradiation	0.0005				0.0921
317	Biased Irradiation	0.0051				0.0420
319	Biased Irradiation	-0.0003				0.0608
320	Biased Irradiation	0.0006				0.0579
321	Biased Irradiation	0.0063				0.0435
322	Biased Irradiation	0.0129				0.0489
323	Control Unit	0.0080	0.0080	0.0080	0.0080	0.0080
324	Control Unit	0.0000	0.0000	0.0000	0.0000	0.0000
	All GND'd Irradiation Statistics					
	Average All GND'd	0.0014	0.0023	0.0333	0.0347	0.0707
	Std Dev All GND'd	0.0023	0.0146	0.0212	0.0221	0.0196
	Ps90%/90% (+KTL) All GND'd	0.0078	0.0422	0.0915	0.0954	0.1244
	Ps90%/90% (-KTL) All GND'd	-0.0051	-0.0377	-0.0249	-0.0260	0.0171
	Biased Irradiation Statistics					
	Average Biased	0.0035	0.0044	0.0246	0.0387	0.0506
	Std Dev Biased	0.0033	0.0142	0.0080	0.0135	0.0084
	Ps90%/90% (+KTL) Biased	0.0125	0.0433	0.0465	0.0757	0.0737
	Ps90%/90% (-KTL) Biased	-0.0055	-0.0344	0.0027	0.0018	0.0275
	Specificaiton MIN					
	Status (Measurements) All GND'd					
	Status (Measurements) Biased					
	Specification MAX	12	12	12	13.5	15
	Status (Measurements) All GND'd	PASS	PASS	PASS	PASS	PASS
	Status (Measurements) Biased	PASS	PASS	PASS	PASS	PASS
	Status (-KTL) All GND'd					
	Status (+KTL) All GND'd	PASS	PASS	PASS	PASS	PASS
	Status (-KTL) Biased					
	Status (+KTL) Biased	PASS	PASS	PASS	PASS	PASS

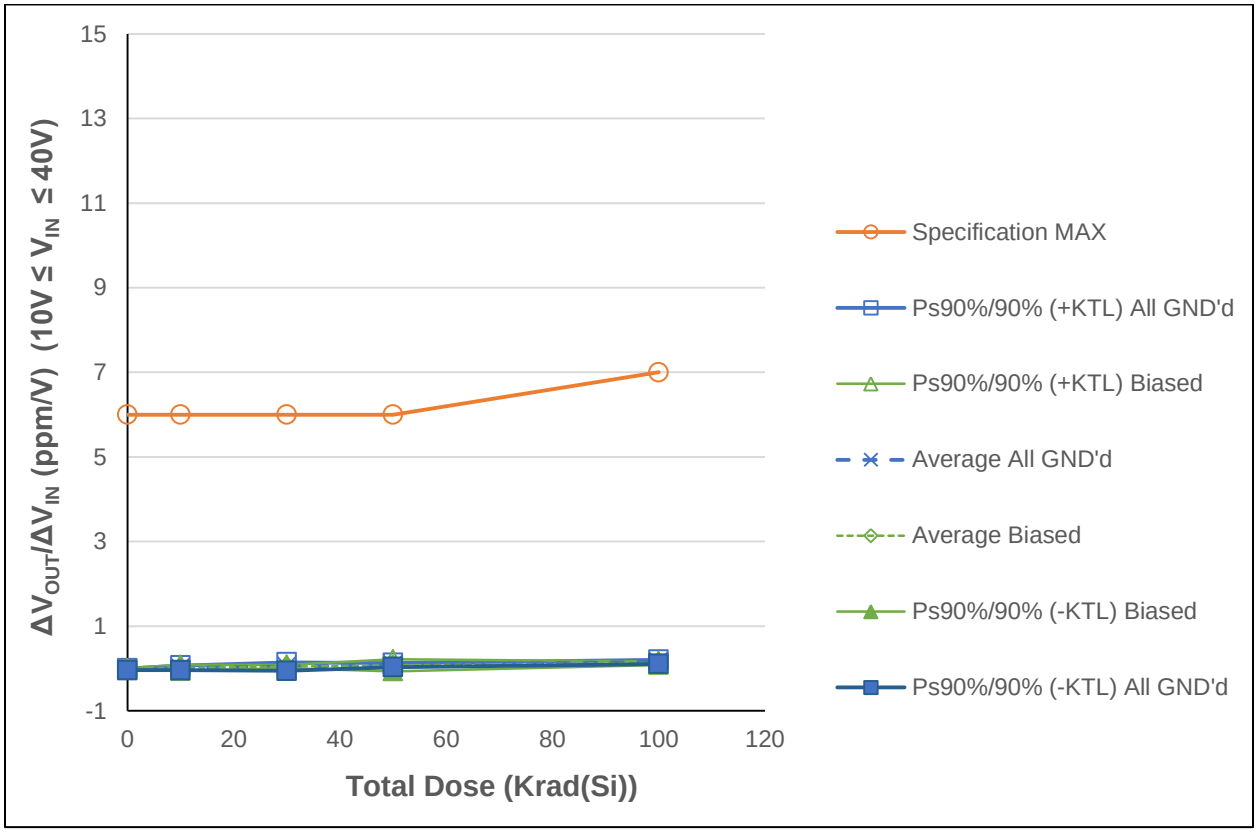

Figure 5.4: Plot of Line Regulation (10V ≤ V_{IN} ≤ 40V) versus Total Dose

All measured data points are well under datasheet upper limits.

Table 5.4: Raw data for line regulation (ppm/V) with 10V ≤ V_{IN} ≤ 40V versus total dose including the statistical calculations, minimum specification, maximum specification, and the status of the test (PASS/FAIL).

Parameter	ΔVOUT/ΔVIN (10V ≤ VIN ≤ 40V)	Total Dose (Krad(Si)) @ 50 rads(Si)/s				
Unit #	(ppm/V)	0	10	30	50	100
267	All GND'd Irradiation	-0.0077	0.0145			
268	All GND'd Irradiation	-0.0230	0.0161			
269	All GND'd Irradiation	-0.0265	0.0439			
270	All GND'd Irradiation	-0.0150	-0.0115			
271	All GND'd Irradiation	-0.0168	0.0057			
272	Biased Irradiation	-0.0112	0.0031			
273	Biased Irradiation	-0.0021	0.0533			
274	Biased Irradiation	-0.0181	0.0141			
275	Biased Irradiation	-0.0107	-0.0126			
276	Biased Irradiation	-0.0117	0.0357			
277	All GND'd Irradiation	-0.0108		0.0770		
278	All GND'd Irradiation	-0.0059		0.0189		
279	All GND'd Irradiation	0.0095		0.0795		
280	All GND'd Irradiation	-0.0069		0.0573		
281	All GND'd Irradiation	-0.0168		-0.0023		
282	Biased Irradiation	-0.0087		0.0714		
283	Biased Irradiation	-0.0164		0.0422		
284	Biased Irradiation	-0.0080		0.0322		
285	Biased Irradiation	-0.0288		0.0435		
286	Biased Irradiation	-0.0153		0.0444		
287	All GND'd Irradiation	-0.0129			0.0622	
288	All GND'd Irradiation	-0.0211			0.0768	
289	All GND'd Irradiation	-0.0039			0.0761	
290	All GND'd Irradiation	-0.0020			0.1099	
291	All GND'd Irradiation	-0.0179			0.0795	
292	Biased Irradiation	-0.0097			0.0774	
293	Biased Irradiation	-0.0243			0.0501	
294	Biased Irradiation	-0.0049			0.0527	
295	Biased Irradiation	0.0631			0.1648	
296	Biased Irradiation	-0.0221			0.0367	
297	All GND'd Irradiation	0.0151				0.1818
298	All GND'd Irradiation	-0.0141				0.1470
299	All GND'd Irradiation	-0.0136				0.1439
300	All GND'd Irradiation	-0.0049				0.1694
316	All GND'd Irradiation	-0.0113				0.1420
317	Biased Irradiation	-0.0076				0.1315
319	Biased Irradiation	-0.0172				0.0985
320	Biased Irradiation	0.0074				0.1309
321	Biased Irradiation	-0.0148				0.1301
322	Biased Irradiation	-0.0177				0.1369
323	Control Unit	-0.0132	-0.0132	-0.0132	-0.0132	-0.0132
324	Control Unit	-0.0119	-0.0119	-0.0119	-0.0119	-0.0119
	All GND'd Irradiation Statistics					
	Average All GND'd	-0.0178	0.0137	0.0461	0.0809	0.1568
	Std Dev All GND'd	0.0073	0.0201	0.0364	0.0176	0.0178
	Ps90%/90% (+KTL) All GND'd	0.0022	0.0688	0.1458	0.1291	0.2056
	Ps90%/90% (-KTL) All GND'd	-0.0379	-0.0414	-0.0536	0.0327	0.1080
	Biased Irradiation Statistics					
	Average Biased	-0.0108	0.0187	0.0467	0.0764	0.1256
	Std Dev Biased	0.0057	0.0261	0.0146	0.0516	0.0154
	Ps90%/90% (+KTL) Biased	0.0049	0.0903	0.0869	0.2177	0.1677
	Ps90%/90% (-KTL) Biased	-0.0264	-0.0529	0.0066	-0.0650	0.0834
	Specificaiton MIN					
	Status (Measurements) All GND'd					
	Status (Measurements) Biased					
	Specification MAX	6	6	6	6	7
	Status (Measurements) All GND'd	PASS	PASS	PASS	PASS	PASS
	Status (Measurements) Biased	PASS	PASS	PASS	PASS	PASS
	Status (-KTL) All GND'd					
	Status (+KTL) All GND'd	PASS	PASS	PASS	PASS	PASS
	Status (-KTL) Biased					
	Status (+KTL) Biased	PASS	PASS	PASS	PASS	PASS

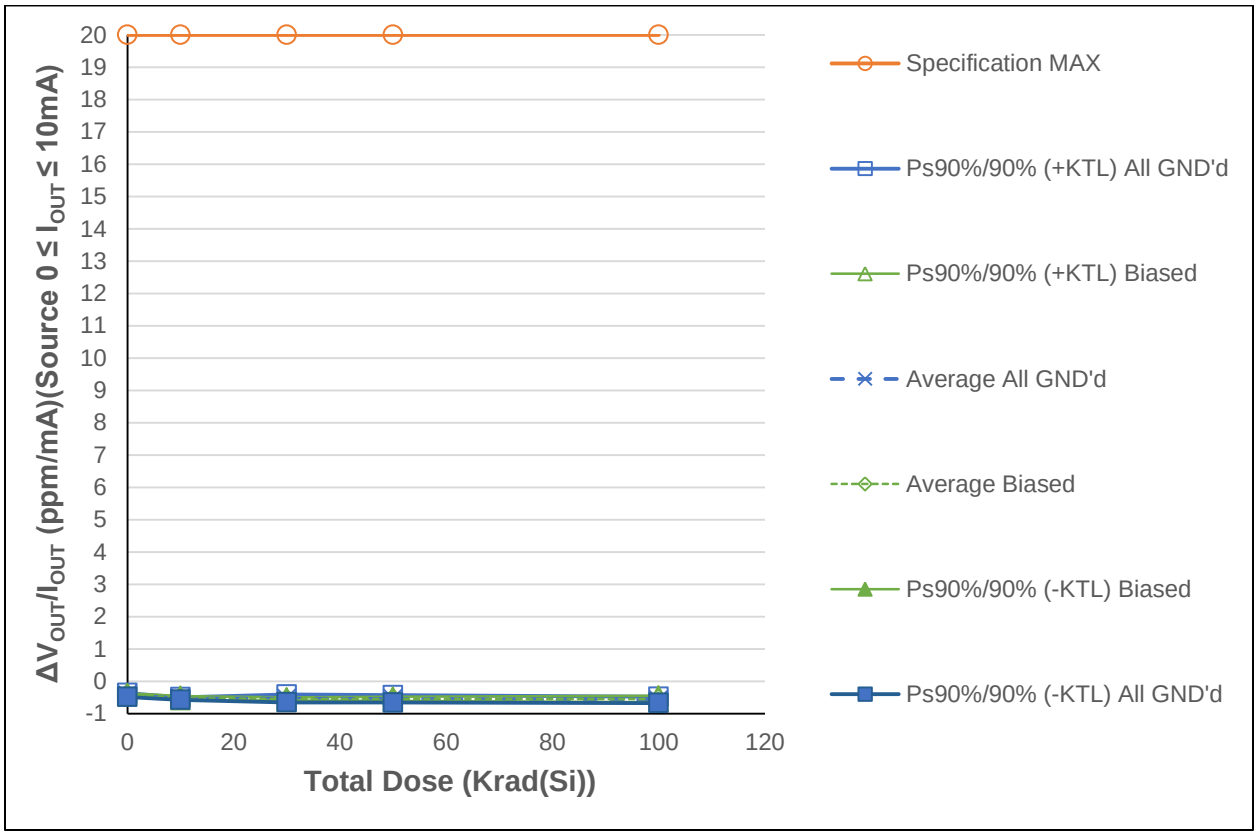

Figure 5.5: Plot of Load Regulation (Sourcing 0 ≤ I_{OUT} ≤ 10mA) versus Total Dose

The measured parameters are well under the specification maximum limits.

Table 5.5: Raw data for load regulation sourcing (ppm/mA) with $0 \leq I_{OUT} \leq 10mA$ versus total dose including the statistical calculations, minimum specification, maximum specification, and the status of the test (PASS/FAIL)

Parameter	ΔVO/ΔIO (Source 0≤ I_{OUT} ≤10mA)	Total Dose (Krad(Si)) @ 50 rads(Si)/s				
Unit #	(ppm/mA)	0	10	30	50	100
267	All GND'd Irradiation	-0.3841	-0.5476			
268	All GND'd Irradiation	-0.4309	-0.5127			
269	All GND'd Irradiation	-0.4291	-0.5292			
270	All GND'd Irradiation	-0.4396	-0.5417			
271	All GND'd Irradiation	-0.4301	-0.5219			
272	Biased Irradiation	-0.4141	-0.5527			
273	Biased Irradiation	-0.3935	-0.5088			
274	Biased Irradiation	-0.3884	-0.5387			
275	Biased Irradiation	-0.3915	-0.4916			
276	Biased Irradiation	-0.4071	-0.5112			
277	All GND'd Irradiation	-0.4204		-0.4941		
278	All GND'd Irradiation	-0.4519		-0.5484		
279	All GND'd Irradiation	-0.4472		-0.4767		
280	All GND'd Irradiation	-0.4277		-0.5428		
281	All GND'd Irradiation	-0.3733		-0.5880		
282	Biased Irradiation	-0.4040		-0.5444		
283	Biased Irradiation	-0.4080		-0.5217		
284	Biased Irradiation	-0.3952		-0.5427		
285	Biased Irradiation	-0.4231		-0.5709		
286	Biased Irradiation	-0.4355		-0.5453		
287	All GND'd Irradiation	-0.4340			-0.4828	
288	All GND'd Irradiation	-0.4202			-0.5833	
289	All GND'd Irradiation	-0.4119			-0.5692	
290	All GND'd Irradiation	-0.3951			-0.5157	
291	All GND'd Irradiation	-0.4226			-0.5580	
292	Biased Irradiation	-0.4353			-0.5686	
293	Biased Irradiation	-0.3940			-0.5244	
294	Biased Irradiation	-0.4117			-0.5289	
295	Biased Irradiation	-0.4239			-0.5185	
296	Biased Irradiation	-0.4188			-0.5630	
297	All GND'd Irradiation	-0.4643				-0.6181
298	All GND'd Irradiation	-0.4126				-0.5619
299	All GND'd Irradiation	-0.4124				-0.5592
300	All GND'd Irradiation	-0.4234				-0.6019
316	All GND'd Irradiation	-0.4397				-0.5316
317	Biased Irradiation	-0.4345				-0.5410
319	Biased Irradiation	-0.4196				-0.5168
320	Biased Irradiation	-0.4494				-0.5991
321	Biased Irradiation	-0.4233				-0.5463
322	Biased Irradiation	-0.4194				-0.5075
323	Control Unit	-0.4323	-0.4323	-0.4323	-0.4323	-0.4323
324	Control Unit	-0.4068	-0.4068	-0.4068	-0.4068	-0.4068
	All GND'd Irradiation Statistics					
	Average All GND'd	-0.4227	-0.5306	-0.5300	-0.5418	-0.5745
	Std Dev All GND'd	0.0220	0.0142	0.0447	0.0415	0.0349
	Ps90%/90% (+KTL) All GND'd	-0.3623	-0.4916	-0.4075	-0.4279	-0.4787
	Ps90%/90% (-KTL) All GND'd	-0.4832	-0.5696	-0.6525	-0.6557	-0.6704
	Biased Irradiation Statistics					
	Average Biased	-0.3989	-0.5206	-0.5450	-0.5407	-0.5421
	Std Dev Biased	0.0111	0.0246	0.0175	0.0233	0.0357
	Ps90%/90% (+KTL) Biased	-0.3685	-0.4531	-0.4971	-0.4767	-0.4442
	Ps90%/90% (-KTL) Biased	-0.4293	-0.5882	-0.5929	-0.6046	-0.6401
	Specificaiton MIN					
	Status (Measurements) All GND'd					
	Status (Measurements) Biased					
	Specification MAX	20	20	20	20	20
	Status (Measurements) All GND'd	PASS	PASS	PASS	PASS	PASS
	Status (Measurements) Biased	PASS	PASS	PASS	PASS	PASS
	Status (-KTL) All GND'd					
	Status (+KTL) All GND'd	PASS	PASS	PASS	PASS	PASS
	Status (-KTL) Biased					
	Status (+KTL) Biased	PASS	PASS	PASS	PASS	PASS

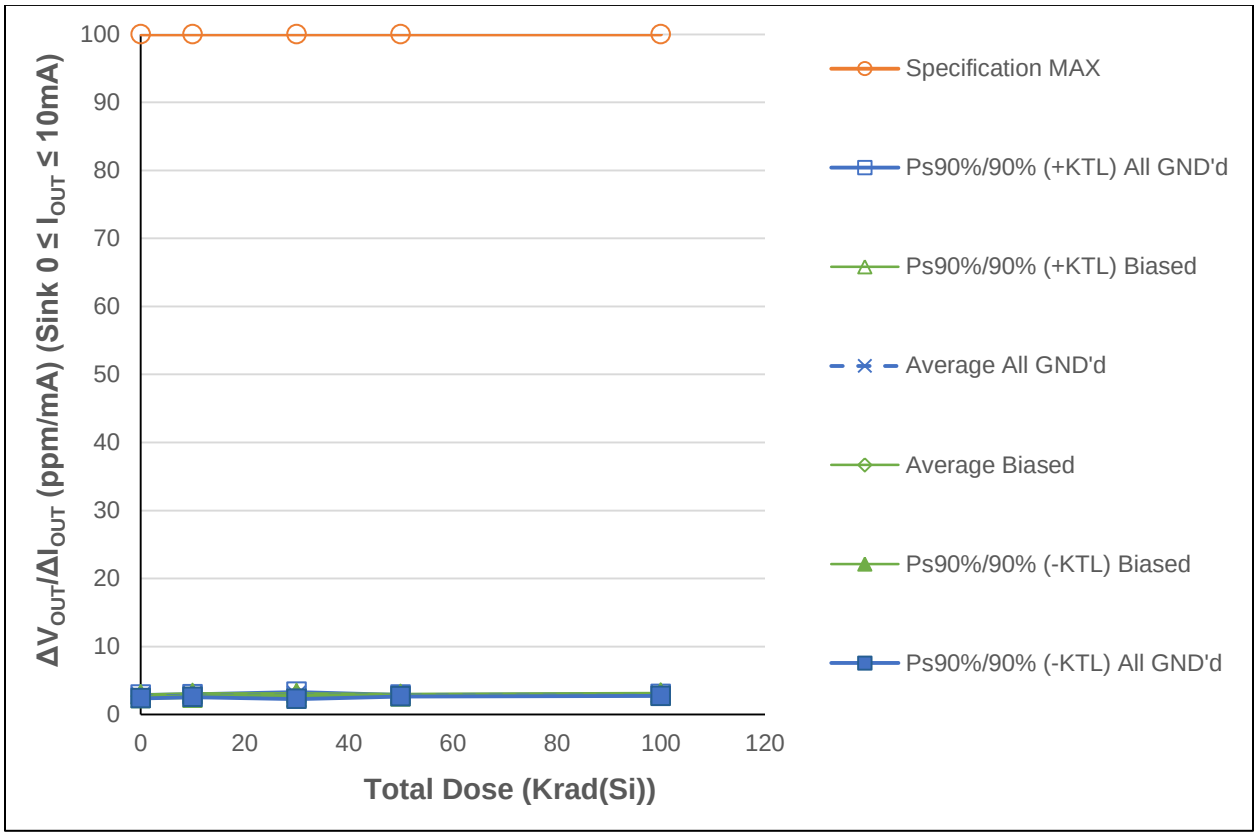

Figure 5.6: Plot of Load Regulation (Sinking 0 ≤ I_{OUT} ≤ 10mA) versus Total Dose

The maximum limits at different post-irradiation doses of the parameter are at 100 ppm/mA and the measured values are in the 2-3 ppm/mA range.

Table 5.6: Raw data for load regulation sinking (ppm/mA) with $0 \le I_{OUT} \le 10mA$ versus total dose including the statistical calculations, minimum specification, maximum specification, and thestatus of the test (PASS/FAIL)

Parameter	ΔVO/ΔIO (sink $0 \le I_{OUT} \le 10mA$)	Total Dose (Krad(Si)) @ 50 rads(Si)/s				
Unit #	(ppm/mA)	0	10	30	50	100
267	All GND'd Irradiation	2.6627	2.7964			
268	All GND'd Irradiation	2.6246	2.7507			
269	All GND'd Irradiation	2.5106	2.6820			
270	All GND'd Irradiation	2.7743	2.8821			
271	All GND'd Irradiation	2.5964	2.7358			
272	Biased Irradiation	2.6650	2.6898			
273	Biased Irradiation	2.6872	2.8326			
274	Biased Irradiation	2.7749	2.9546			
275	Biased Irradiation	2.6816	2.8255			
276	Biased Irradiation	2.4946	2.6506			
277	All GND'd Irradiation	2.5080		2.5974		
278	All GND'd Irradiation	2.5334		2.7418		
279	All GND'd Irradiation	2.9983		3.0772		
280	All GND'd Irradiation	2.5051		2.6983		
281	All GND'd Irradiation	2.6119		2.8887		
282	Biased Irradiation	2.7491		2.9141		
283	Biased Irradiation	2.4867		2.7007		
284	Biased Irradiation	2.5905		2.7933		
285	Biased Irradiation	2.5223		2.7714		
286	Biased Irradiation	2.7524		2.9606		
287	All GND'd Irradiation	2.5728			2.7190	
288	All GND'd Irradiation	2.4255			2.7794	
289	All GND'd Irradiation	2.5884			2.7927	
290	All GND'd Irradiation	2.6577			2.8232	
291	All GND'd Irradiation	2.4834			2.7406	
292	Biased Irradiation	2.6719			2.8818	
293	Biased Irradiation	2.6508			2.8979	
294	Biased Irradiation	2.5579			2.7943	
295	Biased Irradiation	2.5630			2.7195	
296	Biased Irradiation	2.5352			2.8326	
297	All GND'd Irradiation	2.6447				2.9021
298	All GND'd Irradiation	2.5633				2.7929
299	All GND'd Irradiation	2.6043				2.8796
300	All GND'd Irradiation	2.6255				2.9298
316	All GND'd Irradiation	2.6408				2.8723
317	Biased Irradiation	2.7174				3.0367
319	Biased Irradiation	2.6584				2.8963
320	Biased Irradiation	2.7053				3.0102
321	Biased Irradiation	2.8006				3.0024
322	Biased Irradiation	2.6534				2.8657
323	Control Unit	2.7372	2.7372	2.7372	2.7372	2.7372
324	Control Unit	2.5753	2.5753	2.5753	2.5753	2.5753
	All GND'd Irradiation Statistics					
	Average All GND'd	2.6337	2.7694	2.8007	2.7710	2.8753
	Std Dev All GND'd	0.0965	0.0751	0.1867	0.0415	0.0513
	Ps90%/90% (+KTL) All GND'd	2.8982	2.9753	3.3127	2.8848	3.0159
	Ps90%/90% (-KTL) All GND'd	2.3692	2.5636	2.2887	2.6571	2.7347
	Biased Irradiation Statistics					
	Average Biased	2.6607	2.7906	2.8280	2.8252	2.9622
	Std Dev Biased	0.1022	0.1221	0.1068	0.0719	0.0760
	Ps90%/90% (+KTL) Biased	2.9409	3.1254	3.1208	3.0223	3.1707
	Ps90%/90% (-KTL) Biased	2.3804	2.4558	2.5353	2.6281	2.7538
	Specificaiton MIN					
	Status (Measurements) All GND'd					
	Status (Measurements) Biased					
	Specification MAX	100	100	100	100	100
	Status (Measurements) All GND'd	PASS	PASS	PASS	PASS	PASS
	Status (Measurements) Biased	PASS	PASS	PASS	PASS	PASS
	Status (-KTL) All GND'd					
	Status (+KTL) All GND'd	PASS	PASS	PASS	PASS	PASS
	Status (-KTL) Biased					
	Status (+KTL) Biased	PASS	PASS	PASS	PASS	PASS

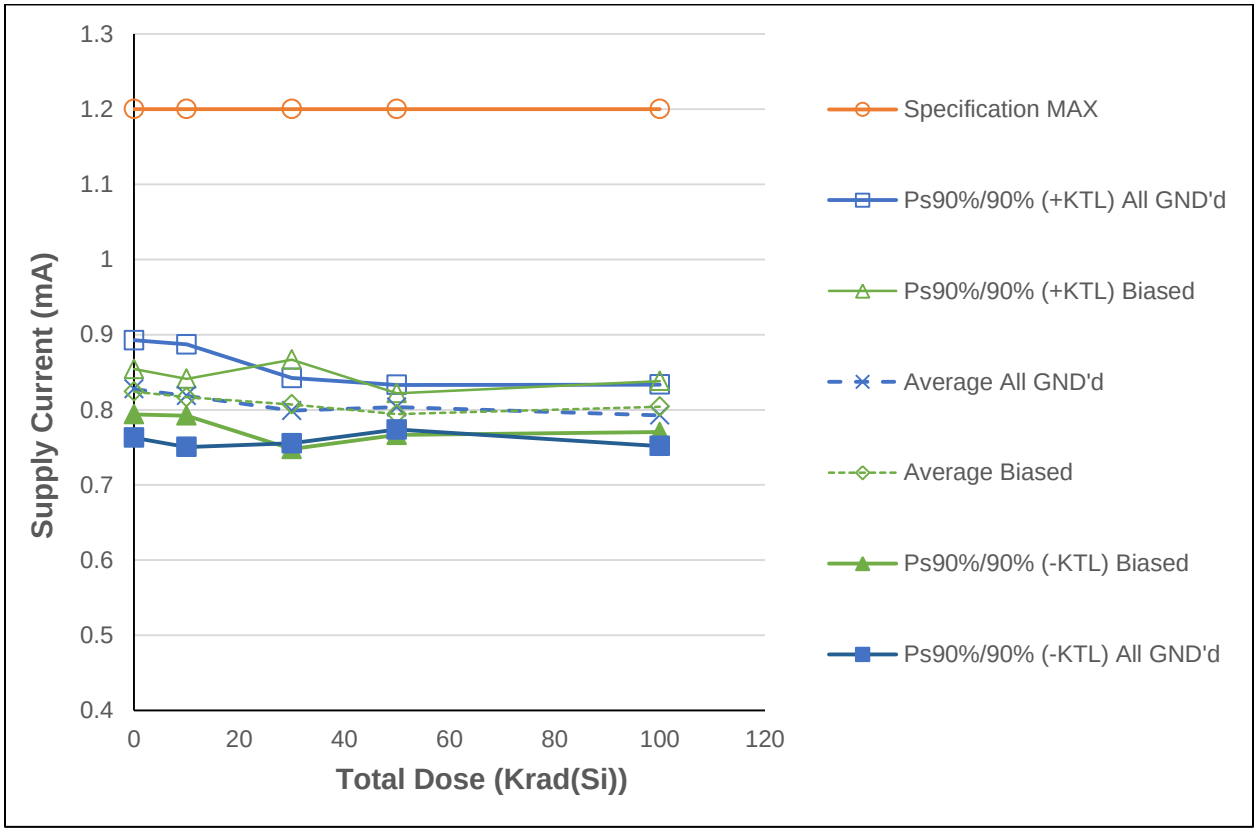

Figure 5.7: Plot of Supply Current versus Total Dose

The average measured values of 10 samples are within datasheet maximum limits.

Table 5.7: Raw data table for supply current (mA) versus total dose including the statistical calculations, minimum specification, maximum specification, and the status of the test (PASS/FAIL)

Parameter	IS	Total Dose (Krad(Si)) @ 50 rads(Si)/s				
Unit #	(mA)	0	10	30	50	100
267	All GND'd Irradiation	0.8330	0.8261			
268	All GND'd Irradiation	0.7941	0.7855			
269	All GND'd Irradiation	0.8523	0.8421			
270	All GND'd Irradiation	0.8448	0.8394			
271	All GND'd Irradiation	0.8142	0.8002			
272	Biased Irradiation	0.8121	0.8162			
273	Biased Irradiation	0.8205	0.8108			
274	Biased Irradiation	0.8181	0.8074			
275	Biased Irradiation	0.8293	0.8184			
276	Biased Irradiation	0.8403	0.8306			
277	All GND'd Irradiation	0.8062		0.7924		
278	All GND'd Irradiation	0.8221		0.8076		
279	All GND'd Irradiation	0.8114		0.7938		
280	All GND'd Irradiation	0.8385		0.8209		
281	All GND'd Irradiation	0.8051		0.7796		
282	Biased Irradiation	0.8449		0.8320		
283	Biased Irradiation	0.8463		0.8285		
284	Biased Irradiation	0.8050		0.7886		
285	Biased Irradiation	0.8169		0.8004		
286	Biased Irradiation	0.8045		0.7865		
287	All GND'd Irradiation	0.8199			0.8014	
288	All GND'd Irradiation	0.8424			0.8161	
289	All GND'd Irradiation	0.8328			0.8101	
290	All GND'd Irradiation	0.8021			0.7873	
291	All GND'd Irradiation	0.8287			0.8026	
292	Biased Irradiation	0.8039			0.7877	
293	Biased Irradiation	0.8325			0.8113	
294	Biased Irradiation	0.8043			0.7868	
295	Biased Irradiation	0.8127			0.7953	
296	Biased Irradiation	0.8080			0.7898	
297	All GND'd Irradiation	0.8408				0.8076
298	All GND'd Irradiation	0.8331				0.8013
299	All GND'd Irradiation	0.8137				0.7840
300	All GND'd Irradiation	0.8035				0.7710
316	All GND'd Irradiation	0.8266				0.7996
317	Biased Irradiation	0.8379				0.8123
319	Biased Irradiation	0.8377				0.8093
320	Biased Irradiation	0.8395				0.8162
321	Biased Irradiation	0.8185				0.7978
322	Biased Irradiation	0.8093				0.7858
323	Control Unit	0.8058	0.8058	0.8058	0.8058	0.8058
324	Control Unit	0.8445	0.8445	0.8445	0.8445	0.8445
	All GND'd Irradiation Statistics					
	Average All GND'd	0.8277	0.8186	0.7989	0.8035	0.7927
	Std Dev All GND'd	0.0236	0.0249	0.0158	0.0108	0.0149
	Ps90%/90% (+KTL) All GND'd	0.8925	0.8868	0.8423	0.8332	0.8336
	Ps90%/90% (-KTL) All GND'd	0.7628	0.7505	0.7555	0.7738	0.7518
	Biased Irradiation Statistics					
	Average Biased	0.8241	0.8167	0.8072	0.7942	0.8043
	Std Dev Biased	0.0110	0.0089	0.0217	0.0101	0.0124
	Ps90%/90% (+KTL) Biased	0.8542	0.8411	0.8667	0.8220	0.8383
	Ps90%/90% (-KTL) Biased	0.7940	0.7922	0.7477	0.7664	0.7702
	Specificaiton MIN					
	Status (Measurements) All GND'd					
	Status (Measurements) Biased					
	Specification MAX	1.2	1.2	1.2	1.2	1.2
	Status (Measurements) All GND'd	PASS	PASS	PASS	PASS	PASS
	Status (Measurements) Biased	PASS	PASS	PASS	PASS	PASS
	Status (-KTL) All GND'd					
	Status (+KTL) All GND'd	PASS	PASS	PASS	PASS	PASS
	Status (-KTL) Biased					
	Status (+KTL) Biased	PASS	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: Side View showing serial number

Appendix B

Radiation Bias Connection Tables

Table B1: Biased Conditions

Pin	Function	Connection / Bias
1	NC	NC
2	V_{IN}	To 15V, 0.1uF decoupling to pin 4
3	NC	NC
4	GND	To -15V, 0.1uF decoupling to pin 2
5	TRIM	NC
6	V_{OUT}	NC
7	NC	NC
8	NC	NC

Table B2: All GND'd

Pin	Function	Connection / Bias
1	NC	GND
2	V_{IN}	GND
3	NC	GND
4	GND	GND
5	TRIM	GND
6	V_{OUT}	GND
7	NC	GND
8	NC	GND

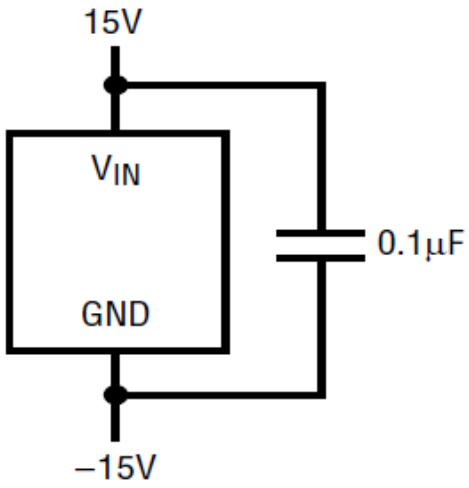

Figure B1: Total Dose Bias Circuit

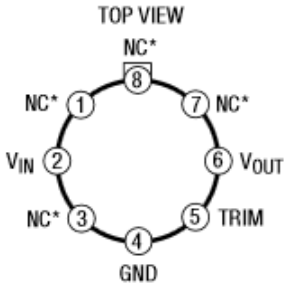

Figure B2: Pin-Out

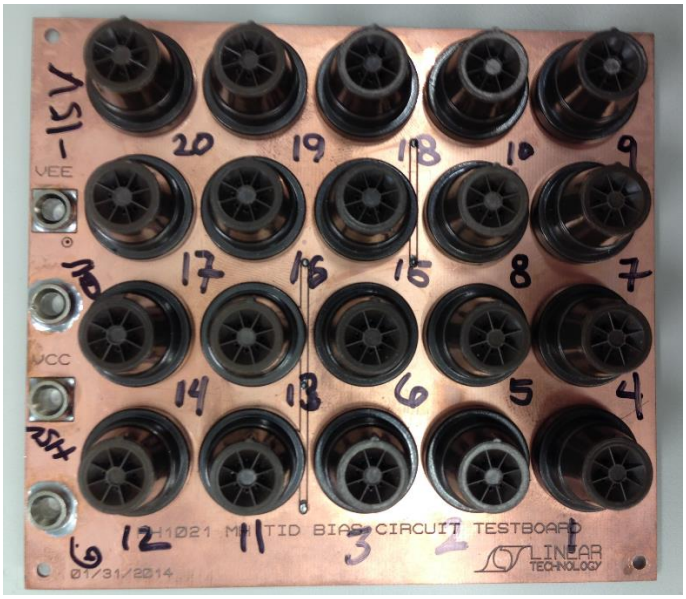

Figure B3: Bias Board (top view)

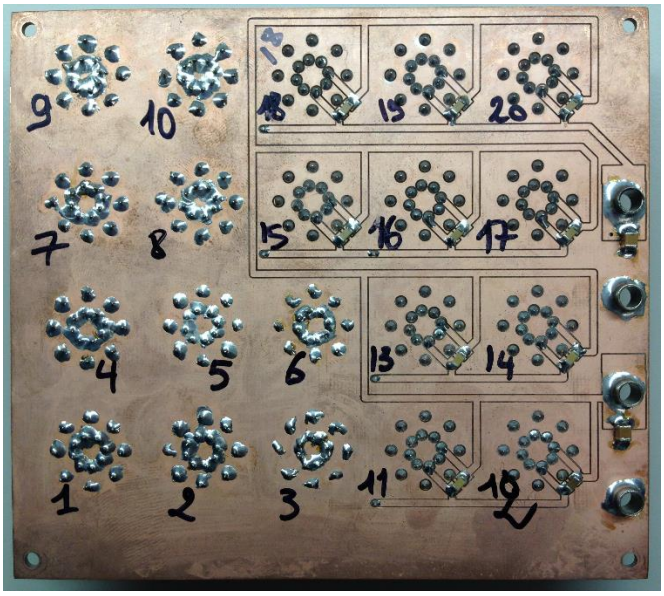

Figure B4: Bias Board (bottom view)

Appendix C

TEST CERTIFICATE

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

ACCREDITED
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: 2014-02-26 Test Certificate #: 2014-NRC-024 Total Pages (except cover): 2

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Appendix D

Table D1: Electrical Characteristics of Device-Under-Test

Parameter	Pre-irradiation MIN	Pre-irradiation MAX	10 Krad(Si) MIN	10 Krad(Si) MAX	20 Krad(Si) MIN	20 Krad(Si) MAX	50 Krad(Si) MIN	50 Krad(Si) MAX	100 Krad(Si) MIN	100 Krad(Si) MAX	Units
Output Voltage	4.9975	5.0025	4.9945	5.0055	4.9993	5.0070	4.9910	5.0090	4.9875	5.0125	V
Output Voltage Temperature Coefficient		20		20		20		20		22	ppm/°C
Line Regulation ($7.2V \le V_{IN} \le 10V$)		12		12		12		13.5		15	ppm/V
Line Regulation ($10V \le V_{IN} \le 40V$)		6		6		6		6		7	ppm/V
Load Regulation (Source)*		20		20		20		20		20	ppm/mA
Load Regulation (Sink)*		100		100		100		100		100	ppm/mA
Supply Current		1.2		1.2		1.2		1.2		1.2	mA

* ($0 \le I_{OUT} \le 10mA$)