

Total Ionization Dose (TID) Test Results of the RH1021BMH-10 Precision 10V Reference @ High Dose Rate (HDR)

HDR = 50 rads(Si)/s

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Acknowledgements

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TID HDR Testing of the RH1021BMH-10 Precision 10V Reference

Part Type Tested: RH1021-10 Precision 10V Reference

Traceability Information: Fab Lot# 1245822.1; Wafer # 1; Assembly Lot # 724755.1; Date Code: 1332A. 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 93-97, 105-109, 116-120, 180, and 187-191 had all pins tied to ground during irradiation. Serial numbers 99-103, 110-114, 182-186, and 192-198 were biased during irradiation. Serial numbers 199 and 200 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 93-103 were irradiated to 10 Krads(Si). Serial numbers 105-114 were used for 30 Krads(Si) group. The following serial numbers 116-120, 180, and 182-186 were irradiated to 50 Krads(Si). The last group with serial numbers 187-198 were exposed to 100 Krads(Si). All 42 samples were electrically tested pre- and post-irradiation.

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 ERHB102110.01; LTX post-irradiation test program ERHB102110.01; 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 $24^{\circ}\text{C}\pm 6^{\circ}\text{C}$ 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 10 mrad(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 groups were biased at +/- 15V and other five of the same 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 high dose-rate test is that five samples irradiated under electrical bias of each group 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 $7.2V \leq V_{IN} \leq 10V$ (ppm/V)
- Line Regulation with condition $710V \leq V_{IN} \leq 40V$ (ppm/V)
- Load Regulation (Sourcing Current) (ppm/mA)
- Load Regulation (Sinking Current) (ppm/mA)
- Supply Current (Series Mode) (mA)
- Minimum Supply Current (Shunt Mode) (μA)

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 eight 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

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

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

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 $P_{s90\%/90\%}$ 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.

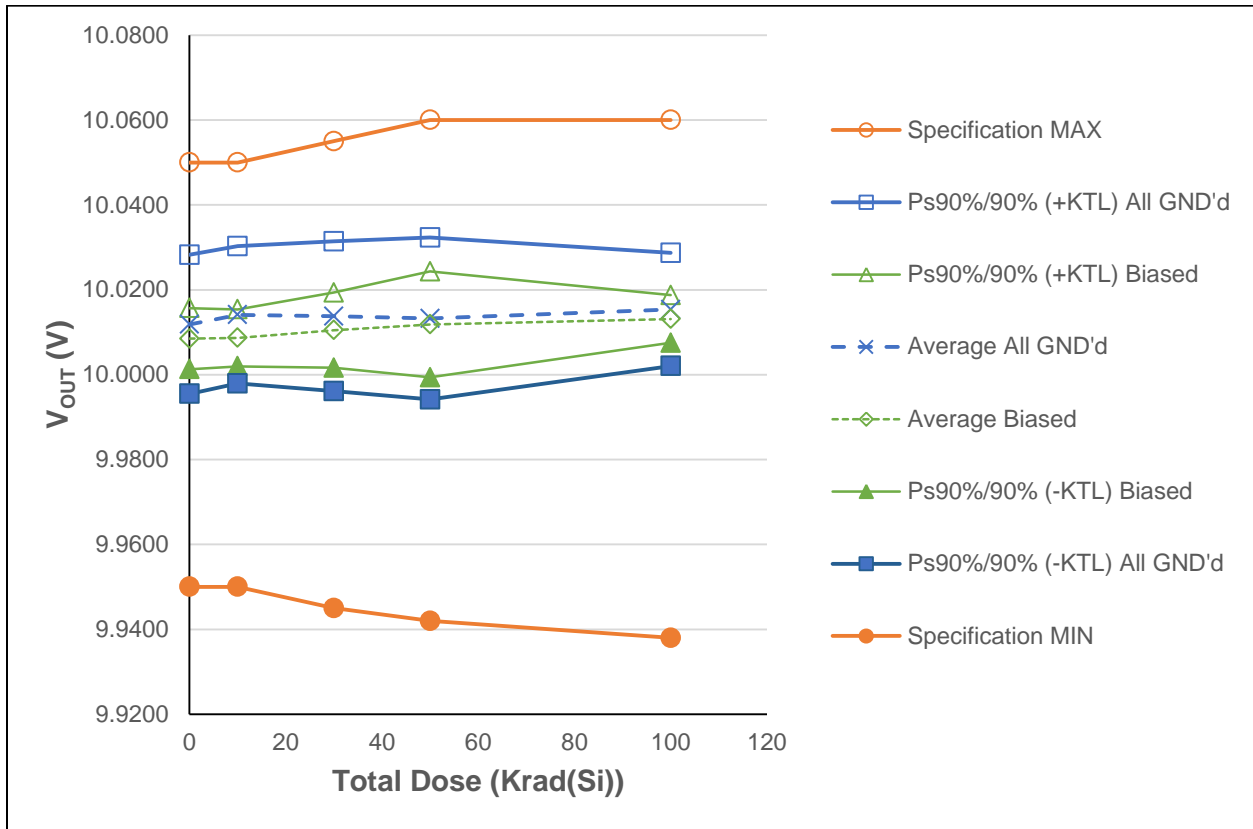


Figure 5.1 Plot of Output Voltage versus Total Dose

The post-irradiation measured values are within specification datasheet limits.

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 Unit #	VOUT (V)	Total Dose (Krad(Si)) @ 50 rads(Si)/s				
		0	10	30	50	100
93	All GND'd Irradiation	10.0079	10.0104			
94	All GND'd Irradiation	10.0034	10.0057			
95	All GND'd Irradiation	10.0166	10.0185			
96	All GND'd Irradiation	10.0142	10.0163			
97	All GND'd Irradiation	10.0172	10.0196			
99	Biased Irradiation	10.0060	10.0064			
100	Biased Irradiation	10.0102	10.0103			
101	Biased Irradiation	10.0111	10.0111			
102	Biased Irradiation	10.0097	10.0099			
103	Biased Irradiation	10.0054	10.0058			
105	All GND'd Irradiation	10.0134		10.0160		
106	All GND'd Irradiation	10.0171		10.0193		
107	All GND'd Irradiation	10.0015		10.0041		
108	All GND'd Irradiation	10.0079		10.0106		
109	All GND'd Irradiation	10.0162		10.0188		
110	Biased Irradiation	10.0084		10.0076		
111	Biased Irradiation	10.0147		10.0139		
112	Biased Irradiation	10.0150		10.0140		
113	Biased Irradiation	10.0081		10.0075		
114	Biased Irradiation	10.0105		10.0094		
116	All GND'd Irradiation	10.0148			10.0172	
118	All GND'd Irradiation	10.0006			10.0034	
119	All GND'd Irradiation	10.0147			10.0173	
120	All GND'd Irradiation	10.0057			10.0085	
180	All GND'd Irradiation	10.0179			10.0198	
182	Biased Irradiation	10.0177			10.0160	
183	Biased Irradiation	10.0066			10.0058	
184	Biased Irradiation	10.0109			10.0100	
185	Biased Irradiation	10.0187			10.0168	
186	Biased Irradiation	10.0122			10.0107	
187	All GND'd Irradiation	10.0201				10.0221
188	All GND'd Irradiation	10.0143				10.0163
189	All GND'd Irradiation	10.0072				10.0104
190	All GND'd Irradiation	10.0079				10.0108
191	All GND'd Irradiation	10.0144				10.0172
192	Biased Irradiation	10.0142				10.0121
193	Biased Irradiation	10.0175				10.0152
196	Biased Irradiation	10.0172				10.0138
197	Biased Irradiation	10.0116				10.0101
198	Biased Irradiation	10.0164				10.0145
199	Control Unit	10.0081	10.0081	10.0081	10.0081	10.0081
200	Control Unit	10.0129	10.0129	10.0129	10.0129	10.0129
All GND'd Irradiation Statistics						
Average All GND'd		10.0119	10.0141	10.0138	10.0132	10.0154
Std Dev All GND'd		0.0060	0.0059	0.0064	0.0070	0.0049
Ps90%/90% (+KTL) All GND'd		10.0282	10.0303	10.0314	10.0323	10.0287
Ps90%/90% (-KTL) All GND'd		9.9955	9.9979	9.9961	9.9942	10.0020
Biased Irradiation Statistics						
Average Biased		10.0085	10.0087	10.0105	10.0119	10.0131
Std Dev Biased		0.0026	0.0024	0.0032	0.0046	0.0020
Ps90%/90% (+KTL) Biased		10.0157	10.0154	10.0193	10.0243	10.0187
Ps90%/90% (-KTL) Biased		10.0013	10.0020	10.0016	9.9994	10.0075
Specification MIN		9.95	9.95	9.945	9.942	9.938
Status (Measurements) All GND'd		PASS	PASS	PASS	PASS	PASS
Status (Measurements) Biased		PASS	PASS	PASS	PASS	PASS
Specification MAX		10.05	10.05	10.055	10.06	10.06
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		PASS	PASS	PASS	PASS	PASS
Status (-KTL) Biased		PASS	PASS	PASS	PASS	PASS
Status (+KTL) Biased		PASS	PASS	PASS	PASS	PASS

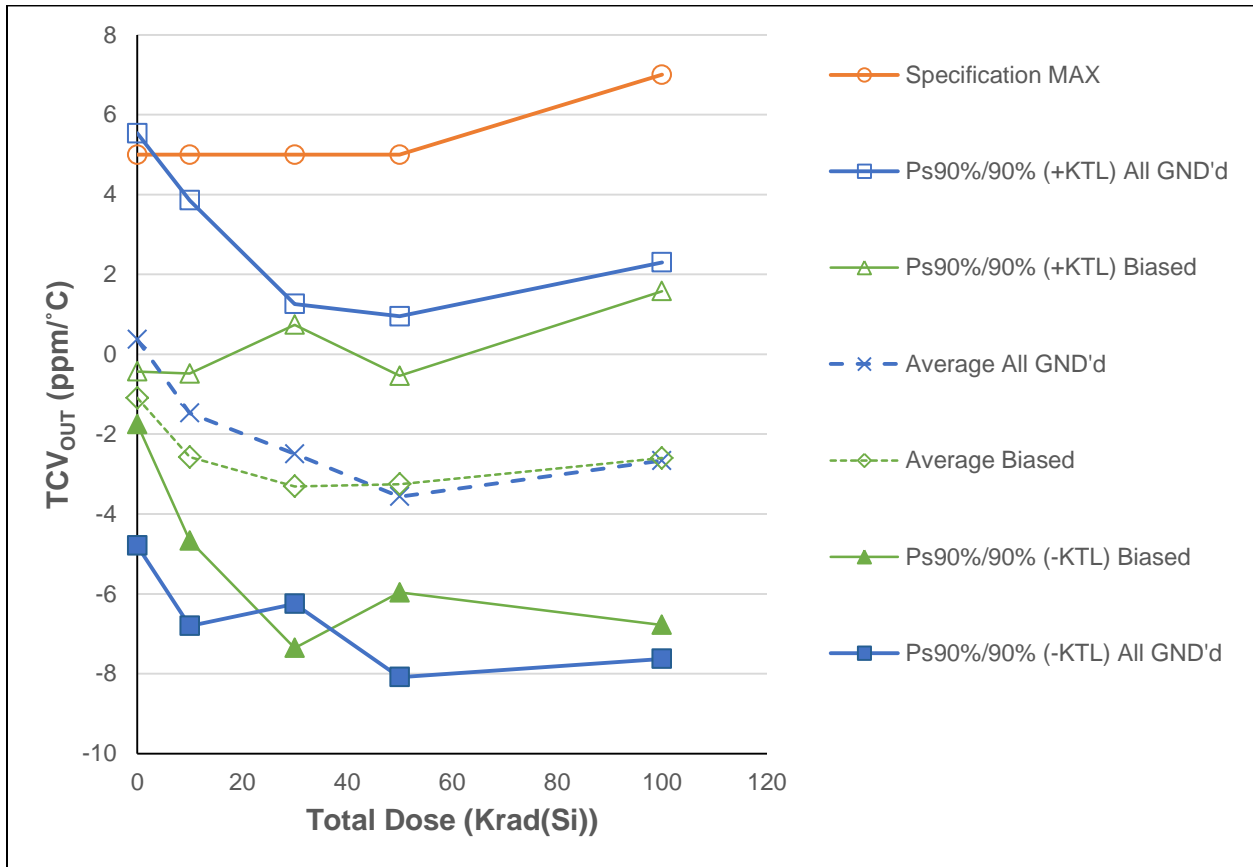


Figure 5.2: Plot of Output Voltage Temperature Coefficient versus Total Dose

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 Unit #	TCVOUT (ppm/°C)	Total Dose (Krad(Si)) @ 50 rads(Si)/s				
		0	10	30	50	100
93	All GND'd Irradiation	-1.0795	-3.1373			
94	All GND'd Irradiation	-2.0707	-3.9522			
95	All GND'd Irradiation	2.4673	0.2590			
96	All GND'd Irradiation	1.4965	0.1095			
97	All GND'd Irradiation	1.0424	-0.6420			
99	Biased Irradiation	-2.2041	-1.9125			
100	Biased Irradiation	-2.2020	-3.7651			
101	Biased Irradiation	-1.8432	-1.9029			
102	Biased Irradiation	-1.9582	-2.5891			
103	Biased Irradiation	-1.6442	-2.7149			
105	All GND'd Irradiation	0.3410		-2.8786		
106	All GND'd Irradiation	-0.3747		-1.4468		
107	All GND'd Irradiation	-1.7393		-4.2082		
108	All GND'd Irradiation	-1.3211		-3.1476		
109	All GND'd Irradiation	1.2094		-0.7930		
110	Biased Irradiation	-1.6564		-2.9540		
111	Biased Irradiation	-0.2729		-0.8860		
112	Biased Irradiation	-1.6227		-3.9578		
113	Biased Irradiation	-2.8492		-4.5091		
114	Biased Irradiation	-0.8731		-4.2323		
116	All GND'd Irradiation	0.7640			-1.5105	
118	All GND'd Irradiation	-1.9384			-5.9971	
119	All GND'd Irradiation	-0.1504			-4.0866	
120	All GND'd Irradiation	-2.1225			-2.9552	
180	All GND'd Irradiation	-0.8145			-3.2860	
182	Biased Irradiation	-1.3094			-3.1354	
183	Biased Irradiation	-0.5272			-2.4835	
184	Biased Irradiation	-0.6706			-4.1021	
185	Biased Irradiation	-0.8140			-4.4088	
186	Biased Irradiation	0.8101			-2.1334	
187	All GND'd Irradiation	-1.9253				-4.2553
188	All GND'd Irradiation	1.7311				0.3147
189	All GND'd Irradiation	-0.2956				-2.4841
190	All GND'd Irradiation	-0.9501				-3.9243
191	All GND'd Irradiation	0.8858				-2.9636
192	Biased Irradiation	-0.8090				-2.4718
193	Biased Irradiation	1.1913				-2.9255
196	Biased Irradiation	-1.2474				-1.1255
197	Biased Irradiation	-1.7169				-4.9971
198	Biased Irradiation	0.3687				-1.4779
199	Control Unit	-2.0499	-2.0499	-2.0499	-2.0499	-2.0499
200	Control Unit	-1.5130	-1.5130	-1.5130	-1.5130	-1.5130
All GND'd Irradiation Statistics						
Average All GND'd		0.3712	-1.4726	-2.4948	-3.5671	-2.6625
Std Dev All GND'd		1.8826	1.9437	1.3696	1.6476	1.8108
Ps90%/90% (+KTL) All GND'd		5.5334	3.8569	1.2607	0.9505	2.3026
Ps90%/90% (-KTL) All GND'd		-4.7910	-6.8021	-6.2504	-8.0847	-7.6276
Biased Irradiation Statistics						
Average Biased		-1.0925	-2.5769	-3.3079	-3.2526	-2.5996
Std Dev Biased		0.2403	0.7627	1.4757	0.9895	1.5249
Ps90%/90% (+KTL) Biased		-0.4336	-0.4856	0.7385	-0.5395	1.5818
Ps90%/90% (-KTL) Biased		-1.7515	-4.6682	-7.3542	-5.9658	-6.7809
Specification MIN						
Status (Measurements) All GND'd						
Status (Measurements) Biased						
Specification MAX						
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		FAIL	PASS	PASS	PASS	PASS
Status (-KTL) Biased						
Status (+KTL) Biased		PASS	PASS	PASS	PASS	PASS

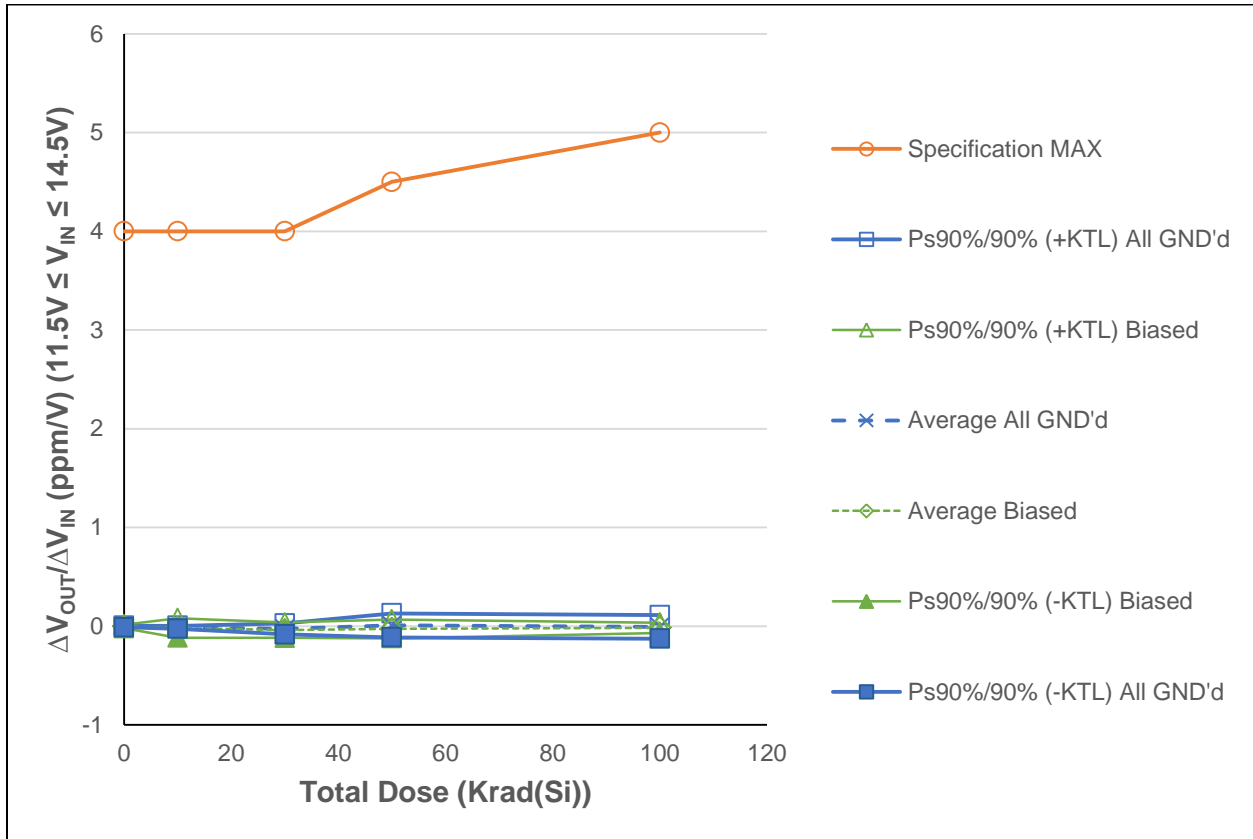


Figure 5.3: Plot of Line Regulation ($11.5V \leq V_{IN} \leq 14.5V$) versus Total Dose

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

Table 5.3: Raw data for line regulation (ppm/V) with $11.5V \leq V_{IN} \leq 14.5V$ versus total dose including the statistical calculations, minimum specification, maximum specification, and the status of the test (PASS/FAIL).

Parameter Unit #	$\Delta V_{OUT}/\Delta V_{IN}$ ($11.5V \leq V_{IN} \leq 14.5V$) (ppm/V)	Total Dose (Krad(Si)) @ 50 rads(Si)/s				
		0	10	30	50	100
93	All GND'd Irradiation	-0.0052	-0.0068			
94	All GND'd Irradiation	-0.0045	-0.0037			
95	All GND'd Irradiation	0.0022	-0.0172			
96	All GND'd Irradiation	-0.0024	-0.0104			
97	All GND'd Irradiation	-0.0050	-0.0138			
99	Biased Irradiation	0.0050	-0.0002			
100	Biased Irradiation	-0.0098	-0.0083			
101	Biased Irradiation	-0.0021	-0.0439			
102	Biased Irradiation	0.0018	-0.0618			
103	Biased Irradiation	-0.0099	0.0282			
105	All GND'd Irradiation	-0.0058		-0.0281		
106	All GND'd Irradiation	-0.0025		-0.0225		
107	All GND'd Irradiation	-0.0062		-0.0260		
108	All GND'd Irradiation	-0.0102		-0.0018		
109	All GND'd Irradiation	-0.0030		-0.0584		
110	Biased Irradiation	-0.0132		0.0081		
111	Biased Irradiation	-0.0041		-0.0636		
112	Biased Irradiation	-0.0035		-0.0385		
113	Biased Irradiation	-0.0129		-0.0473		
114	Biased Irradiation	-0.0018		-0.0575		
116	All GND'd Irradiation	0.0066			0.0629	
118	All GND'd Irradiation	-0.0118			0.0405	
119	All GND'd Irradiation	-0.0112			-0.0213	
120	All GND'd Irradiation	-0.0047			-0.0461	
180	All GND'd Irradiation	0.0065			0.0078	
182	Biased Irradiation	-0.0097			-0.0375	
183	Biased Irradiation	-0.0072			-0.0103	
184	Biased Irradiation	-0.0076			0.0192	
185	Biased Irradiation	-0.0043			-0.0313	
186	Biased Irradiation	-0.0018			-0.0750	
187	All GND'd Irradiation	-0.0160				0.0255
188	All GND'd Irradiation	-0.0041				0.0054
189	All GND'd Irradiation	-0.0170				-0.0098
190	All GND'd Irradiation	-0.0073				-0.0803
191	All GND'd Irradiation	-0.0052				0.0247
192	Biased Irradiation	-0.0076				-0.0459
193	Biased Irradiation	-0.0048				-0.0074
196	Biased Irradiation	-0.0150				-0.0224
197	Biased Irradiation	0.0001				0.0013
198	Biased Irradiation	-0.0112				-0.0037
199	Control Unit	-0.0032	-0.0032	-0.0032	-0.0032	-0.0032
200	Control Unit	-0.0004	-0.0004	-0.0004	-0.0004	-0.0004
	All GND'd Irradiation Statistics					
	Average All GND'd	-0.0030	-0.0104	-0.0273	0.0087	-0.0069
	Std Dev All GND'd	0.0031	0.0054	0.0203	0.0443	0.0436
	Ps90%/90% (+KTL) All GND'd	0.0055	0.0043	0.0282	0.1302	0.1126
	Ps90%/90% (-KTL) All GND'd	-0.0115	-0.0251	-0.0829	-0.1127	-0.1264
	Biased Irradiation Statistics					
	Average Biased	-0.0030	-0.0172	-0.0398	-0.0270	-0.0156
	Std Dev Biased	0.0067	0.0358	0.0284	0.0348	0.0191
	Ps90%/90% (+KTL) Biased	0.0154	0.0810	0.0382	0.0685	0.0368
	Ps90%/90% (-KTL) Biased	-0.0214	-0.1155	-0.1178	-0.1224	-0.0680
	Specification MIN					
	Status (Measurements) All GND'd					
	Status (Measurements) Biased					
	Specification MAX					
	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

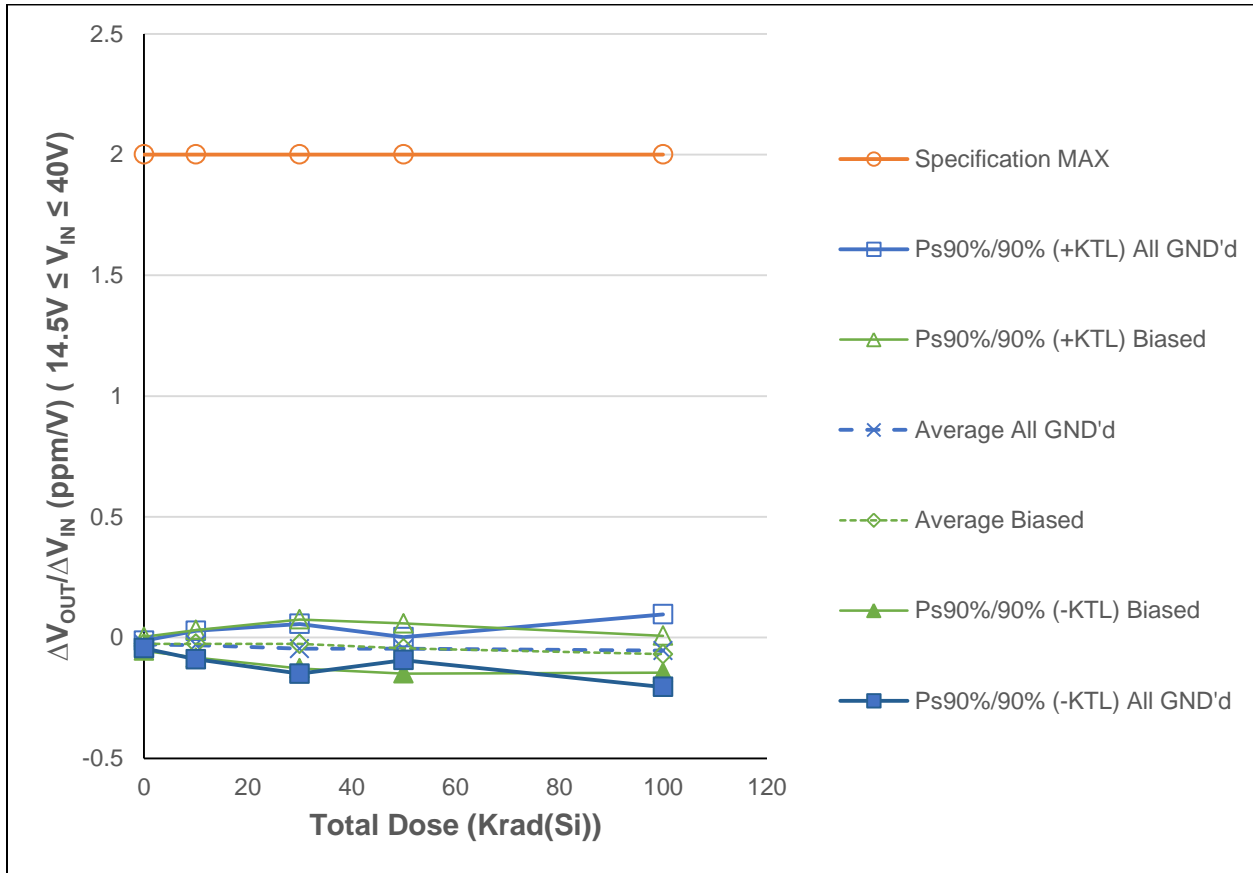


Figure 5.4: Plot of Line Regulation ($14.5V \leq V_{IN} \leq 40V$) versus Total Dose

All measured data points are well under datasheet upper limits.

Table 5.4: Raw data for line regulation (ppm/V) with $14.5V \leq V_{IN} \leq 40V$ versus total dose including the statistical calculations, minimum specification, maximum specification, and the status of the test (PASS/FAIL).

Parameter Unit #	$\Delta V_{OUT}/\Delta V_{IN}$ ($14.5V \leq V_{IN} \leq 40V$) (ppm/V)	Total Dose (Krad(Si)) @ 50 rads(Si)/s					
		0	10	30	50	100	
93	All GND'd Irradiation	-0.0233	-0.0224				
94	All GND'd Irradiation	-0.0306	-0.0469				
95	All GND'd Irradiation	-0.0376	-0.0572				
96	All GND'd Irradiation	-0.0264	-0.0263				
97	All GND'd Irradiation	-0.0250	-0.0023				
99	Biased Irradiation	-0.0440	-0.0312				
100	Biased Irradiation	-0.0189	-0.0063				
101	Biased Irradiation	-0.0257	-0.0324				
102	Biased Irradiation	-0.0182	-0.0053				
103	Biased Irradiation	-0.0237	-0.0554				
105	All GND'd Irradiation	-0.0283		-0.0343			
106	All GND'd Irradiation	-0.0421		-0.0799			
107	All GND'd Irradiation	-0.0519		-0.0336			
108	All GND'd Irradiation	-0.0354		-0.0887			
109	All GND'd Irradiation	-0.0199		0.0031			
110	Biased Irradiation	-0.0347		-0.0770			
111	Biased Irradiation	-0.0170		-0.0032			
112	Biased Irradiation	-0.0356		-0.0548			
113	Biased Irradiation	-0.0197		0.0063			
114	Biased Irradiation	-0.0260		-0.0036			
116	All GND'd Irradiation	-0.0366			-0.0514		
118	All GND'd Irradiation	-0.0488			-0.0737		
119	All GND'd Irradiation	-0.0294			-0.0415		
120	All GND'd Irradiation	-0.0333			-0.0325		
180	All GND'd Irradiation	-0.0264			-0.0317		
182	Biased Irradiation	-0.0240			-0.0239		
183	Biased Irradiation	-0.0349			-0.0533		
184	Biased Irradiation	-0.0365			-0.1075		
185	Biased Irradiation	-0.0329			-0.0290		
186	Biased Irradiation	-0.0224			-0.0129		
187	All GND'd Irradiation	-0.0080				-0.0829	
188	All GND'd Irradiation	-0.0287				-0.0318	
189	All GND'd Irradiation	-0.0336				-0.0788	
190	All GND'd Irradiation	-0.0495				0.0303	
191	All GND'd Irradiation	-0.0357				-0.1084	
192	Biased Irradiation	-0.0308				-0.0822	
193	Biased Irradiation	-0.0234				-0.0260	
196	Biased Irradiation	-0.0354				-0.0615	
197	Biased Irradiation	-0.0323				-0.0761	
198	Biased Irradiation	-0.0296				-0.0998	
199	Control Unit	-0.0305	-0.0305	-0.0305	-0.0305	-0.0305	
200	Control Unit	-0.0090	-0.0090	-0.0090	-0.0090	-0.0090	
	All GND'd Irradiation Statistics						
	Average All GND'd	-0.0286	-0.0310	-0.0467	-0.0462	-0.0543	
	Std Dev All GND'd	0.0057	0.0215	0.0377	0.0173	0.0548	
	Ps90%/90% (+KTL) All GND'd	-0.0129	0.0281	0.0566	0.0014	0.0959	
	Ps90%/90% (-KTL) All GND'd	-0.0443	-0.0901	-0.1500	-0.0937	-0.2045	
	Biased Irradiation Statistics						
	Average Biased	-0.0261	-0.0261	-0.0264	-0.0453	-0.0691	
	Std Dev Biased	0.0105	0.0209	0.0370	0.0377	0.0278	
	Ps90%/90% (+KTL) Biased	0.0027	0.0313	0.0751	0.0581	0.0070	
	Ps90%/90% (-KTL) Biased	-0.0548	-0.0835	-0.1280	-0.1488	-0.1452	
	Specification MIN						
	Status (Measurements) All GND'd						
	Status (Measurements) Biased						
	Specification MAX						
	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	

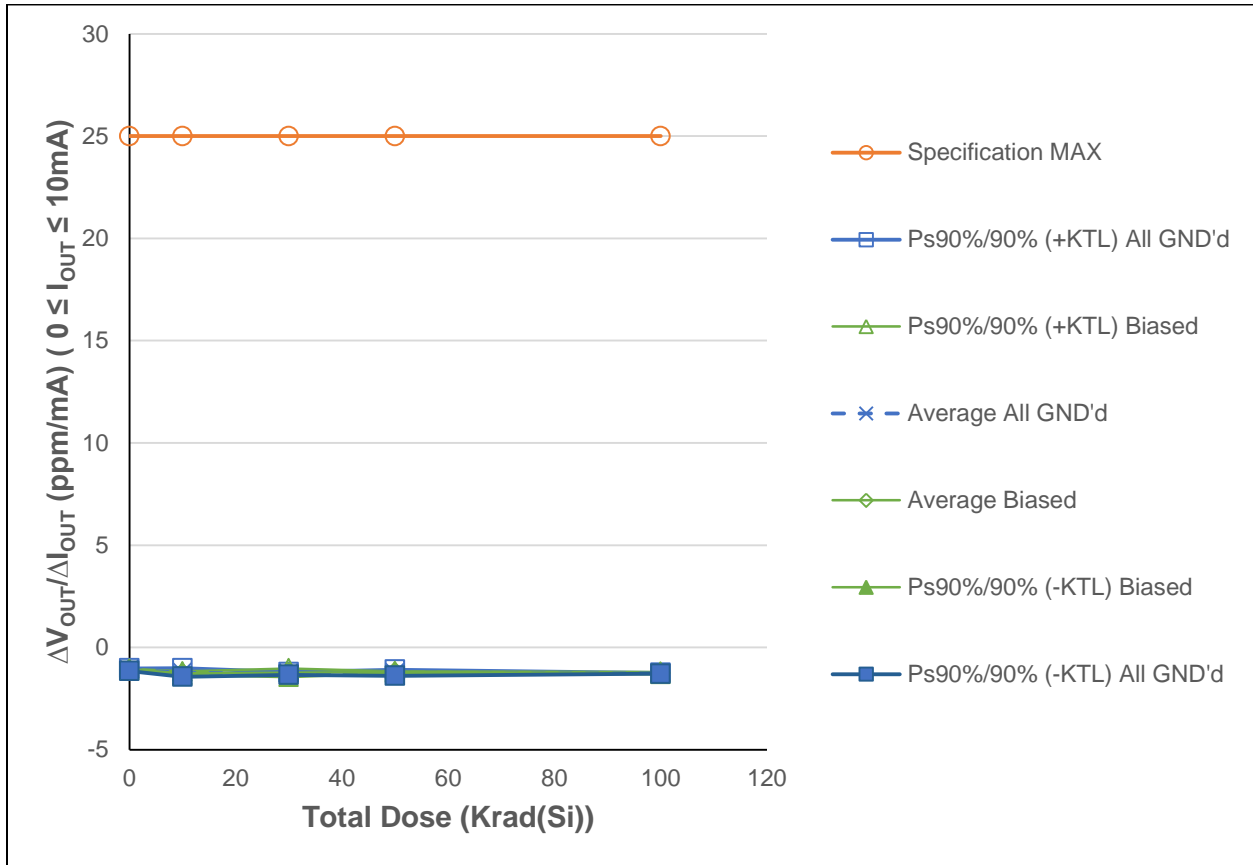


Figure 5.5: Plot of Load Regulation (Sourcing $0 \leq I_{OUT} \leq 10mA$) versus Total Dose

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 Unit #	$\Delta VO/\Delta IO$ (Source $0 \leq I_{OUT} \leq 10mA$) (ppm/mA)	Total Dose (Krad(Si)) @ 50 rads(Si)/s				
		0	10	30	50	100
93	All GND'd Irradiation	-1.0930	-1.2611			
94	All GND'd Irradiation	-1.0751	-1.1377			
95	All GND'd Irradiation	-1.0787	-1.3091			
96	All GND'd Irradiation	-1.0635	-1.1504			
97	All GND'd Irradiation	-1.1249	-1.2634			
99	Biased Irradiation	-1.0679	-1.2358			
100	Biased Irradiation	-1.0761	-1.2747			
101	Biased Irradiation	-1.0959	-1.2795			
102	Biased Irradiation	-1.0664	-1.2167			
103	Biased Irradiation	-1.0862	-1.2925			
105	All GND'd Irradiation	-1.0695		-1.2617		
106	All GND'd Irradiation	-1.0498		-1.2649		
107	All GND'd Irradiation	-1.1148		-1.3116		
108	All GND'd Irradiation	-1.0272		-1.2488		
109	All GND'd Irradiation	-1.0923		-1.2781		
110	Biased Irradiation	-1.0697		-1.2860		
111	Biased Irradiation	-1.0912		-1.2986		
112	Biased Irradiation	-1.0656		-1.2743		
113	Biased Irradiation	-1.0828		-1.1885		
114	Biased Irradiation	-1.0525		-1.1220		
116	All GND'd Irradiation	-1.0702			-1.2204	
118	All GND'd Irradiation	-1.0971			-1.3078	
119	All GND'd Irradiation	-1.1104			-1.2712	
120	All GND'd Irradiation	-1.0849			-1.2165	
180	All GND'd Irradiation	-1.0729			-1.1643	
182	Biased Irradiation	-1.0232			-1.1919	
183	Biased Irradiation	-1.0756			-1.2021	
184	Biased Irradiation	-1.0953			-1.2264	
185	Biased Irradiation	-1.0601			-1.1950	
186	Biased Irradiation	-1.0827			-1.1944	
187	All GND'd Irradiation	-1.0810				-1.2645
188	All GND'd Irradiation	-1.0994				-1.2695
189	All GND'd Irradiation	-1.0804				-1.2578
190	All GND'd Irradiation	-1.0412				-1.2561
191	All GND'd Irradiation	-1.0763				-1.2694
192	Biased Irradiation	-1.0318				-1.2628
193	Biased Irradiation	-1.0359				-1.2781
196	Biased Irradiation	-1.0470				-1.2506
197	Biased Irradiation	-1.0737				-1.2240
198	Biased Irradiation	-1.0754				-1.2447
199	Control Unit	-1.0618	-1.0618	-1.0618	-1.0618	-1.0618
200	Control Unit	-1.0640	-1.0640	-1.0640	-1.0640	-1.0640
	All GND'd Irradiation Statistics					
	Average All GND'd	-1.0870	-1.2243	-1.2730	-1.2360	-1.2635
	Std Dev All GND'd	0.0236	0.0759	0.0240	0.0551	0.0063
	Ps90%/90% (+KTL) All GND'd	-1.0223	-1.0162	-1.2073	-1.0848	-1.2461
	Ps90%/90% (-KTL) All GND'd	-1.1518	-1.4325	-1.3387	-1.3872	-1.2808
	Biased Irradiation Statistics					
	Average Biased	-1.0785	-1.2598	-1.2339	-1.2019	-1.2520
	Std Dev Biased	0.0125	0.0321	0.0760	0.0142	0.0202
	Ps90%/90% (+KTL) Biased	-1.0441	-1.1719	-1.0255	-1.1631	-1.1966
	Ps90%/90% (-KTL) Biased	-1.1129	-1.3478	-1.4423	-1.2408	-1.3075
	Specification MIN					
	Status (Measurements) All GND'd					
	Status (Measurements) Biased					
	Specification MAX					
	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

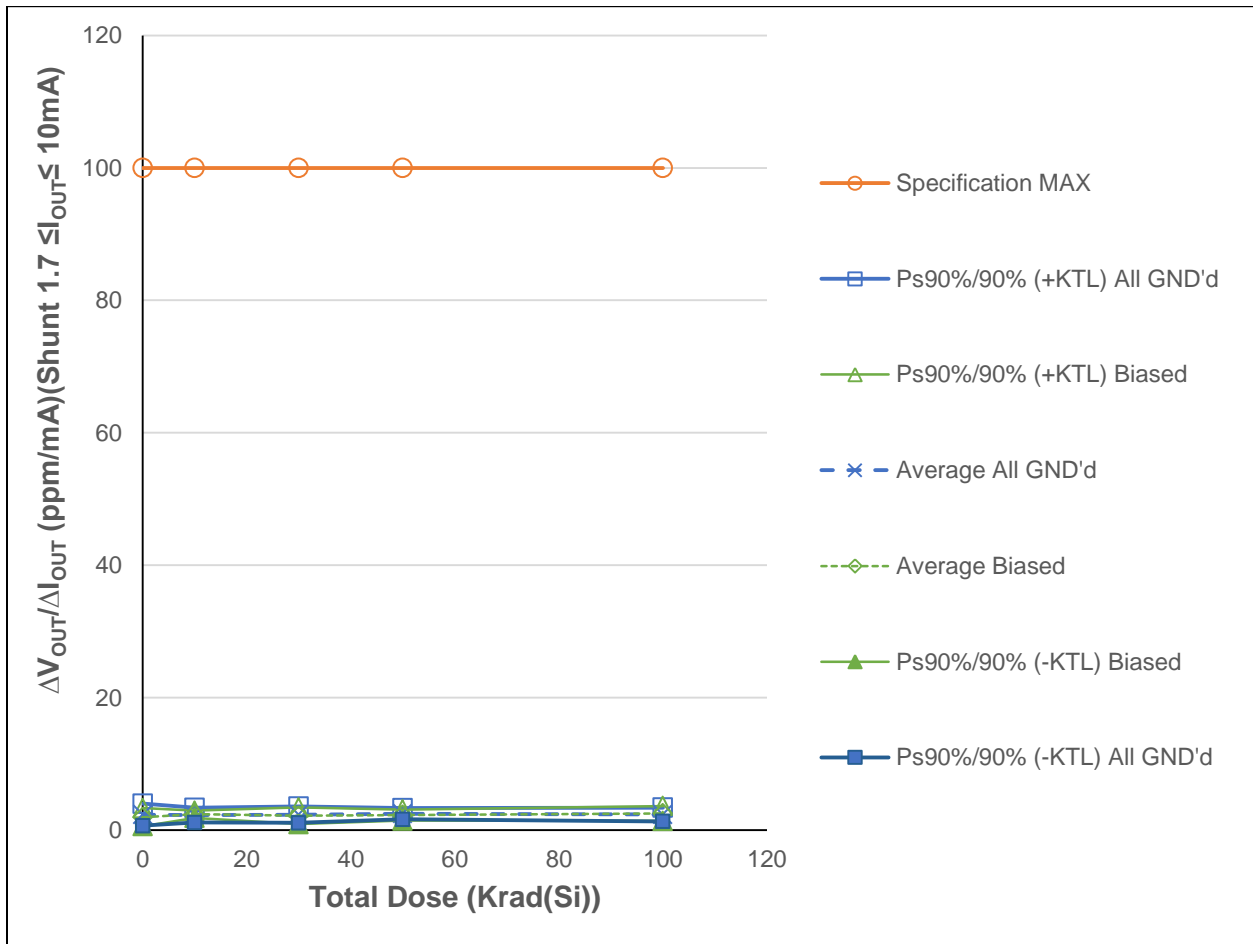


Figure 5.6: Plot of Load Regulation (Shunting $1.7\text{mA} \leq I_{OUT} \leq 10\text{mA}$) versus Total Dose

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 shunting (ppm/mA) with $1.7\text{mA} \leq I_{\text{OUT}} \leq 10\text{mA}$ versus total dose including the statistical calculations, minimum specification, maximum specification, and the status of the test (PASS/FAIL)

Parameter	$\Delta V_O/\Delta I_O$ (Shunt $1.7 \leq I_{\text{OUT}} \leq 10\text{mA}$)	Total Dose (Krad(Si)) @ 50 rads(Si)/s				
Unit #	(ppm/mA)	0	10	30	50	100
93	All GND'd Irradiation	1.5782	1.8927			
94	All GND'd Irradiation	2.7202	1.8927			
95	All GND'd Irradiation	3.0248	2.8106			
96	All GND'd Irradiation	1.8066	2.5046			
97	All GND'd Irradiation	2.4157	2.1222			
99	Biased Irradiation	2.4918	2.3516			
100	Biased Irradiation	1.5782	2.0457			
101	Biased Irradiation	1.5782	2.5046			
102	Biased Irradiation	1.5782	2.5046			
103	Biased Irradiation	2.4918	2.5046			
105	All GND'd Irradiation	2.1873		1.8162		
106	All GND'd Irradiation	2.7964		2.6576		
107	All GND'd Irradiation	2.0350		2.8106		
108	All GND'd Irradiation	2.1873		2.4281		
109	All GND'd Irradiation	2.1873		1.8927		
110	Biased Irradiation	2.1873		2.1987		
111	Biased Irradiation	2.5679		2.8106		
112	Biased Irradiation	2.1873		2.1222		
113	Biased Irradiation	2.6441		1.5103		
114	Biased Irradiation	2.3395		2.1222		
116	All GND'd Irradiation	2.4918			2.4281	
118	All GND'd Irradiation	2.5679			2.8106	
119	All GND'd Irradiation	1.9589			2.7341	
120	All GND'd Irradiation	2.4918			2.1987	
180	All GND'd Irradiation	2.8725			2.1222	
182	Biased Irradiation	2.1873			1.8162	
183	Biased Irradiation	2.5679			2.3516	
184	Biased Irradiation	2.1873			2.6576	
185	Biased Irradiation	2.1873			2.2752	
186	Biased Irradiation	2.0350			2.1987	
187	All GND'd Irradiation	2.4157				1.8927
188	All GND'd Irradiation	1.7305				2.2752
189	All GND'd Irradiation	2.1873				2.1222
190	All GND'd Irradiation	1.8827				2.6576
191	All GND'd Irradiation	1.5021				2.8106
192	Biased Irradiation	2.9486				2.4281
193	Biased Irradiation	2.3395				2.2752
196	Biased Irradiation	2.8725				2.1222
197	Biased Irradiation	1.8827				2.5046
198	Biased Irradiation	2.8725				3.1930
199	Control Unit	1.5021	1.5021	1.5021	1.5021	1.5021
200	Control Unit	2.0350	2.0350	2.0350	2.0350	2.0350
All GND'd Irradiation Statistics						
Average All GND'd		2.3091	2.2446	2.3210	2.4587	2.3516
Std Dev All GND'd		0.6081	0.4033	0.4480	0.3088	0.3786
Ps90%/90% (+KTL) All GND'd		3.9766	3.3504	3.5494	3.3055	3.3898
Ps90%/90% (-KTL) All GND'd		0.6416	1.1387	1.0927	1.6120	1.3135
Biased Irradiation Statistics						
Average Biased		1.9437	2.3822	2.1528	2.2599	2.5046
Std Dev Biased		0.5004	0.1995	0.4608	0.3031	0.4119
Ps90%/90% (+KTL) Biased		3.3158	2.9292	3.4164	3.0909	3.6341
Ps90%/90% (-KTL) Biased		0.5715	1.8353	0.8891	1.4288	1.3752
Specification 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

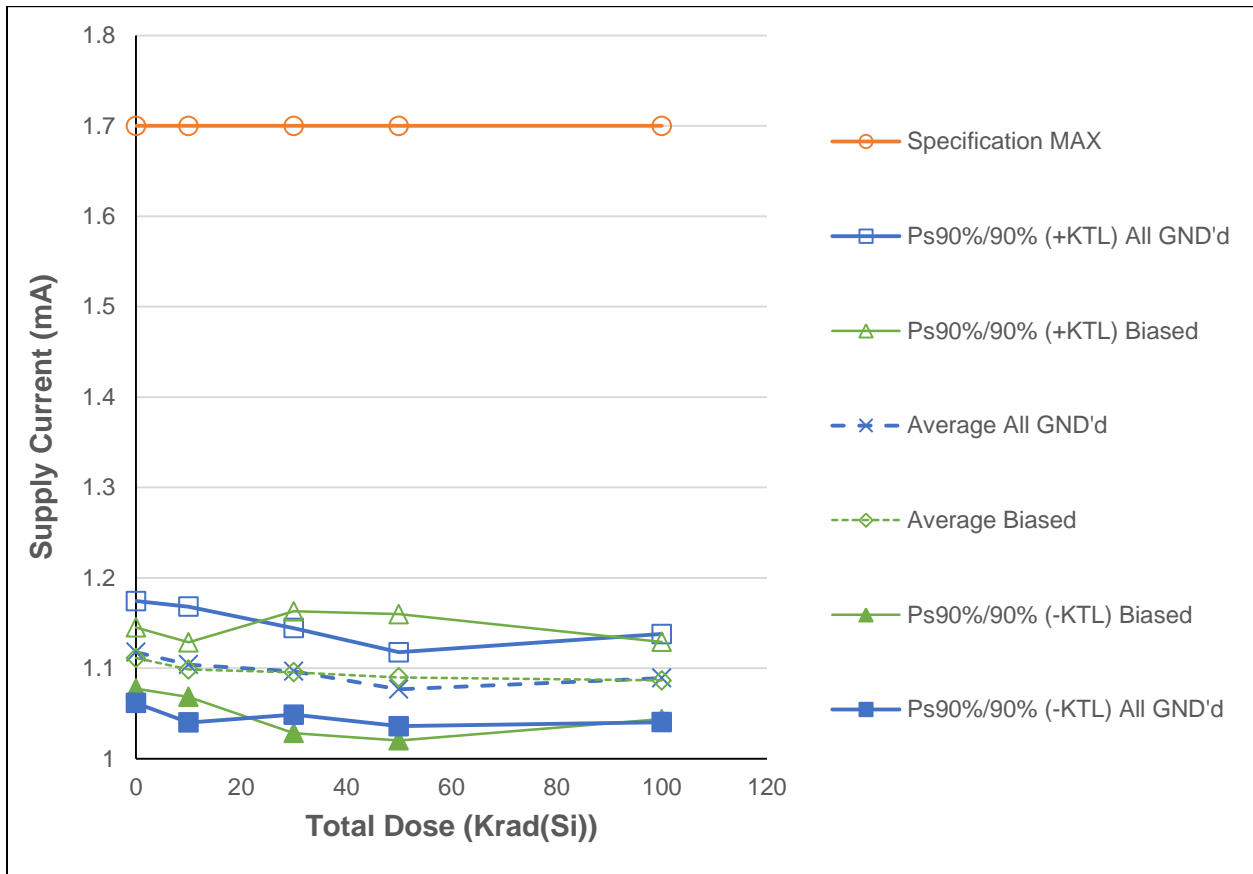


Figure 5.7: Plot of Supply Current versus Total Dose

The average measured values of 40 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 Unit #	IS (mA)	Total Dose (Krad(Si)) @ 50 rads(Si)/s				
		0	10	30	50	100
93	All GND'd Irradiation	1.1075	1.0950			
94	All GND'd Irradiation	1.1093	1.0852			
95	All GND'd Irradiation	1.1446	1.1326			
96	All GND'd Irradiation	1.1338	1.1254			
97	All GND'd Irradiation	1.0946	1.0822			
99	Biased Irradiation	1.1196	1.1076			
100	Biased Irradiation	1.1141	1.1023			
101	Biased Irradiation	1.1081	1.0944			
102	Biased Irradiation	1.0917	1.0813			
103	Biased Irradiation	1.1230	1.1071			
105	All GND'd Irradiation	1.1364		1.1208		
106	All GND'd Irradiation	1.0896		1.0732		
107	All GND'd Irradiation	1.1057		1.0906		
108	All GND'd Irradiation	1.1145		1.0948		
109	All GND'd Irradiation	1.1224		1.1035		
110	Biased Irradiation	1.1179		1.0951		
111	Biased Irradiation	1.1493		1.1293		
112	Biased Irradiation	1.1302		1.1094		
113	Biased Irradiation	1.0964		1.0715		
114	Biased Irradiation	1.0912		1.0730		
116	All GND'd Irradiation	1.0895			1.0688	
118	All GND'd Irradiation	1.1131			1.0832	
119	All GND'd Irradiation	1.0973			1.0709	
120	All GND'd Irradiation	1.1131			1.0996	
180	All GND'd Irradiation	1.1089			1.0617	
182	Biased Irradiation	1.0862			1.0638	
183	Biased Irradiation	1.1396			1.1207	
184	Biased Irradiation	1.1159			1.0975	
185	Biased Irradiation	1.0952			1.0635	
186	Biased Irradiation	1.1180			1.1043	
187	All GND'd Irradiation	1.1076				1.0796
188	All GND'd Irradiation	1.1169				1.0915
189	All GND'd Irradiation	1.0958				1.0643
190	All GND'd Irradiation	1.1309				1.1011
191	All GND'd Irradiation	1.1340				1.1093
192	Biased Irradiation	1.1285				1.0922
193	Biased Irradiation	1.1279				1.0981
196	Biased Irradiation	1.0903				1.0645
197	Biased Irradiation	1.1304				1.1013
198	Biased Irradiation	1.1103				1.0765
199	Control Unit	1.1191	1.1191	1.1191	1.1191	1.1191
200	Control Unit	1.1323	1.1323	1.1323	1.1323	1.1323
All GND'd Irradiation Statistics						
Average All GND'd		1.1179	1.1041	1.0966	1.0769	1.0892
Std Dev All GND'd		0.0206	0.0234	0.0175	0.0149	0.0178
Ps90%/90% (+KTL) All GND'd		1.1743	1.1682	1.1445	1.1178	1.1379
Ps90%/90% (-KTL) All GND'd		1.0615	1.0400	1.0487	1.0360	1.0404
Biased Irradiation Statistics						
Average Biased		1.1113	1.0985	1.0957	1.0900	1.0865
Std Dev Biased		0.0123	0.0110	0.0246	0.0255	0.0156
Ps90%/90% (+KTL) Biased		1.1451	1.1288	1.1630	1.1598	1.1293
Ps90%/90% (-KTL) Biased		1.0775	1.0683	1.0283	1.0202	1.0438
Specification MIN						
Status (Measurements) All GND'd						
Status (Measurements) Biased						
Specification MAX						
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

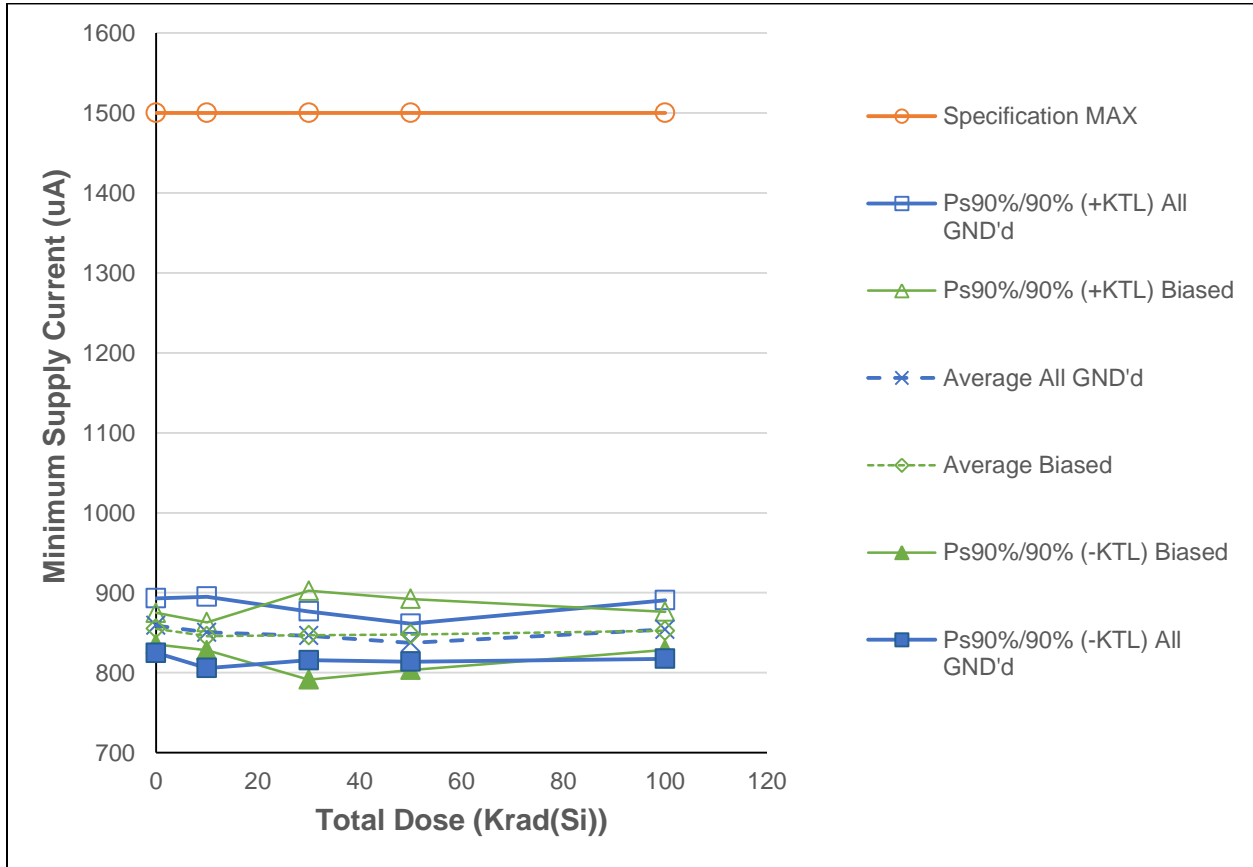


Figure 5.4: Plot of Minimum Supply Current versus Total Dose

All measured data points are well under datasheet upper limits.

Table 5.8: Raw data table for minimum supply current (μA) versus total dose including the statistical calculations, minimum specification, maximum specification, and the status of the test (PASS/FAIL)

Parameter Unit #	Imin (μA)	Total Dose (Krad(Si)) @ 50 rads(Si)/s				
		0	10	30	50	100
93	All GND'd Irradiation	850.35	839.97			
94	All GND'd Irradiation	850.35	833.82			
95	All GND'd Irradiation	875.89	870.60			
96	All GND'd Irradiation	868.77	864.98			
97	All GND'd Irradiation	849.66	842.98			
99	Biased Irradiation	864.63	855.50			
100	Biased Irradiation	853.38	843.73			
101	Biased Irradiation	853.36	843.71			
102	Biased Irradiation	845.41	838.03			
103	Biased Irradiation	858.94	847.05			
105	All GND'd Irradiation	866.75		863.30		
106	All GND'd Irradiation	843.57		836.28		
107	All GND'd Irradiation	846.01		838.36		
108	All GND'd Irradiation	852.06		842.10		
109	All GND'd Irradiation	859.37		851.20		
110	Biased Irradiation	856.52		844.35		
111	Biased Irradiation	881.47		873.54		
112	Biased Irradiation	872.86		860.97		
113	Biased Irradiation	838.10		825.99		
114	Biased Irradiation	838.18		830.06		
116	All GND'd Irradiation	843.89			836.51	
118	All GND'd Irradiation	853.44			837.49	
119	All GND'd Irradiation	840.28			829.02	
120	All GND'd Irradiation	853.74			851.81	
180	All GND'd Irradiation	858.00			833.07	
182	Biased Irradiation	838.35			830.66	
183	Biased Irradiation	872.75			867.98	
184	Biased Irradiation	855.31			850.21	
185	Biased Irradiation	847.06			832.37	
186	Biased Irradiation	859.05			858.03	
187	All GND'd Irradiation	854.23				851.88
188	All GND'd Irradiation	860.38				859.37
189	All GND'd Irradiation	837.75				832.31
190	All GND'd Irradiation	865.38				860.16
191	All GND'd Irradiation	867.94				867.07
192	Biased Irradiation	863.96				854.42
193	Biased Irradiation	864.80				861.44
196	Biased Irradiation	844.60				844.64
197	Biased Irradiation	863.49				859.56
198	Biased Irradiation	848.76				842.23
199	Control Unit	855.07	855.07	855.07	855.07	855.07
200	Control Unit	867.04	867.04	867.04	867.04	867.04
	All GND'd Irradiation Statistics					
	Average All GND'd	859.00	850.47	846.25	837.58	854.16
	Std Dev All GND'd	12.42	16.27	11.11	8.62	13.34
	Ps90%/90% (+KTL) All GND'd	893.06	895.09	876.72	861.21	890.74
	Ps90%/90% (-KTL) All GND'd	824.94	805.85	815.77	813.95	817.57
	Biased Irradiation Statistics					
	Average Biased	855.14	845.60	846.98	847.85	852.46
	Std Dev Biased	7.17	6.41	20.21	16.20	8.67
	Ps90%/90% (+KTL) Biased	874.79	863.18	902.41	892.27	876.23
	Ps90%/90% (-KTL) Biased	835.49	828.03	791.55	803.43	828.68
	Specification MIN					
	Status (Measurements) All GND'd					
	Status (Measurements) Biased					
	Specification MAX					
	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

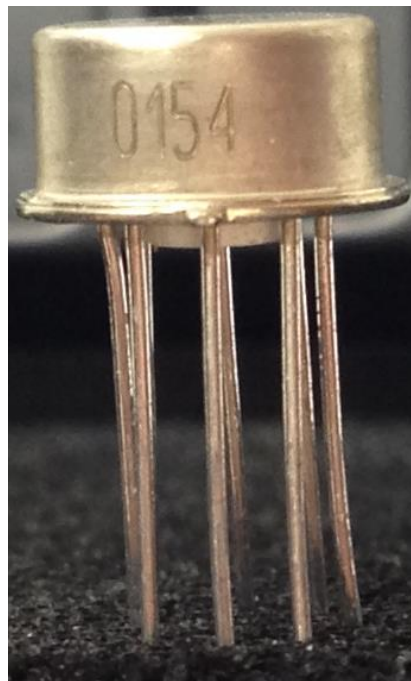


Figure A2: Side View showing serial number

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

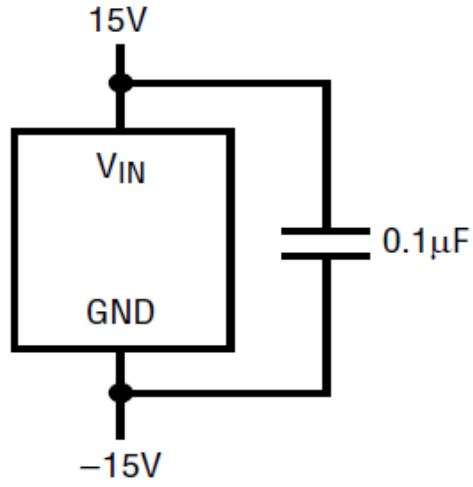


Figure B1: Total Dose Bias Circuit

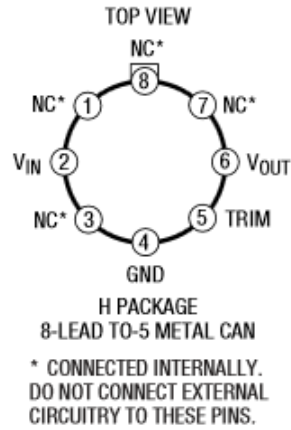


Figure B2: Pin-Out

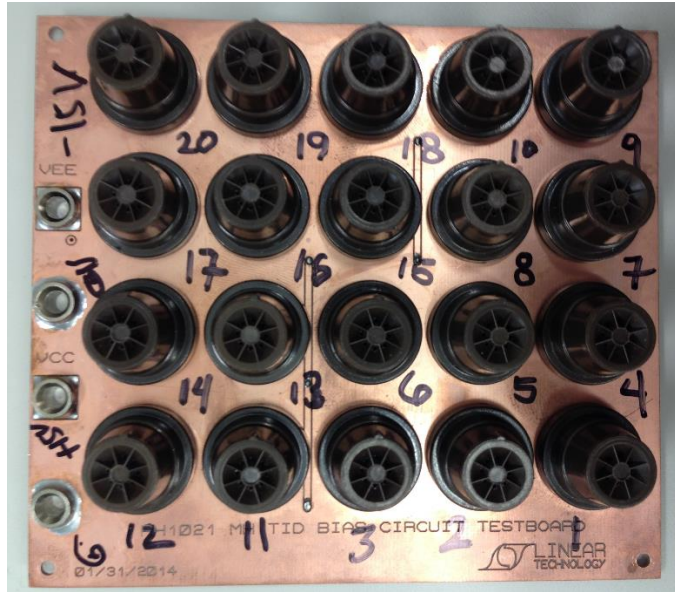


Figure B3: Bias Board (top view)

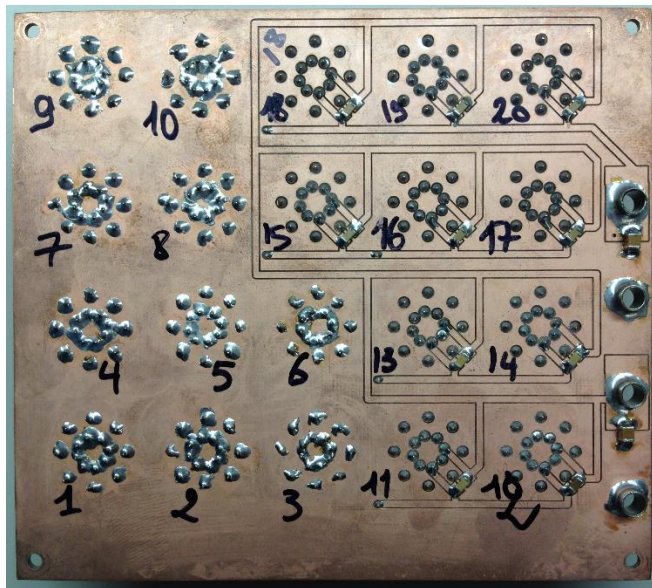




Figure B4: Bias Board (bottom view)

Appendix C

TEST CERTIFICATE		
		
Defense Microelectronics Activity Science and Engineering Gamma Irradiation Test Facility DMEA/MEBC 4234 54th Street McClellan, CA 95652		
		
Testing Certificate Number: 1691.01		
<p>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.</p>		
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		10 Krad(Si)		20 Krad(Si)		50 Krad(Si)		100 Krad(Si)		Units
	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
Output Voltage	9.950	10.050	9.950	10.050	9.945	10.055	9.942	10.060	9.938	10.060	V
Output Voltage Temperature Coefficient		5		5		5		5		7	ppm/°C
Line Regulation (11.5V ≤ V _N ≤ 14.5V)		4		4		4		4		4.5	ppm/V
Line Regulation (14.5V ≤ V _N ≤ 40V)		2		2		2		2		2	ppm/V
Load Regulation (Source)*		25		25		25		25		25	ppm/mA
Load Regulation (Shunt)†		100		100		100		100		100	ppm/mA
Supply Current		1.7		1.7		1.7		1.7		1.7	mA
Minimum Supply Current		1.5		1.5		1.5		1.5		1.5	mA

*(0mA ≤ I_{OUT} ≤ 10mA)

†(1.7mA ≤ I_{OUT} ≤ 10mA)