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

LDR = 10 mrads(Si)/s

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TID LDR 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: 12 units received, 2 units for control, 5 units for biased irradiation, and 5 units for unbiased irradiation. Serial numbers 145 to 149 had all pins tied to ground during irradiation. Serial numbers 150 to 154 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: Ionizing radiation with the following electrical test increments: pre-irradiation, 10 Krads(Si), 22 Krads(Si), 50 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 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°C±6°C per MIL-STD-883 and MIL-STD-750.

SUMMARY

ALL 10 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 D (for low-dose rates ranging from less than or equal to 10 mrads(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 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 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 were biased at +/- 15V and other five had all pads grounded. The devices were irradiated up to 100 Krad(Si) with increments of 10, 20, and 50 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:

- 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)
- 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 ten 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

$+K_{TL}$ = 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 22 Krads(Si) test limits are using Linear Technology datasheet 20 Krads(Si) specification limits.

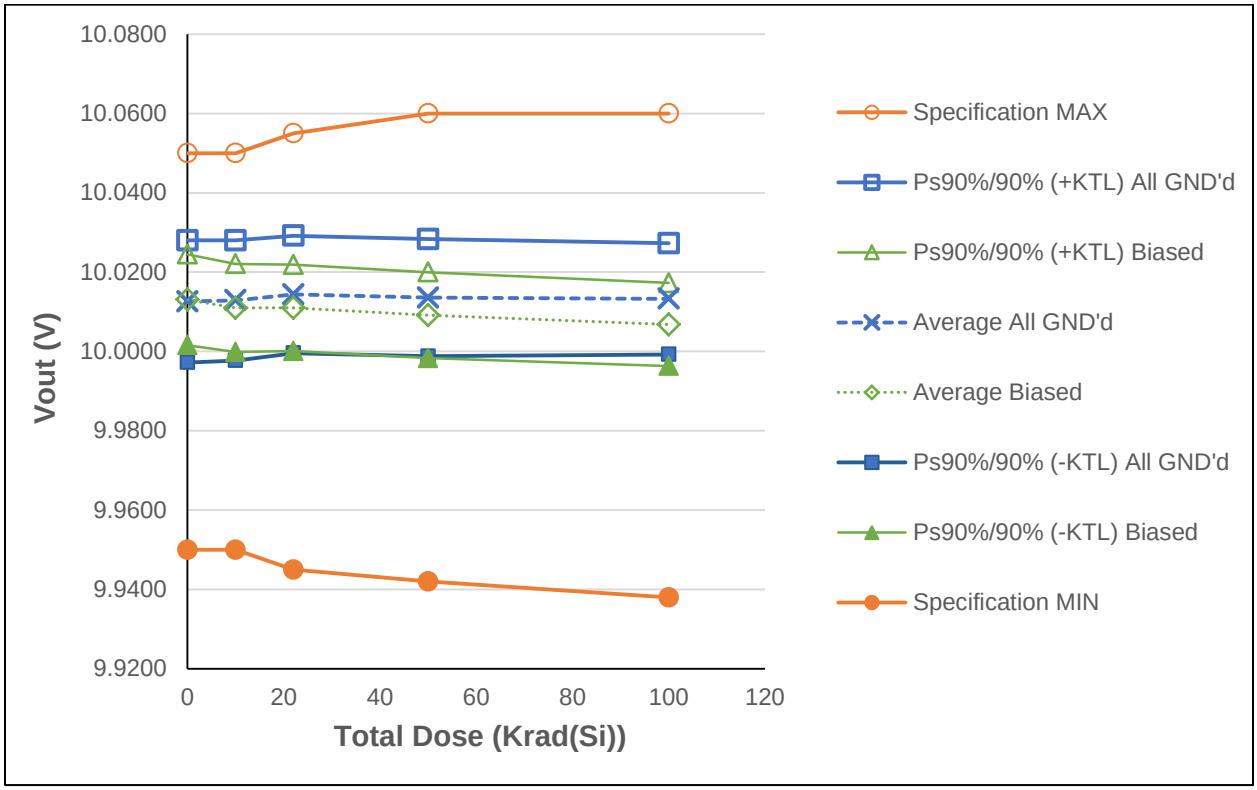

Figure 5.1 Plot of Output Voltage versus Total Dose

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	VOUT	Total Dose (Krad(Si)) @ 10 mrads(Si)/second				
Unit #	(V)	0	10	22	50	100
145	All GND'd Irradiation	10.0192	10.0193	10.0206	10.0200	10.0193
146	All GND'd Irradiation	10.0126	10.0129	10.0146	10.0136	10.0134
147	All GND'd Irradiation	10.0169	10.0171	10.0185	10.0175	10.0170
148	All GND'd Irradiation	10.0055	10.0058	10.0075	10.0068	10.0067
149	All GND'd Irradiation	10.0088	10.0093	10.0107	10.0100	10.0099
150	Biased Irradiation	10.0163	10.0141	10.0140	10.0120	10.0093
151	Biased Irradiation	10.0114	10.0096	10.0096	10.0077	10.0056
152	Biased Irradiation	10.0066	10.0046	10.0048	10.0030	10.0008
153	Biased Irradiation	10.0143	10.0121	10.0120	10.0103	10.0079
154	Biased Irradiation	10.0166	10.0145	10.0146	10.0128	10.0104
199	Control Unit	10.0081	10.0078	10.0088	10.0081	10.0077
200	Control Unit	10.0129	10.0124	10.0134	10.0128	10.0124
	All GND'd Irradiation Statistics					
	Average All GND'd	10.0126	10.0129	10.0144	10.0136	10.0133
	Std Dev All GND'd	0.0056	0.0055	0.0054	0.0054	0.0051
	Ps90%/90% (+KTL) All GND'd	10.0280	10.0280	10.0292	10.0283	10.0273
	Ps90%/90% (-KTL) All GND'd	9.9972	9.9977	9.9996	9.9988	9.9992
	Biased Irradiation Statistics					
	Average Biased	10.0130	10.0110	10.0110	10.0091	10.0068
	Std Dev Biased	0.0042	0.0041	0.0040	0.0039	0.0038
	Ps90%/90% (+KTL) Biased	10.0245	10.0221	10.0219	10.0200	10.0173
	Ps90%/90% (-KTL) Biased	10.0016	9.9999	10.0001	9.9983	9.9963
	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

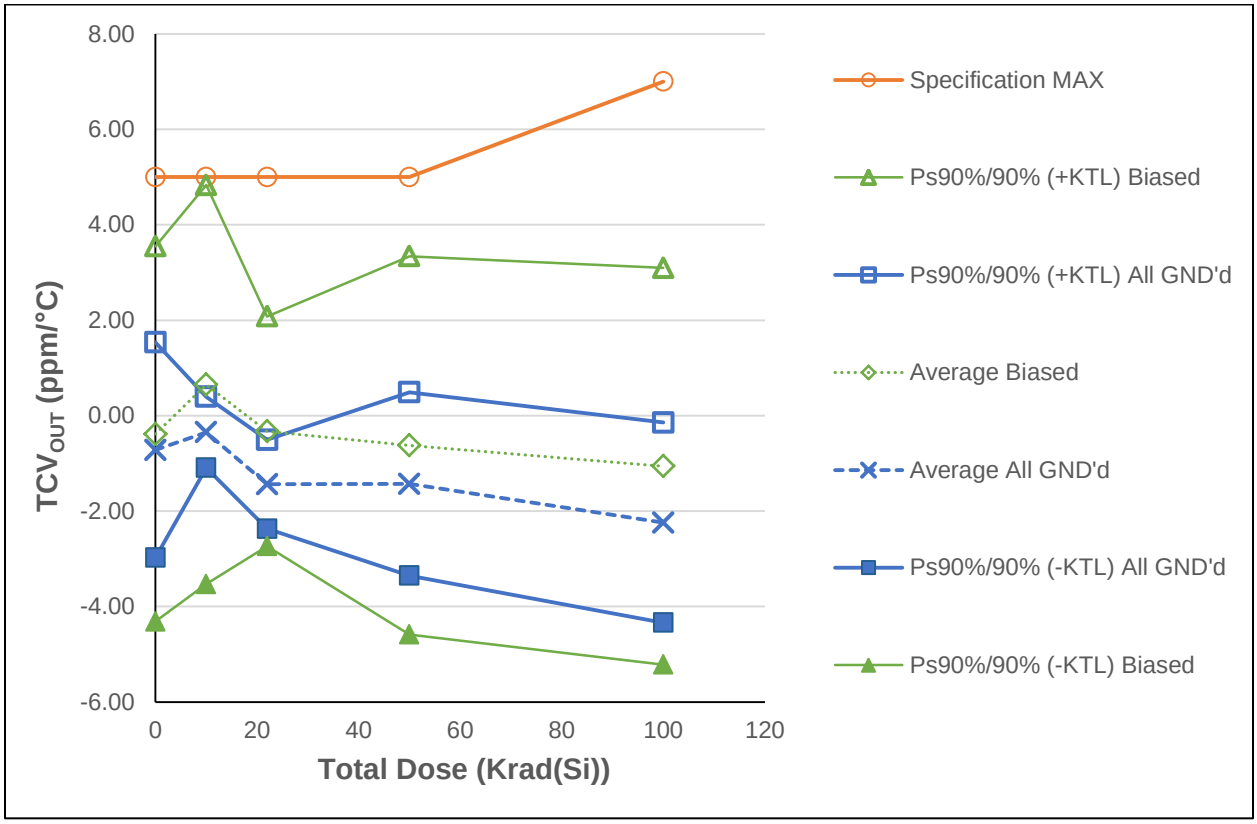

Figure 5.2: Plot of Output Voltage Temperature Coefficient versus Total Dose

The measured values of 10 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)) @ 10 mrads(Si)/second				
Unit #	(ppm/°C)	0	10	22	50	100
145	All GND'd Irradiation	0.3881	-0.0770	-1.2355	-1.1600	-1.6247
146	All GND'd Irradiation	-0.9957	-0.4406	-1.6485	-1.3777	-2.0438
147	All GND'd Irradiation	-1.1644	-0.6181	-1.8973	-2.5111	-3.4232
148	All GND'd Irradiation	-1.6671	-0.5600	-1.3661	-1.5108	-2.5335
149	All GND'd Irradiation	-0.1604	-0.0394	-1.0380	-0.5861	-1.5803
150	Biased Irradiation	0.7824	1.9343	0.2886	0.9500	0.3057
151	Biased Irradiation	-1.7956	-0.5325	-1.1580	-1.1573	-2.1015
152	Biased Irradiation	-0.6651	-0.3606	-0.8895	-1.7197	-1.6474
153	Biased Irradiation	1.4027	2.6584	0.8966	0.8847	0.7848
154	Biased Irradiation	-1.6466	-0.4440	-0.7745	-2.0780	-2.6373
199	Control Unit	-2.0499	-1.0789	-1.4922	-1.5279	-0.5758
200	Control Unit	-1.5130	0.3365	-0.5778	0.8164	1.1075
	All GND'd Irradiation Statistics					
	Average All GND'd	-0.7199	-0.3470	-1.4371	-1.4291	-2.2411
	Std Dev All GND'd	0.8233	0.2716	0.3397	0.7005	0.7646
	Ps90%/90% (+KTL) All GND'd	1.5377	0.3978	-0.5057	0.4917	-0.1446
	Ps90%/90% (-KTL) All GND'd	-2.9775	-1.0918	-2.3685	-3.3500	-4.3376
	Biased Irradiation Statistics					
	Average Biased	-0.3844	0.6511	-0.3274	-0.6241	-1.0591
	Std Dev Biased	1.4334	1.5247	0.8780	1.4450	1.5154
	Ps90%/90% (+KTL) Biased	3.5459	4.8320	2.0800	3.3382	3.0962
	Ps90%/90% (-KTL) Biased	-4.3148	-3.5297	-2.7348	-4.5863	-5.2145
	Specification MIN					
	Status (Measurements) All GND'd					
	Status (Measurements) Biased					
	Specification MAX	5	5	5	5	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

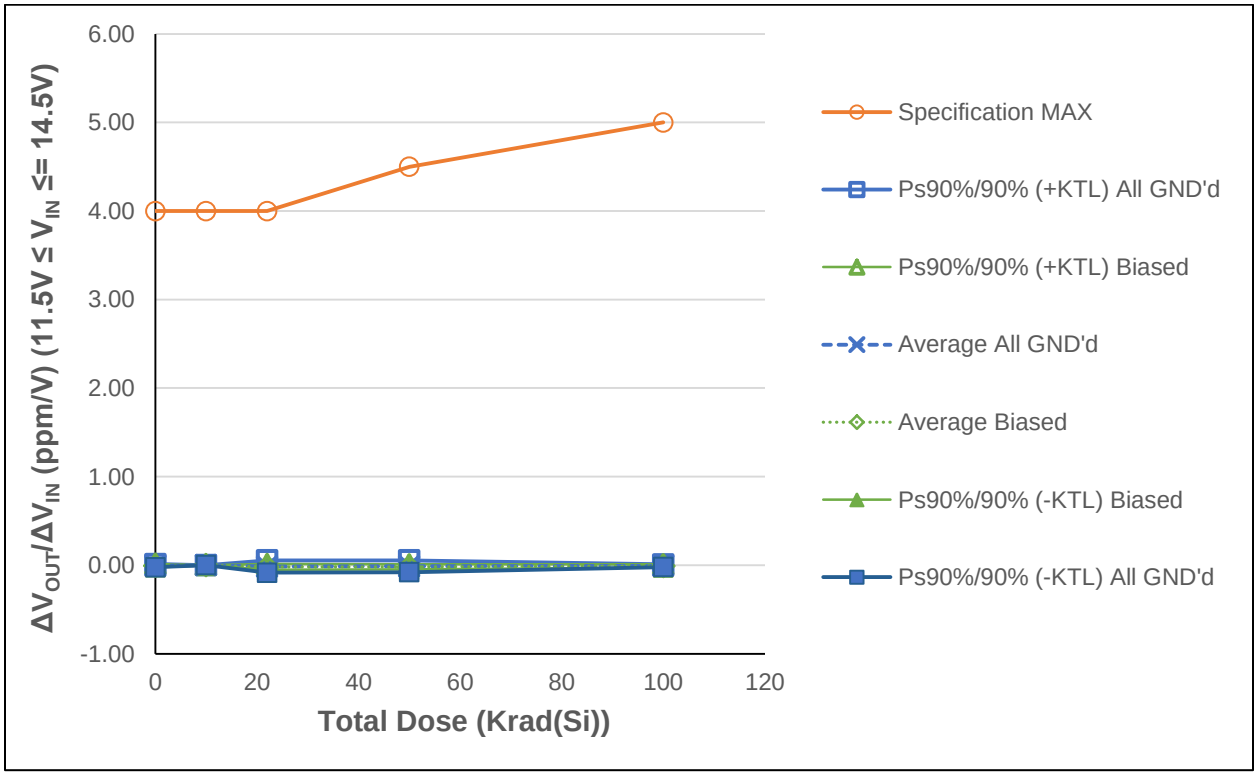

Figure 5.3: Plot of Line Regulation (11.5V ≤ V_{IN} ≤ 14.5V) versus Total Dose

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

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

Parameter	ΔVOUT/ΔVIN (11.5V≤V_{IN}≤14.5V)	Total Dose (Krad(Si)) @ 10 mrads(Si)/second				
Unit #	(ppm/V)	0	10	22	50	100
145	All GND'd Irradiation	-0.0037	2.57E-07	0.0120	-0.0258	-0.0060
146	All GND'd Irradiation	0.0024	7.26E-06	-0.0350	-0.0163	-0.0135
147	All GND'd Irradiation	-0.0142	-1.34E-05	-0.0434	-0.0399	0.0002
148	All GND'd Irradiation	-0.0093	-1.89E-05	0.0098	-0.0047	-0.0102
149	All GND'd Irradiation	-0.0014	-4.48E-06	-0.0195	0.0245	-0.0023
150	Biased Irradiation	-0.0056	-6.78E-06	-0.0189	-0.0279	-0.0029
151	Biased Irradiation	-0.0067	-3.71E-06	-0.0173	-0.0065	-0.0150
152	Biased Irradiation	-0.0080	-2.39E-05	-0.0140	-0.0215	-0.0121
153	Biased Irradiation	0.0061	1.62E-07	-0.0386	-0.0108	-0.0128
154	Biased Irradiation	-0.0139	-1.22E-05	-0.0070	-0.0305	-0.0004
199	Control Unit	-0.0032	-3.40E-06	-0.0170	-0.0395	-0.0022
200	Control Unit	-0.0004	-7.75E-06	-0.0366	0.0393	-0.0071
	All GND'd Irradiation Statistics					
	Average All GND'd	-0.0053	-5.85E-06	-0.0152	-0.0125	-0.0064
	Std Dev All GND'd	0.0066	1.05E-05	0.0253	0.0243	0.0056
	Ps90%/90% (+KTL) All GND'd	0.0128	2.28E-05	0.0543	0.0543	0.0089
	Ps90%/90% (-KTL) All GND'd	-0.0233	-3.46E-05	-0.0847	-0.0792	-0.0217
	Biased Irradiation Statistics					
	Average Biased	-0.0056	-9.28E-06	-0.0192	-0.0194	-0.0086
	Std Dev Biased	0.0073	9.33E-06	0.0118	0.0105	0.0065
	Ps90%/90% (+KTL) Biased	0.0144	1.63E-05	0.0131	0.0094	0.0093
	Ps90%/90% (-KTL) Biased	-0.0256	-3.49E-05	-0.0515	-0.0482	-0.0266
	Specification MIN					
	Status (Measurements) All GND'd					
	Status (Measurements) Biased					
	Specification MAX	4	4	4	4.5	5
	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

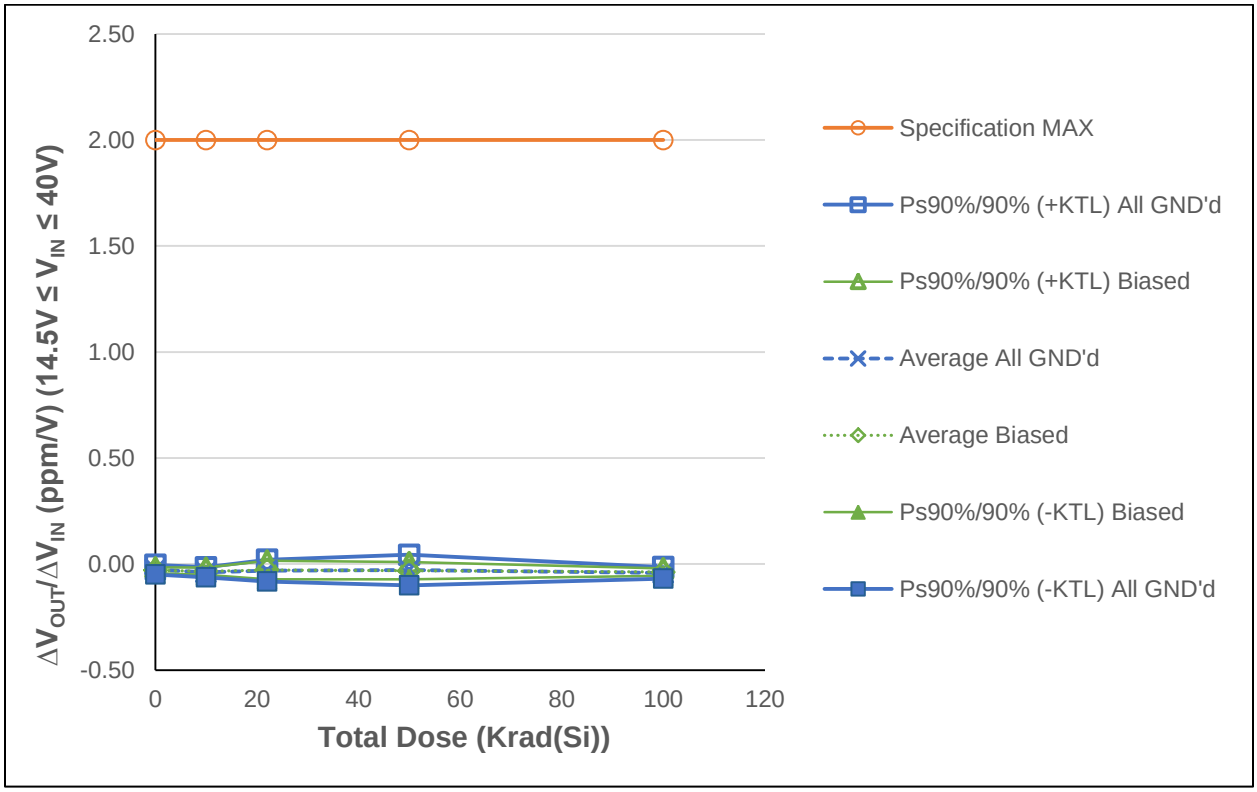

Figure 5.4: Plot of Line Regulation (14.5V ≤ V_{IN} ≤ 40V) versus Total Dose

All measured data points are well under datasheet upper limits.

Table 5.4: Raw data for line regulation (ppm/V) with 14.5V ≤ 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 (14.5V ≤ V_{IN} ≤ 40V)	Total Dose (Krad(Si)) @ 10 mrads(Si)/second				
Unit #	(ppm/V)	0	10	22	50	100
145	All GND'd Irradiation	-0.0302	-0.0377	-0.0551	0.0021	-0.0294
146	All GND'd Irradiation	-0.0273	-0.0528	-0.0182	-0.0390	-0.0469
147	All GND'd Irradiation	-0.0273	-0.0327	-0.0278	-0.0021	-0.0505
148	All GND'd Irradiation	-0.0339	-0.0387	-0.0440	-0.0456	-0.0474
149	All GND'd Irradiation	-0.0124	-0.0303	-0.0092	-0.0554	-0.0313
150	Biased Irradiation	-0.0271	-0.0437	-0.0448	-0.0126	-0.0379
151	Biased Irradiation	-0.0280	-0.0264	-0.0153	-0.0312	-0.0419
152	Biased Irradiation	-0.0385	-0.0324	-0.0272	-0.0478	-0.0425
153	Biased Irradiation	-0.0268	-0.0313	-0.0092	-0.0434	-0.0266
154	Biased Irradiation	-0.0267	-0.0351	-0.0428	-0.0212	-0.0395
199	Control Unit	-0.0305	-0.0394	-0.0433	0.0062	-0.0446
200	Control Unit	-0.0090	-0.0297	-0.0074	-0.0705	-0.0187
	All GND'd Irradiation Statistics					
	Average All GND'd	-0.0262	-0.0385	-0.0309	-0.0280	-0.0411
	Std Dev All GND'd	0.0082	0.0087	0.0187	0.0263	0.0100
	Ps90%/90% (+KTL) All GND'd	-0.0038	-0.0145	0.0204	0.0440	-0.0138
	Ps90%/90% (-KTL) All GND'd	-0.0487	-0.0624	-0.0821	-0.1000	-0.0684
	Biased Irradiation Statistics					
	Average Biased	-0.0294	-0.0338	-0.0279	-0.0312	-0.0377
	Std Dev Biased	0.0051	0.0064	0.0159	0.0147	0.0064
	Ps90%/90% (+KTL) Biased	-0.0154	-0.0162	0.0158	0.0092	-0.0200
	Ps90%/90% (-KTL) Biased	-0.0435	-0.0513	-0.0716	-0.0716	-0.0554
	Specification MIN					
	Status (Measurements) All GND'd					
	Status (Measurements) Biased					
	Specification MAX	2	2	2	2	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

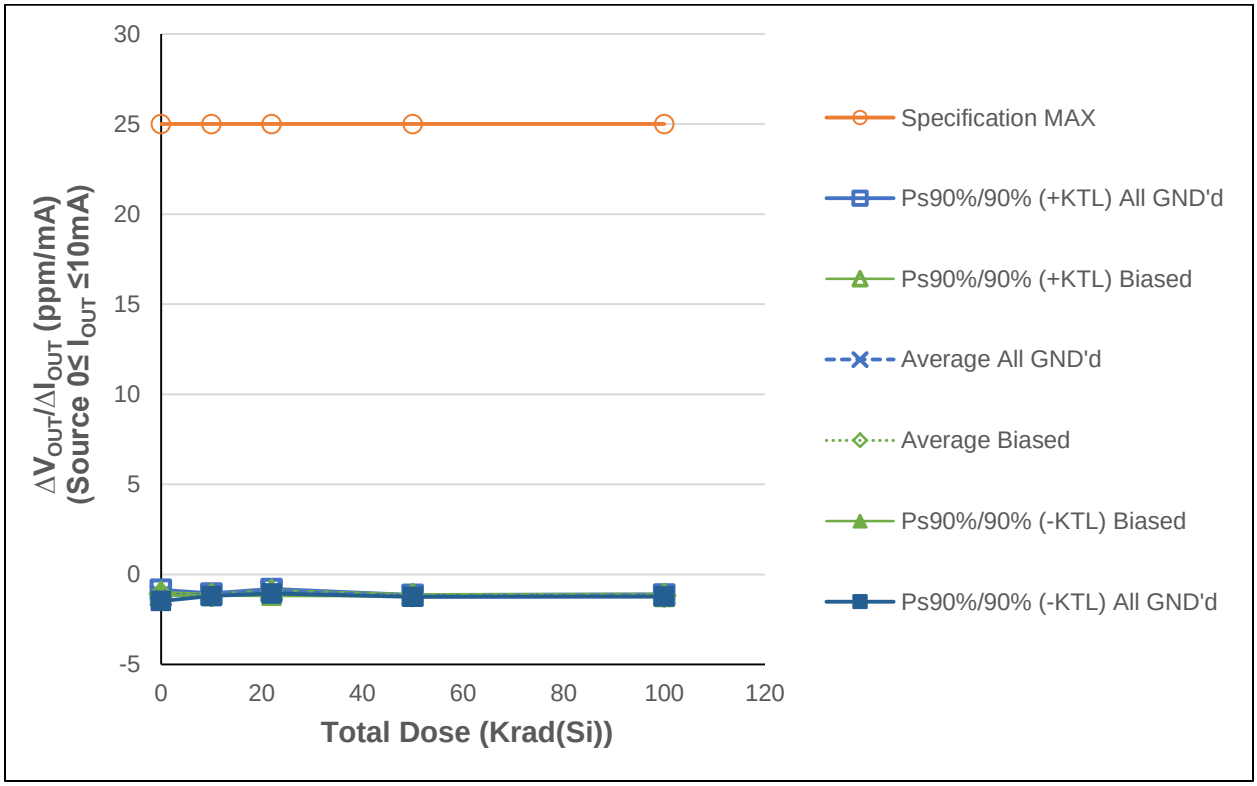

Figure 5.5: Plot of Load Regulation (Sourcing 0 ≤ I_{OUT} ≤ 10mA) versus Total Dose

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 $0 \leq I_{OUT} \leq 10mA$)	Total Dose (Krad(Si)) @ 10 mrads(Si)/second				
Unit #	(ppm/mA)	0	10	22	50	100
145	All GND'd Irradiation	-1.1019	-1.1117	-0.9086	-1.1749	-1.1769
146	All GND'd Irradiation	-1.0807	-1.1302	-0.8722	-1.1816	-1.1306
147	All GND'd Irradiation	-1.1235	-1.1694	-0.9895	-1.1856	-1.1772
148	All GND'd Irradiation	-1.1547	-1.1238	-0.9578	-1.2230	-1.1820
149	All GND'd Irradiation	-1.3616	-1.1001	-0.9308	-1.1914	-1.1712
150	Biased Irradiation	-1.0262	-1.1207	-0.9299	-1.1269	-1.1470
151	Biased Irradiation	-1.1050	-1.1240	-1.0597	-1.1488	-1.1438
152	Biased Irradiation	-1.0560	-1.1409	-1.0356	-1.1650	-1.1507
153	Biased Irradiation	-1.1102	-1.1647	-1.0375	-1.1763	-1.2130
154	Biased Irradiation	-1.0749	-1.1359	-1.0852	-1.1618	-1.1919
199	Control Unit	-1.0618	-1.0524	-0.9615	-1.1569	-1.1873
200	Control Unit	-1.0640	-1.0213	-0.8796	-1.1269	-1.1304
	All GND'd Irradiation Statistics					
	Average All GND'd	-1.1645	-1.1270	-0.9318	-1.1913	-1.1676
	Std Dev All GND'd	0.1135	0.0263	0.0450	0.0187	0.0210
	Ps90%/90% (+KTL) All GND'd	-0.8532	-1.0548	-0.8084	-1.1400	-1.1099
	Ps90%/90% (-KTL) All GND'd	-1.4758	-1.1992	-1.0551	-1.2426	-1.2253
	Biased Irradiation Statistics					
	Average Biased	-1.0744	-1.1372	-1.0296	-1.1557	-1.1693
	Std Dev Biased	0.0349	0.0175	0.0592	0.0189	0.0313
	Ps90%/90% (+KTL) Biased	-0.9786	-1.0894	-0.8672	-1.1040	-1.0835
	Ps90%/90% (-KTL) Biased	-1.1702	-1.1851	-1.1920	-1.2074	-1.2551
	Specification MIN					
	Status (Measurements) All GND'd					
	Status (Measurements) Biased					
	Specification MAX	25	25	25	25	25
	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

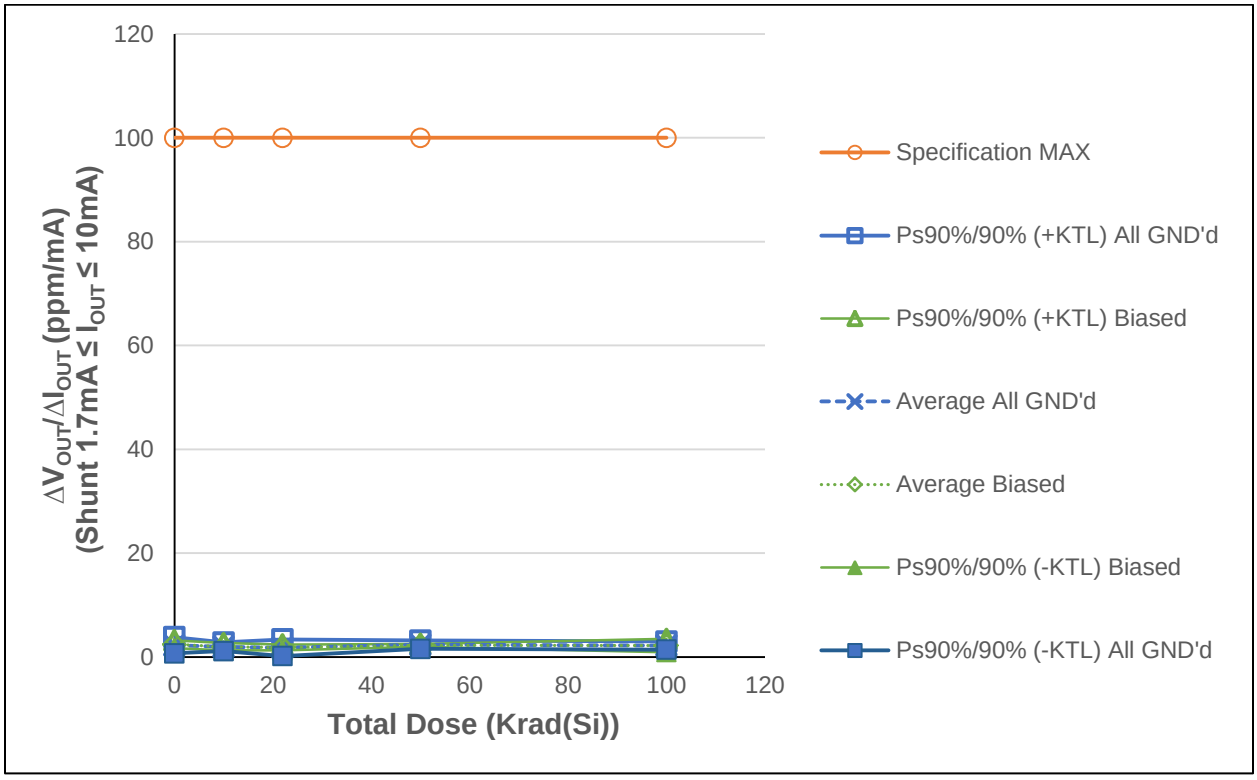

Figure 5.6: Plot of Load Regulation (Shunting 1.7mA ≤ I_{OUT} ≤ 10mA) versus Total Dose

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

Table 5.6: Raw data for load regulation shunting (ppm/mA) with 1.7mA ≤ I_{OUT} ≤ 10mA versus total dose including the statistical calculations, minimum specification, maximum specification, and the status of the test (PASS/FAIL)

Parameter	ΔVO/ΔIO(Shunt 1.7mA≤I_O≤10mA)	Total Dose (Krad(Si)) @ 10 mrads(Si)/second				
Unit #	(ppm/mA)	0	10	22	50	100
145	All GND'd Irradiation	2.2634	2.2069	1.2043	2.8792	1.9767
146	All GND'd Irradiation	1.5021	2.1301	1.3572	2.1925	2.1302
147	All GND'd Irradiation	3.0248	2.2069	1.5867	2.1925	2.2070
148	All GND'd Irradiation	2.4918	1.6697	2.5810	2.2688	2.6674
149	All GND'd Irradiation	1.9589	1.5929	2.1986	2.2688	1.9767
150	Biased Irradiation	2.7964	2.2069	1.8927	2.4214	2.8977
151	Biased Irradiation	2.3395	1.5162	1.8162	2.1925	1.6697
152	Biased Irradiation	2.1873	1.9767	1.5867	2.1925	1.9000
153	Biased Irradiation	2.1873	2.0534	2.1221	2.1925	2.2837
154	Biased Irradiation	2.6441	1.9767	1.6632	2.1925	2.2070
199	Control Unit	1.5021	1.9767	1.8927	2.1925	2.8209
200	Control Unit	2.0350	1.6697	2.1986	2.5740	1.9000
	All GND'd Irradiation Statistics					
	Average All GND'd	2.2482	1.9613	1.7856	2.3604	2.1916
	Std Dev All GND'd	0.5707	0.3041	0.5840	0.2925	0.2841
	Ps90%/90% (+KTL) All GND'd	3.8132	2.7951	3.3869	3.1625	2.9705
	Ps90%/90% (-KTL) All GND'd	0.6832	1.1275	0.1842	1.5583	1.4127
	Biased Irradiation Statistics					
	Average Biased	2.4309	1.9460	1.8162	2.2383	2.1916
	Std Dev Biased	0.2766	0.2580	0.2095	0.1024	0.4649
	Ps90%/90% (+KTL) Biased	3.1894	2.6534	2.3905	2.5190	3.4665
	Ps90%/90% (-KTL) Biased	1.6724	1.2385	1.2418	1.9576	0.9167
	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

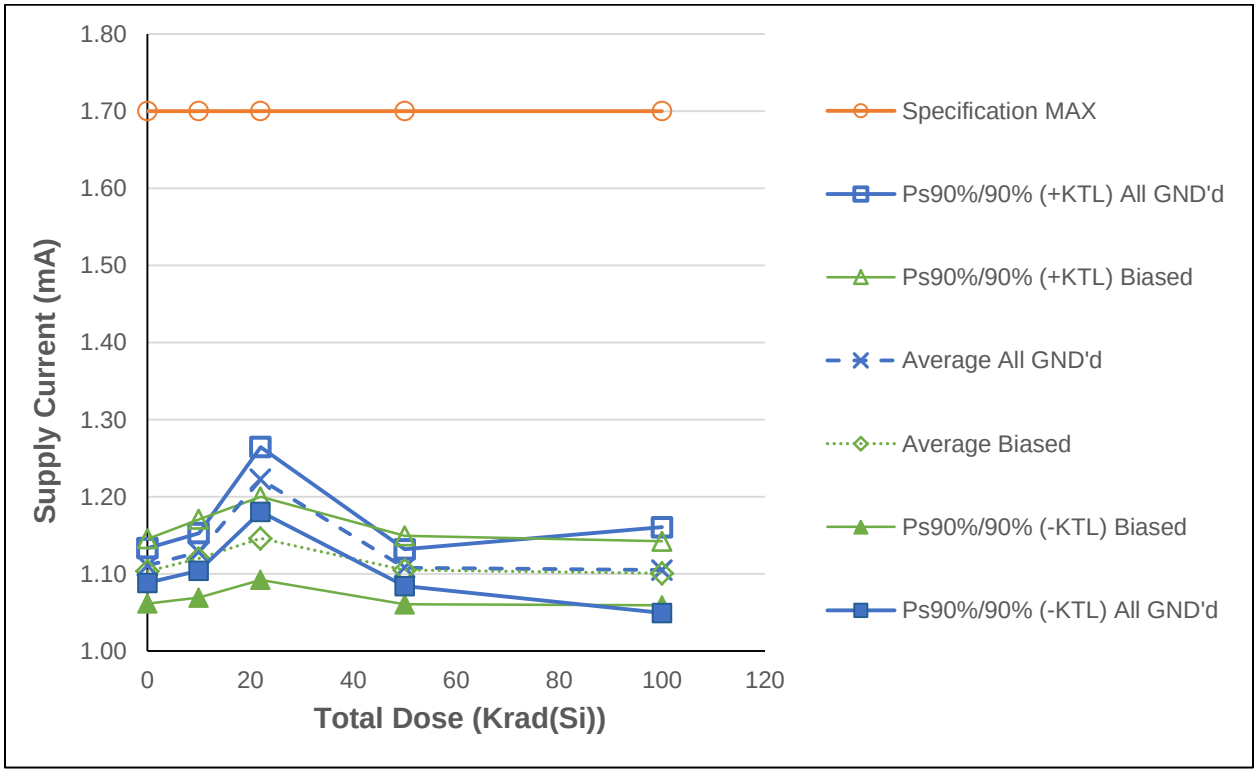

Figure 5.7: Plot of Supply Current versus Total Dose

The average measured values of 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)) @ 10 mrads(Si)/second				
Unit #	(mA)	0	10	22	50	100
145	All GND'd Irradiation	1.1063	1.1234	1.2255	1.0984	1.0713
146	All GND'd Irradiation	1.1058	1.1258	1.2435	1.1056	1.1068
147	All GND'd Irradiation	1.1127	1.1322	1.2029	1.1112	1.1117
148	All GND'd Irradiation	1.1046	1.1188	1.2135	1.1035	1.1087
149	All GND'd Irradiation	1.1243	1.1418	1.2270	1.1213	1.1262
150	Biased Irradiation	1.0802	1.0932	1.1501	1.0774	1.0776
151	Biased Irradiation	1.1012	1.1427	1.1345	1.1169	1.1195
152	Biased Irradiation	1.1163	1.1297	1.1671	1.1130	1.1060
153	Biased Irradiation	1.1014	1.1141	1.1602	1.1038	1.1009
154	Biased Irradiation	1.1184	1.1201	1.1186	1.1138	1.0999
199	Control Unit	1.1191	1.1418	1.1759	1.1258	1.1209
200	Control Unit	1.1323	1.1382	1.2599	1.1439	1.1435
	All GND'd Irradiation Statistics					
	Average All GND'd	1.1108	1.1284	1.2225	1.1080	1.1049
	Std Dev All GND'd	0.0082	0.0089	0.0153	0.0087	0.0203
	Ps90%/90% (+KTL) All GND'd	1.1333	1.1528	1.2644	1.1319	1.1605
	Ps90%/90% (-KTL) All GND'd	1.0883	1.1040	1.1805	1.0841	1.0493
	Biased Irradiation Statistics					
	Average Biased	1.1035	1.1200	1.1461	1.1050	1.1008
	Std Dev Biased	0.0153	0.0185	0.0196	0.0162	0.0152
	Ps90%/90% (+KTL) Biased	1.1454	1.1706	1.2000	1.1493	1.1423
	Ps90%/90% (-KTL) Biased	1.0616	1.0693	1.0922	1.0606	1.0592
	Specification MIN					
	Status (Measurements) All GND'd					
	Status (Measurements) Biased					
	Specification MAX	1.7	1.7	1.7	1.7	1.7
	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

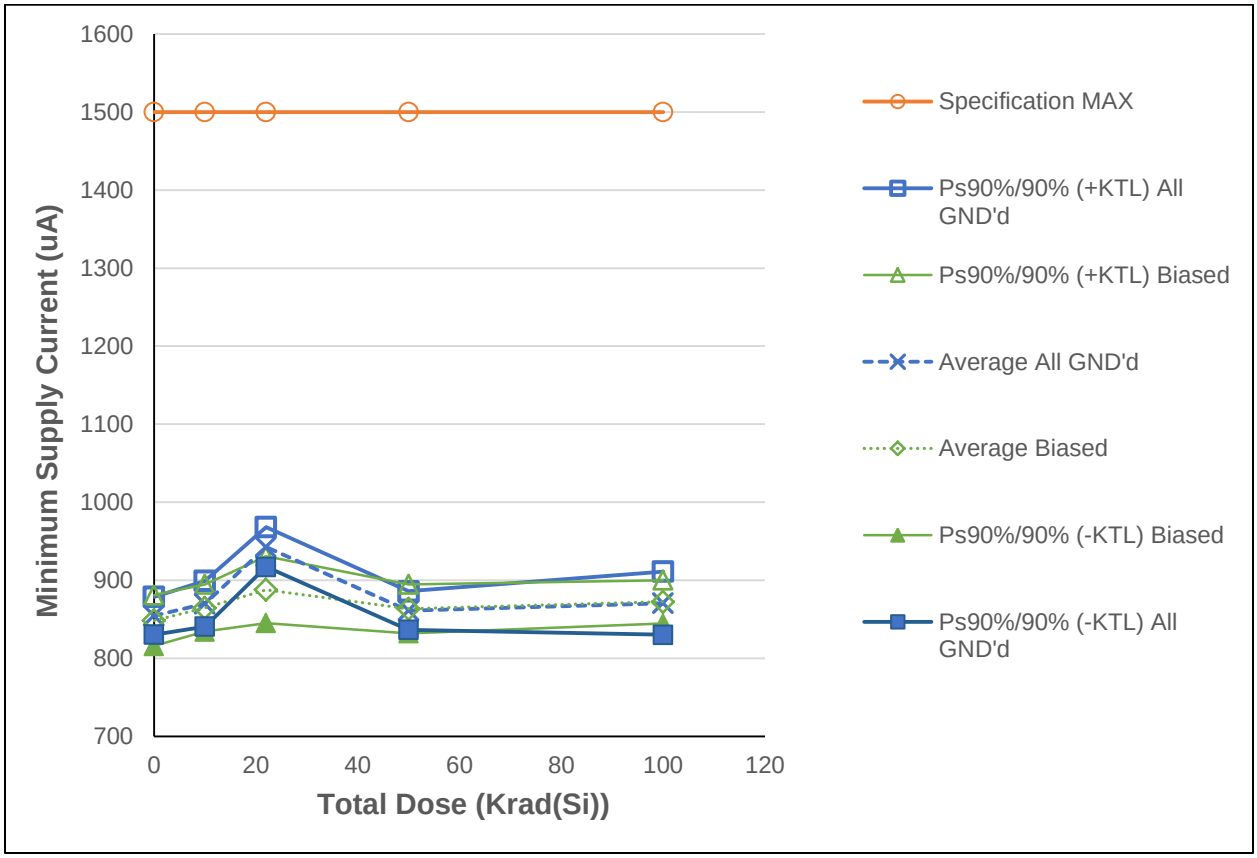

Figure 5.8: Plot of Minimum Supply Current versus Total Dose

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

Table 5.8: 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	Imin	Total Dose (Krad(Si)) @ 10 mrads(Si)/s				
Unit #	(uA)	0	10	22	50	100
145	All GND'd Irradiation	853.14	864.07	948.34	852.07	848.63
146	All GND'd Irradiation	847.16	865.94	954.51	858.55	868.04
147	All GND'd Irradiation	862.59	882.99	935.10	870.89	883.50
148	All GND'd Irradiation	845.67	858.01	931.88	854.53	868.57
149	All GND'd Irradiation	865.06	879.52	943.66	870.89	885.16
150	Biased Irradiation	832.00	847.14	891.64	843.24	857.47
151	Biased Irradiation	842.31	877.40	876.83	868.60	884.51
152	Biased Irradiation	858.67	868.53	902.31	869.46	878.36
153	Biased Irradiation	849.06	864.61	901.98	866.68	871.46
154	Biased Irradiation	860.72	865.94	867.24	869.90	870.68
199	Control Unit	855.07	878.17	904.11	859.64	858.71
200	Control Unit	867.04	873.91	962.94	876.37	880.56
	All GND'd Irradiation Statistics					
	Average All GND'd	854.72	870.11	942.70	861.39	870.78
	Std Dev All GND'd	8.81	10.66	9.32	8.98	14.76
	Ps90%/90% (+KTL) All GND'd	878.88	899.34	968.24	886.00	911.25
	Ps90%/90% (-KTL) All GND'd	830.57	840.87	917.15	836.77	830.31
	Biased Irradiation Statistics					
	Average Biased	848.55	864.72	888.00	863.58	872.50
	Std Dev Bias	11.87	11.02	15.57	11.43	10.11
	Ps90%/90% (+KTL) Biased	881.11	894.94	930.68	894.93	900.22
	Ps90%/90% (-KTL) Biased	816.00	834.51	845.32	832.23	844.77
	Specification MIN					
	Status (Measurements) All GND'd					
	Status (Measurements) Biased					
	Specification MAX	1500	1500	1500	1500	1500
	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

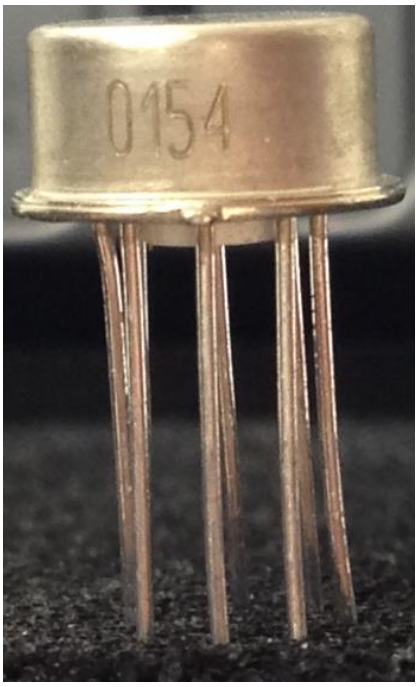

Figure A2: Side View showing serial number

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

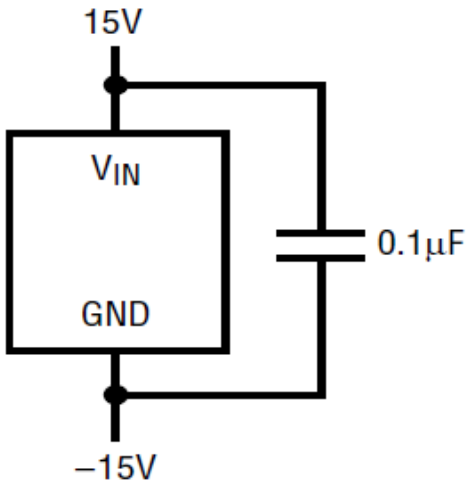

Figure B1: Total Dose Bias Circuit

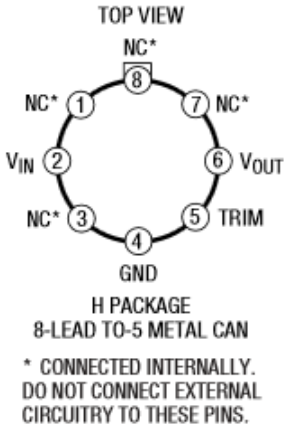

Figure B2: Pin-Out

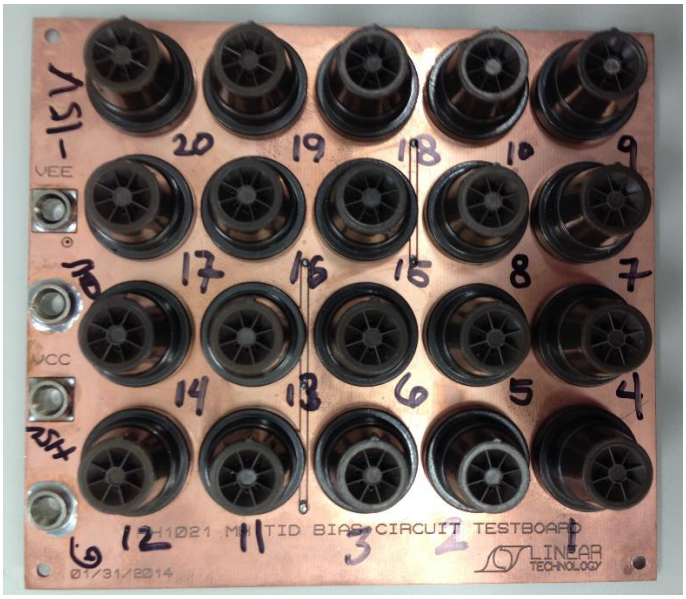

Figure B3: Bias Board (top view)

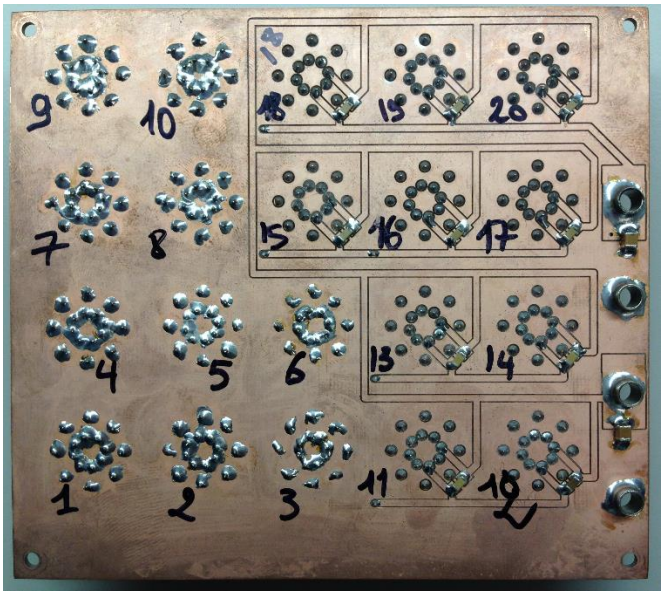

Figure B4: Bias Board (bottom view)

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

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	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 ($11.5V \le V_{IN} \le 14.5V$)		4		4		4		4		4.5	ppm/V
Line Regulation ($14.5V \le V_{IN} \le 40V$)		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

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

†($1.7mA \le I_{OUT} \le 10mA$)