

# **Total Ionization Dose (TID) Test Results of the RH1021CMH-5 Precision 5V Reference @ Low Dose Rate (LDR)**

**LDR = 10 mrads(Si)/s**

22 September 2014

Duc Nguyen, Sana Rezgui

## **Acknowledgements**

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

## TID LDR 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:** 12 units received, 2 units for control, 5 units for biased irradiation, and 5 units for unbiased irradiation. Serial numbers 334, 336 to 339 had all pins tied to ground during irradiation. Serial numbers 340 to 343 and 345 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:** 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 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 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 mrad(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 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, 22, and 50 Krad(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  $7.2V \leq V_{IN} \leq 10V$  (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)

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 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

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

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

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-HBK814, 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.

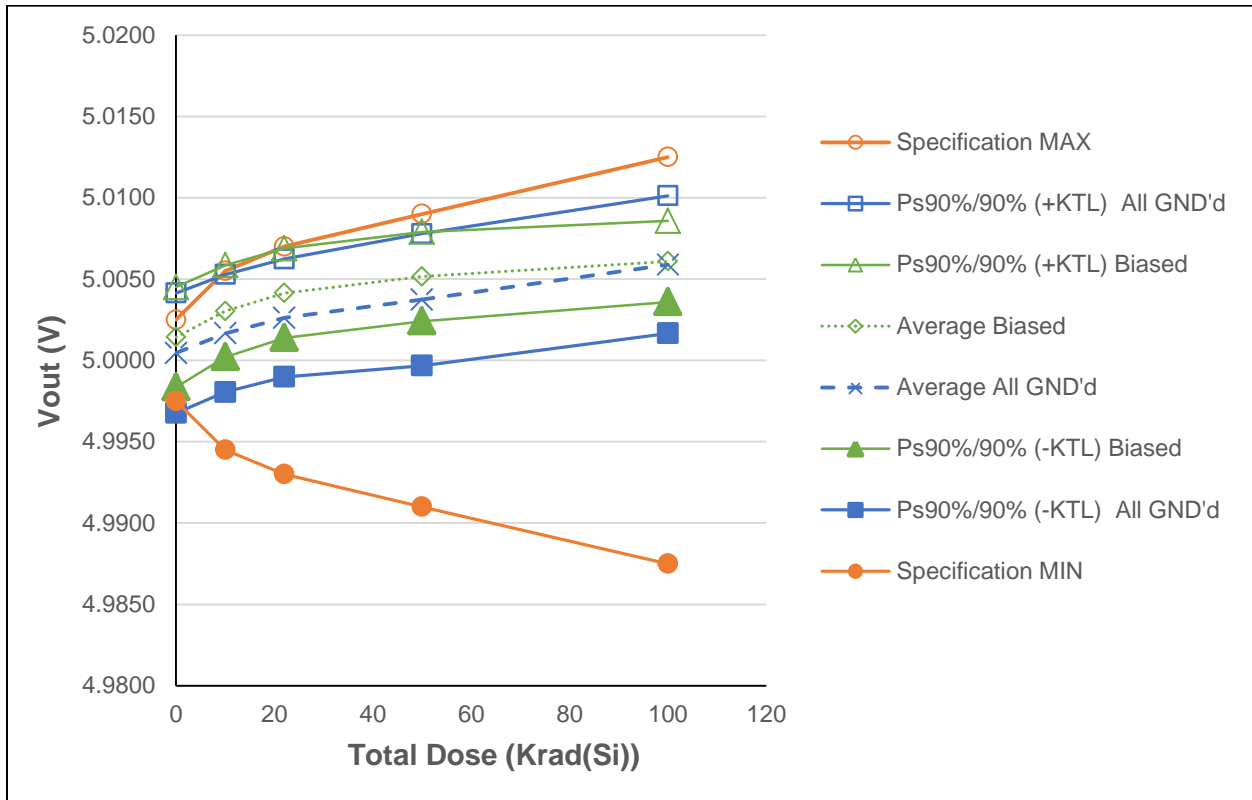


Figure 5.1 Plot of Output Voltage versus Total Dose

All ten samples passed the output voltage test at each post-irradiation interval. Note the KTL square and triangle markers are slightly above the pre-irradiation 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)) at 10 mrad(Si)/second				
Unit #	(V)	0	10	22	50	100
334	All GND'd Irradiation	4.9994	5.0006	5.0016	5.0025	5.0045
336	All GND'd Irradiation	5.0018	5.0029	5.0038	5.0049	5.0070
337	All GND'd Irradiation	4.9992	5.0006	5.0015	5.0025	5.0048
338	All GND'd Irradiation	5.0020	5.0033	5.0043	5.0057	5.0081
339	All GND'd Irradiation	4.9998	5.0009	5.0019	5.0030	5.0052
340	Biased-Irradiation	4.9995	5.0012	5.0025	5.0035	5.0046
341	Biased-Irradiation	5.0020	5.0037	5.0047	5.0059	5.0069
342	Biased-Irradiation	5.0021	5.0036	5.0046	5.0056	5.0065
343	Biased-Irradiation	5.0016	5.0030	5.0040	5.0050	5.0058
345	Biased-Irradiation	5.0020	5.0036	5.0049	5.0058	5.0067
323	Control Unit	5.0020	5.0022	5.0024	5.0024	5.0021
324	Control Unit	4.9997	5.0000	5.0003	5.0001	5.0000
All GND'd Irradiation Statistics						
	Average All GND'd	5.0005	5.0017	5.0026	5.0037	5.0059
	Std Dev All GND'd	0.0013	0.0013	0.0013	0.0015	0.0015
	Ps90%/90% (+KTL) All GND'd	5.0041	5.0053	5.0062	5.0078	5.0101
	Ps90%/90% (-KTL) All GND'd	4.9968	4.9980	4.9990	4.9997	5.0017
Biased-Irradiation Statistics						
	Average Biased	5.0014	5.0030	5.0041	5.0052	5.0061
	Std Dev Biased	0.0011	0.0010	0.0010	0.0010	0.0009
	Ps90%/90% (+KTL) Biased	5.0045	5.0058	5.0069	5.0079	5.0086
	Ps90%/90% (-KTL) Biased	4.9984	5.0002	5.0014	5.0024	5.0036
	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	FAIL	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

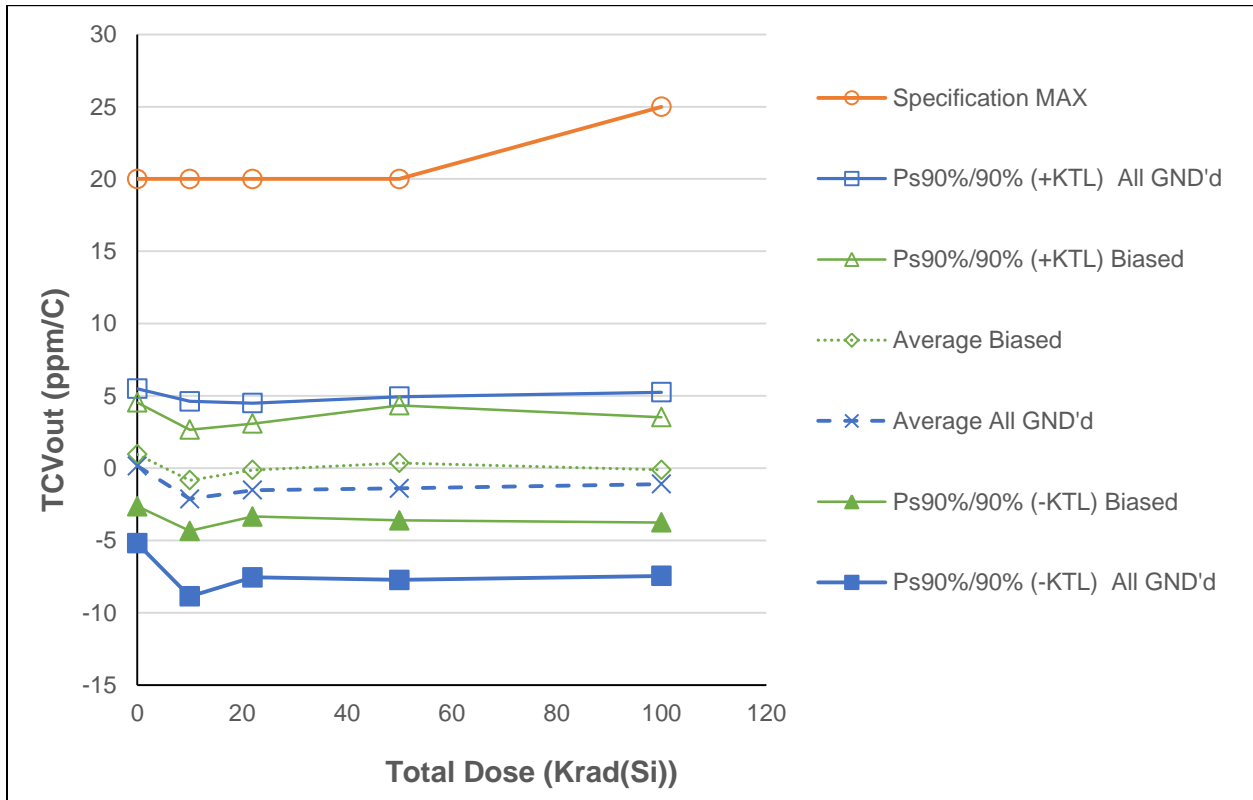


Figure 5.2: Plot of Output Voltage Temperature Coefficient versus Total Dose

The measured values of 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)) at 10 mrad(Si)/second				
Unit #	(ppm/°C)	0	10	22	50	100
334	All GND'd Irradiation	-1.6391	-4.9296	-4.1018	-3.4510	-2.9935
336	All GND'd Irradiation	1.8819	-0.0549	0.0039	0.6234	0.8329
337	All GND'd Irradiation	-1.3206	-4.1598	-2.7175	-3.2128	-3.5509
338	All GND'd Irradiation	2.5956	0.6843	1.3854	1.5338	1.7228
339	All GND'd Irradiation	-0.7640	-2.1650	-2.1863	-2.4756	-1.5167
340	Biased-Irradiation	-0.7821	-2.7760	-1.7327	-1.0056	-2.0894
341	Biased-Irradiation	0.3353	-1.2078	-0.8351	-0.8782	-0.4610
342	Biased-Irradiation	1.4513	-0.3386	0.4685	0.5555	0.4765
343	Biased-Irradiation	1.0354	-0.5338	0.1730	0.5750	-0.0314
345	Biased-Irradiation	2.7456	0.6776	1.2738	2.5791	1.5271
323	Control Unit	-0.1213	-1.2028	-1.2154	-1.5884	-1.4586
324	Control Unit	-1.9747	-3.3525	-3.1274	-3.6538	-4.0282
All GND'd Irradiation Statistics						
	Average All GND'd	0.1508	-2.1250	-1.5233	-1.3964	-1.1011
	Std Dev All GND'd	1.9480	2.4589	2.1970	2.3104	2.3168
	Ps90%/90% (+KTL) All GND'd	5.4922	4.6174	4.5009	4.9386	5.2515
	Ps90%/90% (-KTL) All GND'd	-5.1907	-8.8674	-7.5474	-7.7314	-7.4538
Biased-Irradiation Statistics						
	Average Biased	0.9571	-0.8357	-0.1305	0.3651	-0.1157
	Std Dev Biased	1.3096	1.2779	1.1712	1.4497	1.3296
	Ps90%/90% (+KTL) Biased	4.5481	2.6681	3.0809	4.3404	3.5301
	Ps90%/90% (-KTL) Biased	-2.6339	-4.3396	-3.3419	-3.6101	-3.7614
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

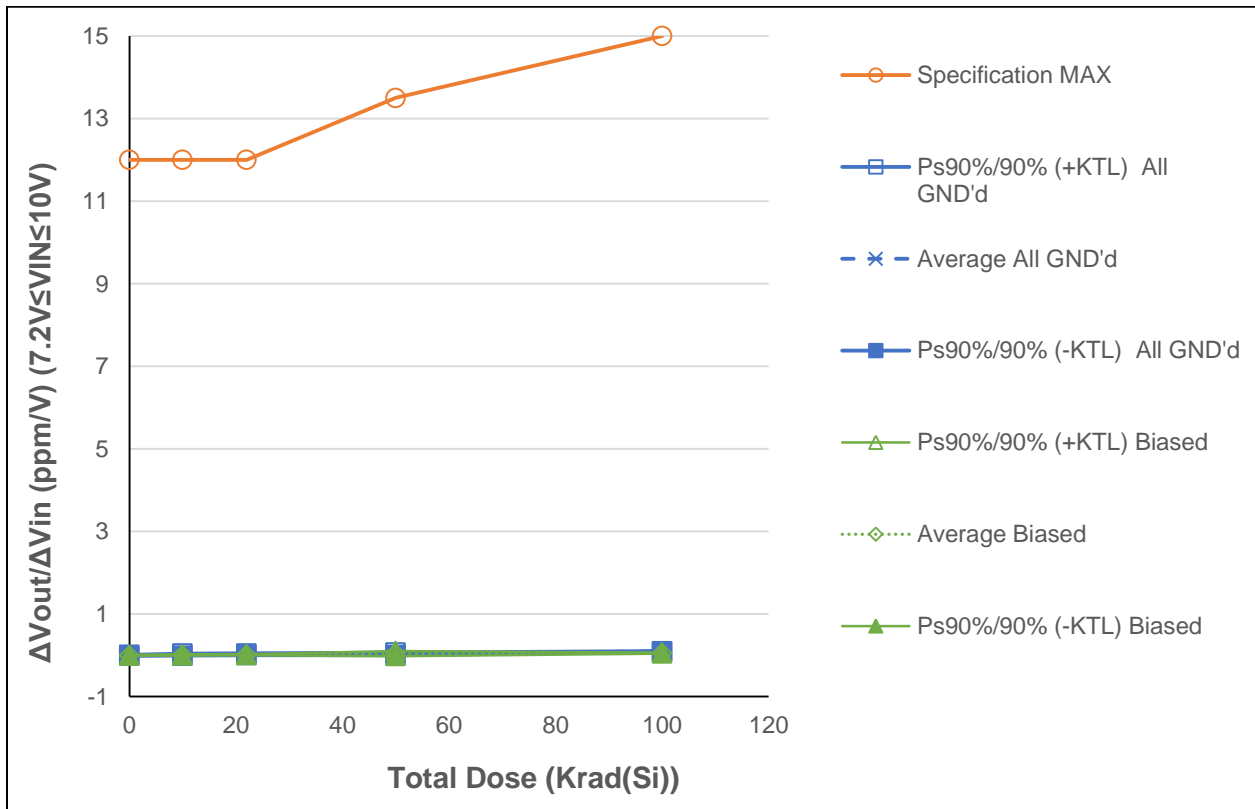


Figure 5.3: Plot of Line Regulation ( $7.2V \leq V_{IN} \leq 10V$ ) versus Total Dose

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

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

Parameter	$\Delta V_{OUT}/\Delta V_{IN}$ ( $7.2V \leq V_{IN} \leq 10V$ )	Total Dose (Krad(Si)) at 10 mrad(Si)/second				
Unit #	(ppm/V)	0	10	22	50	100
334	All GND'd Irradiation	-0.0058	0.0290	0.0315	0.0253	0.0964
336	All GND'd Irradiation	0.0036	0.0199	0.0276	0.0343	0.0975
337	All GND'd Irradiation	-0.0013	0.0156	0.0280	0.0250	0.0922
338	All GND'd Irradiation	0.0047	0.0168	0.0342	0.0425	0.0948
339	All GND'd Irradiation	0.0025	0.0037	0.0135	0.0498	0.0916
340	Biased-Irradiation	-0.0017	0.0124	0.0133	0.0589	0.0538
341	Biased-Irradiation	0.0027	0.0027	0.0238	0.0438	0.0503
342	Biased-Irradiation	0.0018	0.0126	0.0167	0.0611	0.0561
343	Biased-Irradiation	0.0014	0.0144	0.0171	0.0556	0.0528
345	Biased-Irradiation	0.0065	0.0085	0.0135	0.0064	0.0620
323	Control Unit	0.0080	0.0045	0.0081	0.0245	0.0036
324	Control Unit	0.0000	-0.0014	-0.0127	0.0152	-0.0066
All GND'd Irradiation Statistics						
	Average All GND'd	0.0008	0.0170	0.0270	0.0354	0.0945
	Std Dev All GND'd	0.0043	0.0091	0.0080	0.0108	0.0025
	Ps90%/90% (+KTL) All GND'd	0.0125	0.0420	0.0489	0.0651	0.1014
	Ps90%/90% (-KTL) All GND'd	-0.0110	-0.0080	0.0050	0.0057	0.0875
Biased-Irradiation Statistics						
	Average Biased	0.0021	0.0101	0.0169	0.0452	0.0550
	Std Dev Biased	0.0029	0.0047	0.0043	0.0227	0.0044
	Ps90%/90% (+KTL) Biased	0.0102	0.0229	0.0286	0.1073	0.0671
	Ps90%/90% (-KTL) Biased	-0.0059	-0.0027	0.0052	-0.0170	0.0429
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

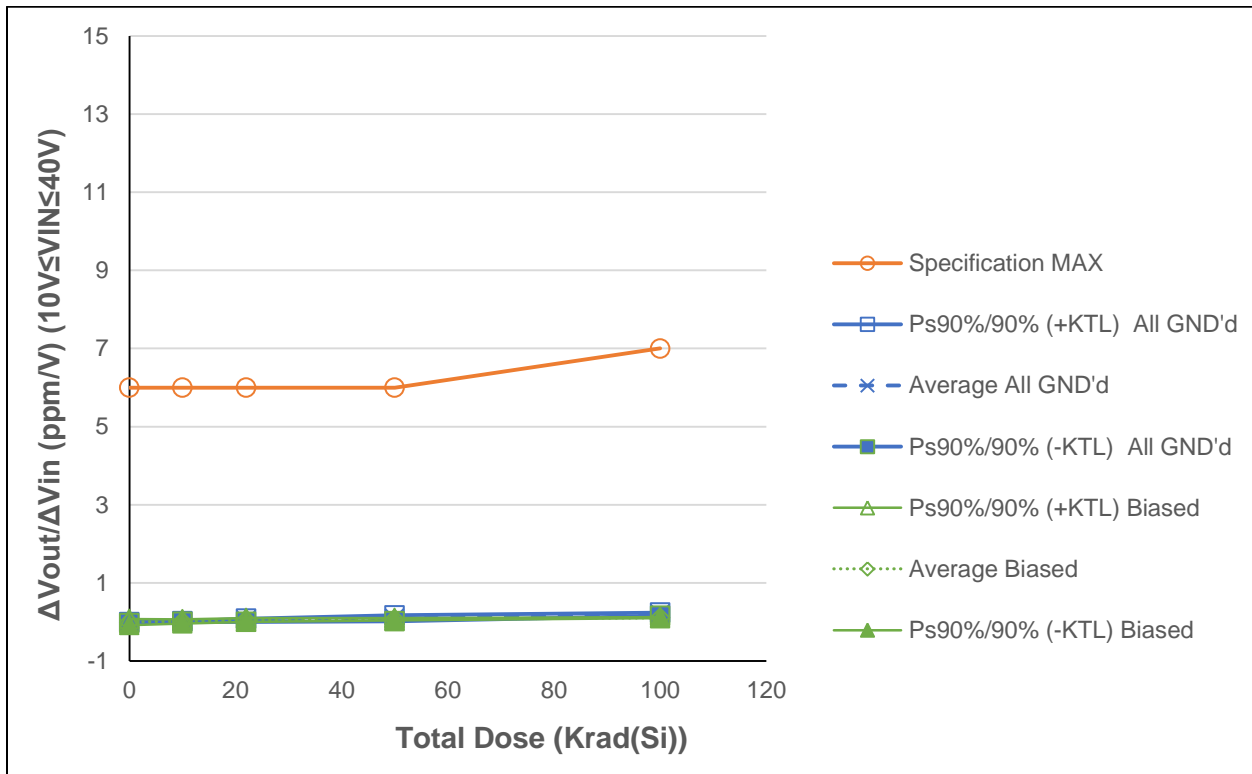


Figure 5.4: Plot of Line Regulation ( $10V \leq V_{IN} \leq 40V$ ) versus Total Dose

All measured data points are well under datasheet upper limits.

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

Parameter	$\Delta V_{OUT}/\Delta V_{IN}$ ( $10V \leq V_{IN} \leq 40V$ )	Total Dose (Krad(Si)) at 10 mrad(Si)/second				
Unit #	(ppm/V)	0	10	22	50	100
334	All GND'd Irradiation	-0.0157	0.0086	0.0381	0.1333	0.2017
336	All GND'd Irradiation	-0.0180	0.0106	0.0295	0.0825	0.2038
337	All GND'd Irradiation	-0.0110	0.0091	0.0471	0.0759	0.2070
338	All GND'd Irradiation	-0.0074	0.0165	0.0667	0.1140	0.2161
339	All GND'd Irradiation	-0.0130	0.0078	0.0316	0.0667	0.1759
340	Biased-Irradiation	0.0512	0.0485	0.0819	0.0861	0.1062
341	Biased-Irradiation	-0.0129	0.0104	0.0413	0.0715	0.1174
342	Biased-Irradiation	-0.0139	0.0041	0.0370	0.0714	0.1048
343	Biased-Irradiation	-0.0117	0.0009	0.0486	0.0655	0.1094
345	Biased-Irradiation	-0.0105	0.0103	0.0516	0.0539	0.1065
323	Control Unit	-0.0132	-0.0159	-0.0286	-0.0361	-0.0078
324	Control Unit	-0.0119	-0.0180	-0.0083	-0.0061	-0.0089
All GND'd Irradiation Statistics						
	Average All GND'd	-0.0130	0.0105	0.0426	0.0945	0.2009
	Std Dev All GND'd	0.0041	0.0035	0.0151	0.0281	0.0150
	Ps90%/90% (+KTL) All GND'd	-0.0018	0.0201	0.0840	0.1715	0.2421
	Ps90%/90% (-KTL) All GND'd	-0.0243	0.0009	0.0012	0.0175	0.1597
Biased-Irradiation Statistics						
	Average Biased	0.0005	0.0148	0.0521	0.0697	0.1089
	Std Dev Biased	0.0284	0.0192	0.0176	0.0116	0.0051
	Ps90%/90% (+KTL) Biased	0.0784	0.0676	0.1005	0.1016	0.1227
	Ps90%/90% (-KTL) Biased	-0.0774	-0.0379	0.0037	0.0378	0.0950
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

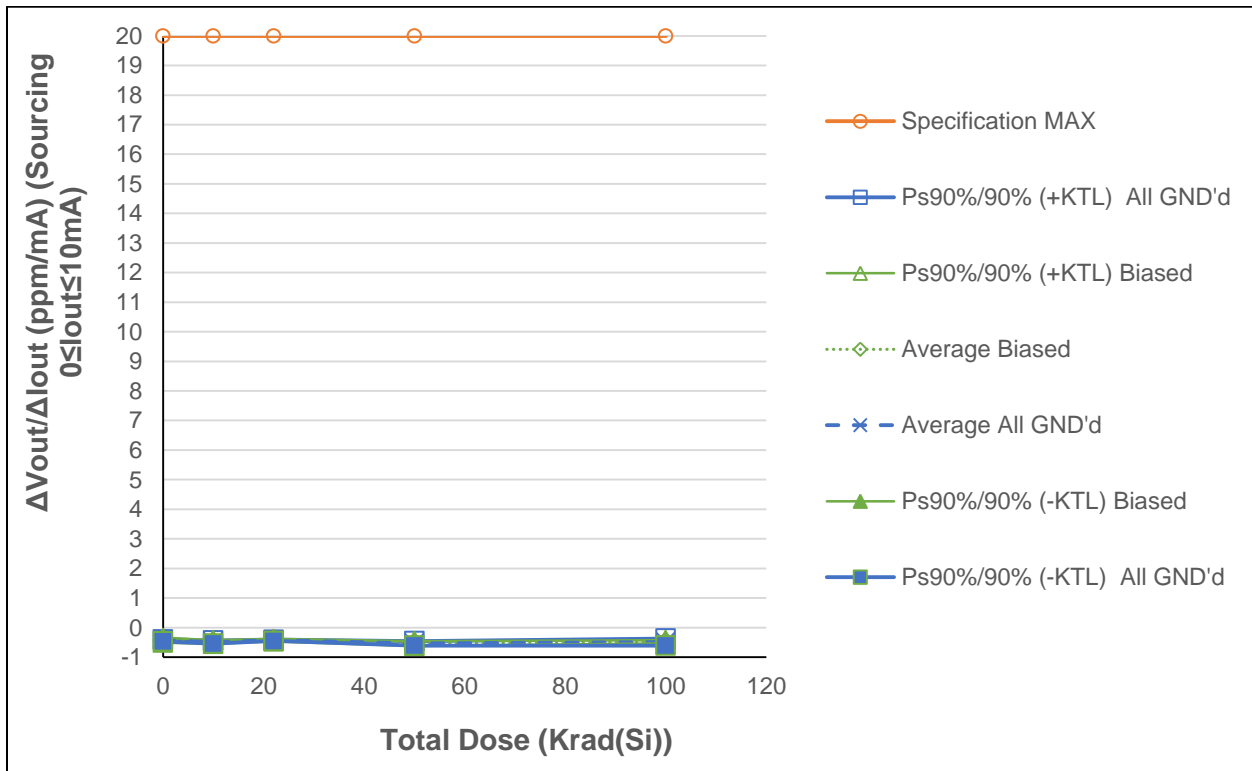


Figure 5.5: Plot of Load Regulation (Sourcing  $0 \leq I_{OUT} \leq 10\text{mA}$ ) versus Total Dose

The measured parameters are well under the specification maximum limits.

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

Parameter	$\Delta VO/\Delta IO$ (Source $0 \leq I_{OUT} \leq 10\text{mA}$ )	Total Dose (Krad(Si)) at 10 mrad(Si)/second				
Unit #	(ppm/mA)	0	10	22	50	100
334	All GND'd Irradiation	-0.4495	-0.5088	-0.4300	-0.5064	-0.5530
336	All GND'd Irradiation	-0.4159	-0.4640	-0.4201	-0.5439	-0.5005
337	All GND'd Irradiation	-0.4304	-0.4872	-0.4263	-0.5584	-0.4351
338	All GND'd Irradiation	-0.4210	-0.5011	-0.4320	-0.5002	-0.4682
339	All GND'd Irradiation	-0.4353	-0.4687	-0.4401	-0.5545	-0.4877
340	Biased-Irradiation	-0.4519	-0.5164	-0.4493	-0.5695	-0.5123
341	Biased-Irradiation	-0.4303	-0.4825	-0.4174	-0.4947	-0.4822
342	Biased-Irradiation	-0.4142	-0.4849	-0.4104	-0.5462	-0.4748
343	Biased-Irradiation	-0.4534	-0.4912	-0.4204	-0.5538	-0.4852
345	Biased-Irradiation	-0.3788	-0.4533	-0.4336	-0.5243	-0.4545
323	Control Unit	-0.4323	-0.5053	-0.3868	-0.5046	-0.4788
324	Control Unit	-0.4068	-0.4560	-0.3515	-0.4675	-0.4661
All GND'd Irradiation Statistics						
	Average All GND'd	-0.4304	-0.4860	-0.4297	-0.5327	-0.4889
	Std Dev All GND'd	0.0131	0.0196	0.0074	0.0274	0.0435
	Ps90%/90% (+KTL) All GND'd	-0.3944	-0.4323	-0.4095	-0.4575	-0.3696
	Ps90%/90% (-KTL) All GND'd	-0.4665	-0.5396	-0.4499	-0.6078	-0.6082
Biased-Irradiation Statistics						
	Average Biased	-0.4257	-0.4857	-0.4262	-0.5377	-0.4818
	Std Dev Biased	0.0309	0.0225	0.0154	0.0290	0.0208
	Ps90%/90% (+KTL) Biased	-0.3411	-0.4239	-0.3840	-0.4581	-0.4247
	Ps90%/90% (-KTL) Biased	-0.5104	-0.5474	-0.4685	-0.6173	-0.5389
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

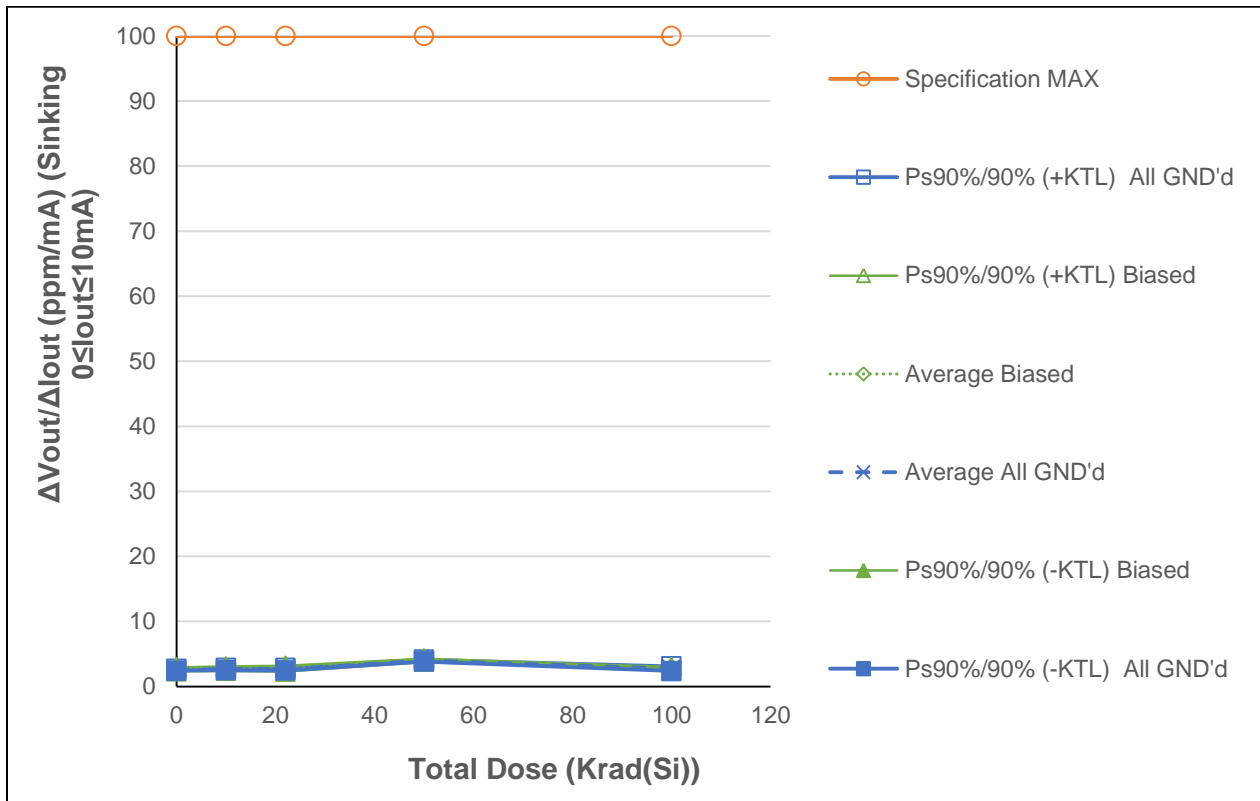


Figure 5.6: Plot of Load Regulation (Sinking  $0 \leq I_{OUT} \leq 10mA$ ) versus Total Dose

The maximum limits at different post-irradiation doses of the parameter are at 100 ppm/mA and the measured values are in the 2-4 ppm/mA range.



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

Parameter Unit #	$\Delta V_O/\Delta I_O$ (Sink $0 \leq I_{OUT} \leq 10\text{mA}$ ) (ppm/mA)	Total Dose (Krad(Si)) at 10 mrad(Si)/second				
		0	10	22	50	100
334	All GND'd Irradiation	2.5426	2.7659	2.6134	3.9620	2.9421
336	All GND'd Irradiation	2.6641	2.7422	2.7840	4.0659	2.7917
337	All GND'd Irradiation	2.5986	2.7019	2.6149	4.0040	2.6503
338	All GND'd Irradiation	2.5736	2.6365	2.6299	3.9494	2.6708
339	All GND'd Irradiation	2.5265	2.6028	2.6977	3.9316	2.6503
340	Biased-Irradiation	2.4537	2.5697	2.5080	3.8931	2.6783
341	Biased-Irradiation	2.6606	2.6686	2.6670	4.0316	2.7289
342	Biased-Irradiation	2.6946	2.8112	2.7427	4.1286	2.8077
343	Biased-Irradiation	2.6740	2.8124	2.7492	4.0392	2.7847
345	Biased-Irradiation	2.7489	2.8600	2.9540	4.0940	2.8902
323	Control Unit	2.7372	2.9356	2.8347	4.1586	2.7995
324	Control Unit	2.5753	2.5556	2.3886	4.0987	2.6555
All GND'd Irradiation Statistics						
	Average All GND'd	2.5811	2.6899	2.6680	3.9826	2.7411
	Std Dev All GND'd	0.0541	0.0691	0.0734	0.0536	0.1269
	Ps90%/90% (+KTL) All GND'd	2.7294	2.8793	2.8694	4.1297	3.0890
	Ps90%/90% (-KTL) All GND'd	2.4327	2.5004	2.4666	3.8355	2.3931
Biased-Irradiation Statistics						
	Average Biased	2.6463	2.7444	2.7242	4.0373	2.7780
	Std Dev Biased	0.1128	0.1212	0.1611	0.0900	0.0804
	Ps90%/90% (+KTL) Biased	2.9558	3.0766	3.1658	4.2840	2.9985
	Ps90%/90% (-KTL) Biased	2.3369	2.4121	2.2825	3.7906	2.5574
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

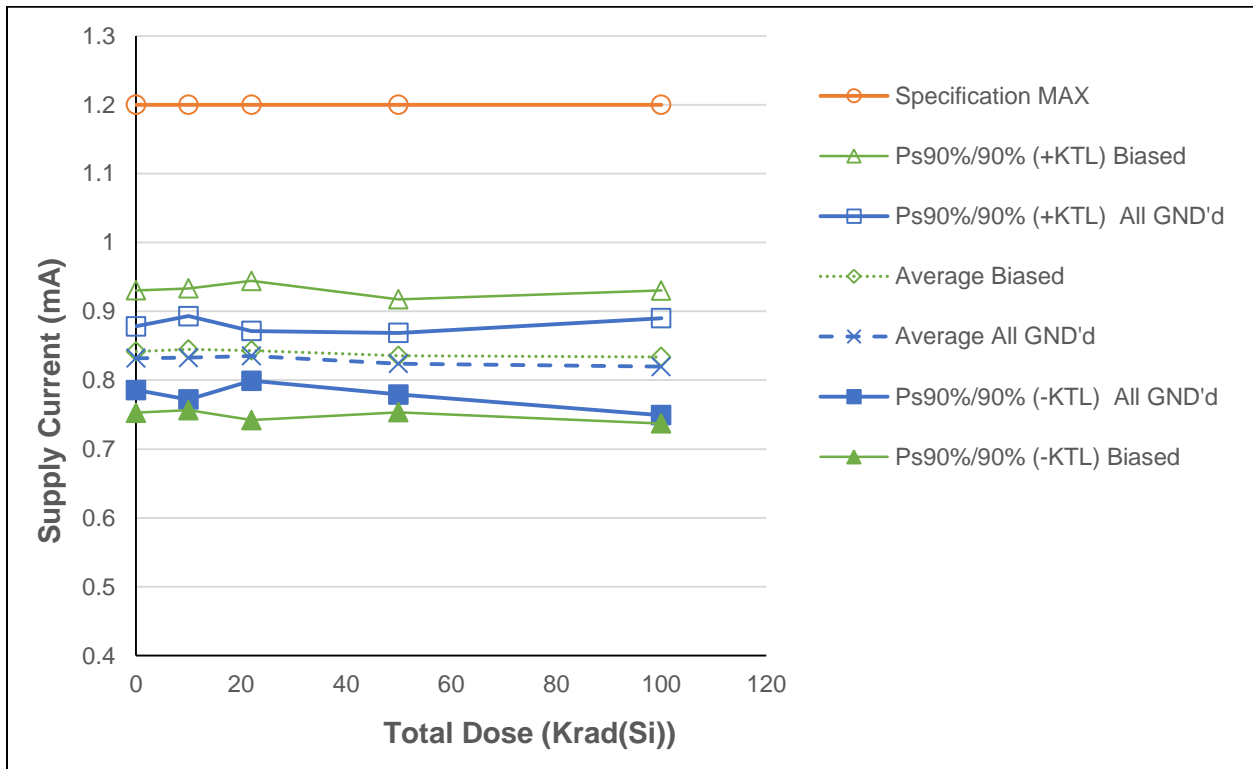


Figure 5.7: Plot of Supply Current versus Total Dose

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)) at 10 mrad(Si)/second				
Unit #	(mA)	0	10	22	50	100
334	All GND'd Irradiation	0.8303	0.8198	0.8287	0.8233	0.7914
336	All GND'd Irradiation	0.8493	0.8578	0.8482	0.8431	0.8488
337	All GND'd Irradiation	0.8043	0.8013	0.8169	0.7986	0.7936
338	All GND'd Irradiation	0.8362	0.8438	0.8473	0.8236	0.8321
339	All GND'd Irradiation	0.8394	0.8399	0.8350	0.8314	0.8319
340	Biased-Irradiation	0.8261	0.8262	0.8336	0.8185	0.8125
341	Biased-Irradiation	0.8442	0.8541	0.8529	0.8394	0.8446
342	Biased-Irradiation	0.8545	0.8570	0.8559	0.8441	0.8450
343	Biased-Irradiation	0.8852	0.8857	0.8864	0.8776	0.8795
345	Biased-Irradiation	0.7981	0.8012	0.7865	0.7977	0.7872
323	Control Unit	0.8058	0.7924	0.7948	0.8150	0.8132
324	Control Unit	0.8445	0.8578	0.8762	0.8499	0.8461
All GND'd Irradiation Statistics						
	Average All GND'd	0.8319	0.8325	0.8352	0.8240	0.8196
	Std Dev All GND'd	0.0169	0.0221	0.0132	0.0163	0.0257
	Ps90%/90% (+KTL) All GND'd	0.8782	0.8931	0.8713	0.8688	0.8899
	Ps90%/90% (-KTL) All GND'd	0.7856	0.7719	0.7991	0.7792	0.7492
Biased-Irradiation Statistics						
	Average Biased	0.8416	0.8448	0.8430	0.8355	0.8338
	Std Dev Biased	0.0324	0.0322	0.0368	0.0299	0.0352
	Ps90%/90% (+KTL) Biased	0.9306	0.9332	0.9441	0.9175	0.9303
	Ps90%/90% (-KTL) Biased	0.7527	0.7565	0.7420	0.7535	0.7372
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

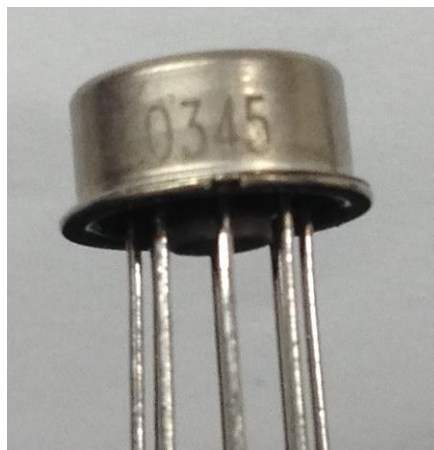


Figure A2: Side View showing serial number

## Appendix B

### Radiation Bias Connection Tables

Table B1: Biased Conditions

Pin	Function	Connection / Bias
1	NC	NC
2	V <sub>IN</sub>	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 <sub>OUT</sub>	NC
7	NC	NC
8	NC	NC

Table B2: All GND'd

Pin	Function	Connection / Bias
1	NC	GND
2	V <sub>IN</sub>	GND
3	NC	GND
4	GND	GND
5	TRIM	GND
6	V <sub>OUT</sub>	GND
7	NC	GND
8	NC	GND

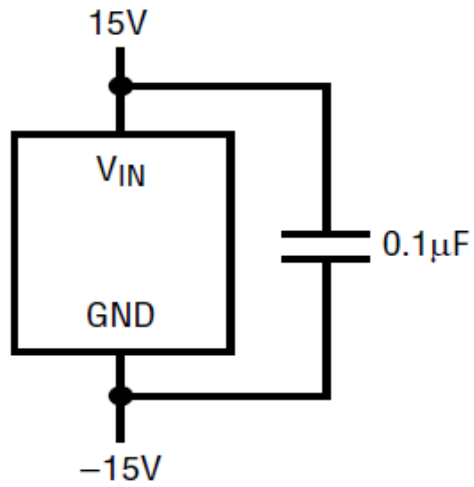


Figure B1: Total Dose Bias Circuit

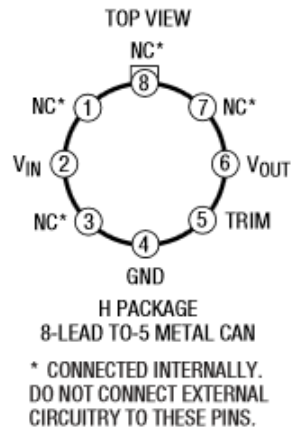


Figure B2: Pin-Out

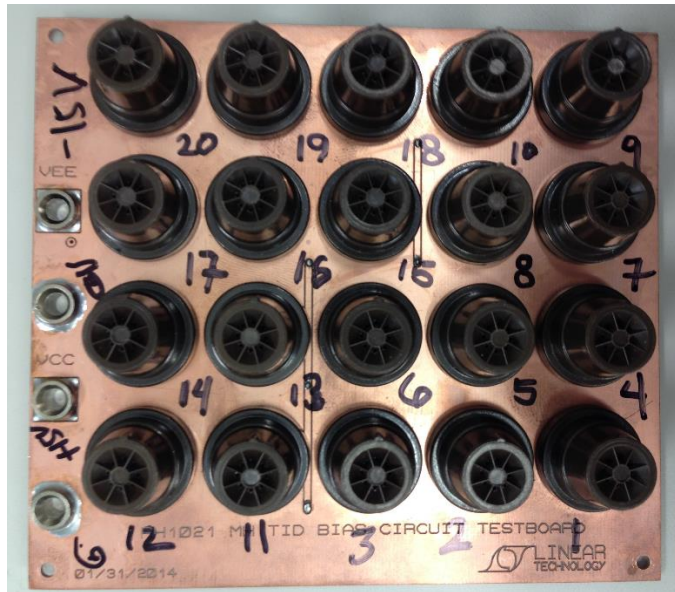


Figure B3: Bias Board (top view)

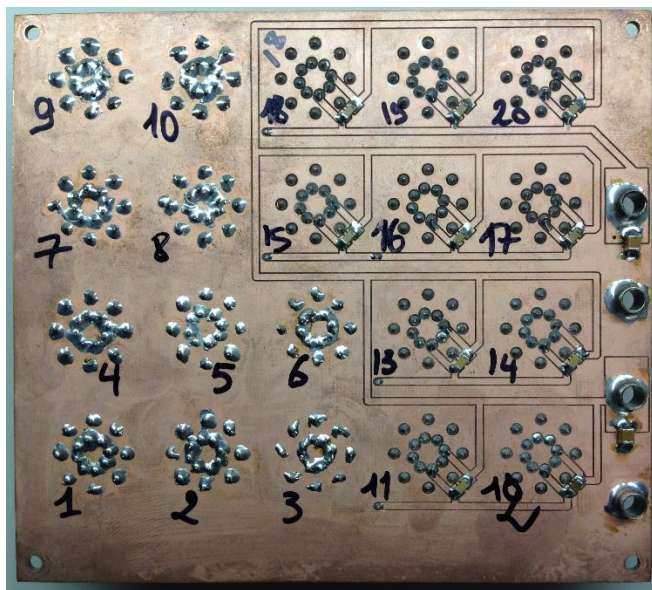




Figure B4: Bias Board (bottom view)

## Appendix C

<b>TEST CERTIFICATE</b>		
		
<b>Defense Microelectronics Activity Science and Engineering Gamma Irradiation Test Facility DMEA/MEBC 4234 54<sup>th</sup> Street McClellan, CA 95652</b>		
		
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

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



## 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	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 ≤ V <sub>IN</sub> ≤ 10V)	12		12		12		13.5		15		ppm/V
Line Regulation (10V ≤ V <sub>IN</sub> ≤ 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 ≤ I<sub>OUT</sub> ≤ 10mA)