

# **Total Ionization Dose (TID) Test Results of the RH1086MH 0.5A Low Dropout Positive Adjustable Regulator @ Low Dose Rate (LDR)**

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

20 November 2014

Duc Nguyen, Sana Rezgui

## **Acknowledgements**

The authors would like to thank the Product Engineering and Design S-Power groups 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 RH1086MH 0.5A Low Dropout Positive Adjustable Regulator

**Part Type Tested:** RH1086MH 0.5A Low Dropout Positive Adjustable Regulator

**Traceability Information:** Fab Lot # W1231270.1; Assembly Lot # 719601.1; Wafer # 4; Date Code 1328A. 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 667-671 had all pins tied to ground during irradiation. Serial numbers 662-666 were biased during irradiation. Serial numbers 660 and 661 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: 10 Krads(Si), 20 Krads(Si), 50 Krads(Si), 73 Krads(Si), 107 Krads(Si).

**Radiation dose:** 10 mrads(Si)/sec.

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

**Test Hardware and Software:** LTX pre- and post-irradiation test program EFCR1086H.02.

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

## 1.0 Overview and Background

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

## 2.0 Radiation Facility and Test Equipment

The samples were irradiated at Defense Micro-Electronics Activity (DMEA) facility in Sacramento, California. DMEA utilizes J.L. Shepherd model 81-22/484 to provide the dose-rate of 10 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 samples were placed in a lead/aluminum container and aligned with the radiation source, Cobalt-60, at DMEA facility in Sacramento, California. During irradiation, five units were biased at +/- 15V and other five had all pads grounded. The devices were irradiated up to 107 Krad(Si) with increments of 10, 20, 50, 73 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 tested 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:

- $V_{REF}$  (V) @  $10\text{mA} \leq I_{OUT} \leq I_{FULL\ LOAD}$ ,  $1.5\text{V} \leq (V_{IN} - V_{OUT}) \leq 15\text{V}$
- Line Regulation (%) @  $I_{LOAD} = 10\text{mA}$ ,  $1.5\text{V} \leq (V_{IN} - V_{OUT}) \leq 15\text{V}$
- Load Regulation (%) @  $(V_{IN} - V_{OUT}) = 3\text{V}$ ,  $10\text{mA} \leq I_{OUT} \leq I_{FULL\ LOAD}$
- Dropout Voltage (V) @  $I_{OUT} = 0.5\text{A}$ ,  $\Delta V_{REF} = 1\%$
- Current Limit (A) @  $(V_{IN} - V_{OUT}) = 5\text{V}$
- Current Limit (A) @  $(V_{IN} - V_{OUT}) = 25\text{V}$
- Minimum Load Current (mA) @  $(V_{IN} - V_{OUT}) = 25\text{V}$
- Adjust Pin Current ( $\mu\text{A}$ )
- Delta Adjust Current ( $\mu\text{A}$ ) @  $10\text{mA} \leq I_{OUT} \leq I_{FULL\ LOAD}$ ,  $1.5\text{V} \leq (V_{IN} - V_{OUT}) \leq 15\text{V}$

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 nine listed parameters in section 4.0 are within the specification limits.

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

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

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

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

However, in most cases, mean and standard deviations 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  $P_{90\%/90\%}$   $K_{TL}$  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 107 Krads(Si) test limits are using Linear Technology datasheet 100 Krads(Si) specification limits.

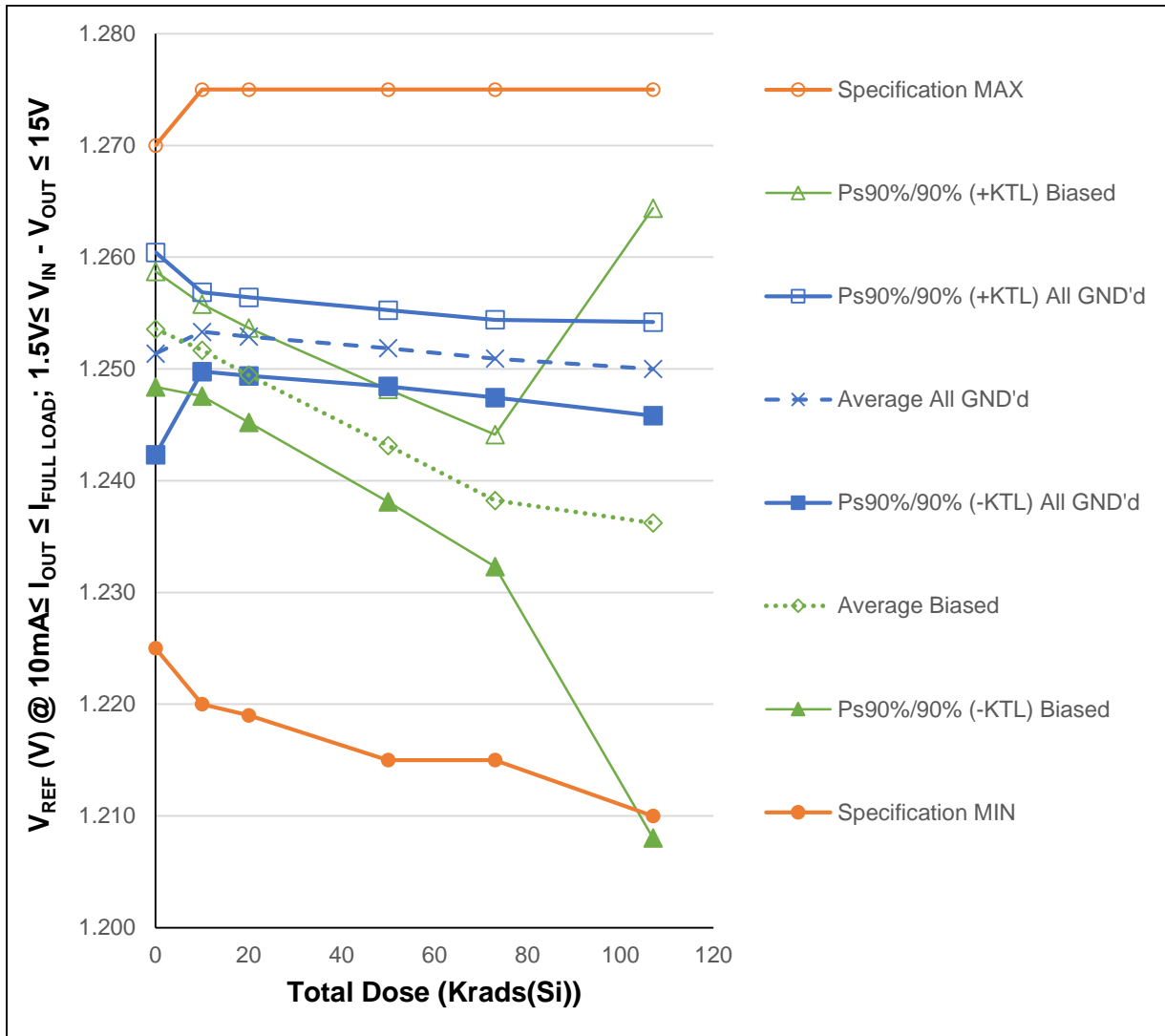


Figure 5.1 Plot of Reference Voltage versus Total Dose

The measured data of 10 samples are within datasheet specification limits. Note the 107 Krad(Si) computed +KTL biased data point is slightly lower than the maximum limit due to the small 5-piece sample size.

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

Parameter	Vref @ 10mA ≤ I <sub>OUT</sub> ≤ I <sub>FULL LOAD</sub> ; 1.5V ≤ V <sub>IN</sub> - V <sub>OUT</sub> ≤ 15V	Total Dose (Krad(Si)) @ 10 mrads(Si)/s					
Units	(V)	0	10	20	50	73	107
667	All GND'd Irradiation	1.25124	1.25185	1.25142	1.25067	1.24991	1.24922
668	All GND'd Irradiation	1.25552	1.25352	1.25302	1.25195	1.25111	1.25028
669	All GND'd Irradiation	1.25060	1.25484	1.25440	1.25325	1.25227	1.25144
670	All GND'd Irradiation	1.24655	1.25422	1.25383	1.25287	1.25196	1.25129
671	All GND'd Irradiation	1.25296	1.25215	1.25180	1.25051	1.24935	1.24777
662	Biased Irradiation	1.25491	1.25207	1.24983	1.24366	1.23909	1.25415
663	Biased Irradiation	1.25593	1.25093	1.24864	1.24210	1.23696	1.23045
664	Biased Irradiation	1.25135	1.24981	1.24753	1.24115	1.23600	1.22988
665	Biased Irradiation	1.25220	1.25169	1.24952	1.24282	1.23754	1.23102
666	Biased Irradiation	1.25342	1.25387	1.25170	1.24599	1.24150	1.23558
660	Control Unit	1.25617	1.25474	1.25461	1.25409	1.25386	1.25402
661	Control Unit	1.25674	1.25185	1.25645	1.25658	1.25600	1.25644
All GND'd Irradiation Statistics							
Average All GND'd		1.25138	1.25331	1.25290	1.25185	1.25092	1.25000
Std Dev All GND'd		0.00330	0.00129	0.00128	0.00124	0.00127	0.00153
Ps90%/90% (+KTL) All GND'd		1.26042	1.25686	1.25640	1.25526	1.25439	1.25420
Ps90%/90% (-KTL) All GND'd		1.24233	1.24977	1.24939	1.24844	1.24744	1.24581
Biased Irradiation Statistics							
Average Biased		1.25356	1.25168	1.24944	1.24314	1.23822	1.23621
Std Dev Biased		0.00188	0.00150	0.00154	0.00184	0.00215	0.01027
Ps90%/90% (+KTL) Biased		1.25872	1.25579	1.25368	1.24818	1.24411	1.26439
Ps90%/90% (-KTL) Biased		1.24840	1.24756	1.24521	1.23810	1.23233	1.20804
Specification MIN		1.225	1.220	1.219	1.215		1.210
Status (Measurements) All GND		PASS	PASS	PASS	PASS		PASS
Status (Measurements) Biased		PASS	PASS	PASS	PASS		PASS
Specification MAX		1.270	1.275	1.275	1.275		1.275
Status (Measurements) All GND		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		FAIL
Status (+KTL) Biased		PASS	PASS	PASS	PASS		PASS

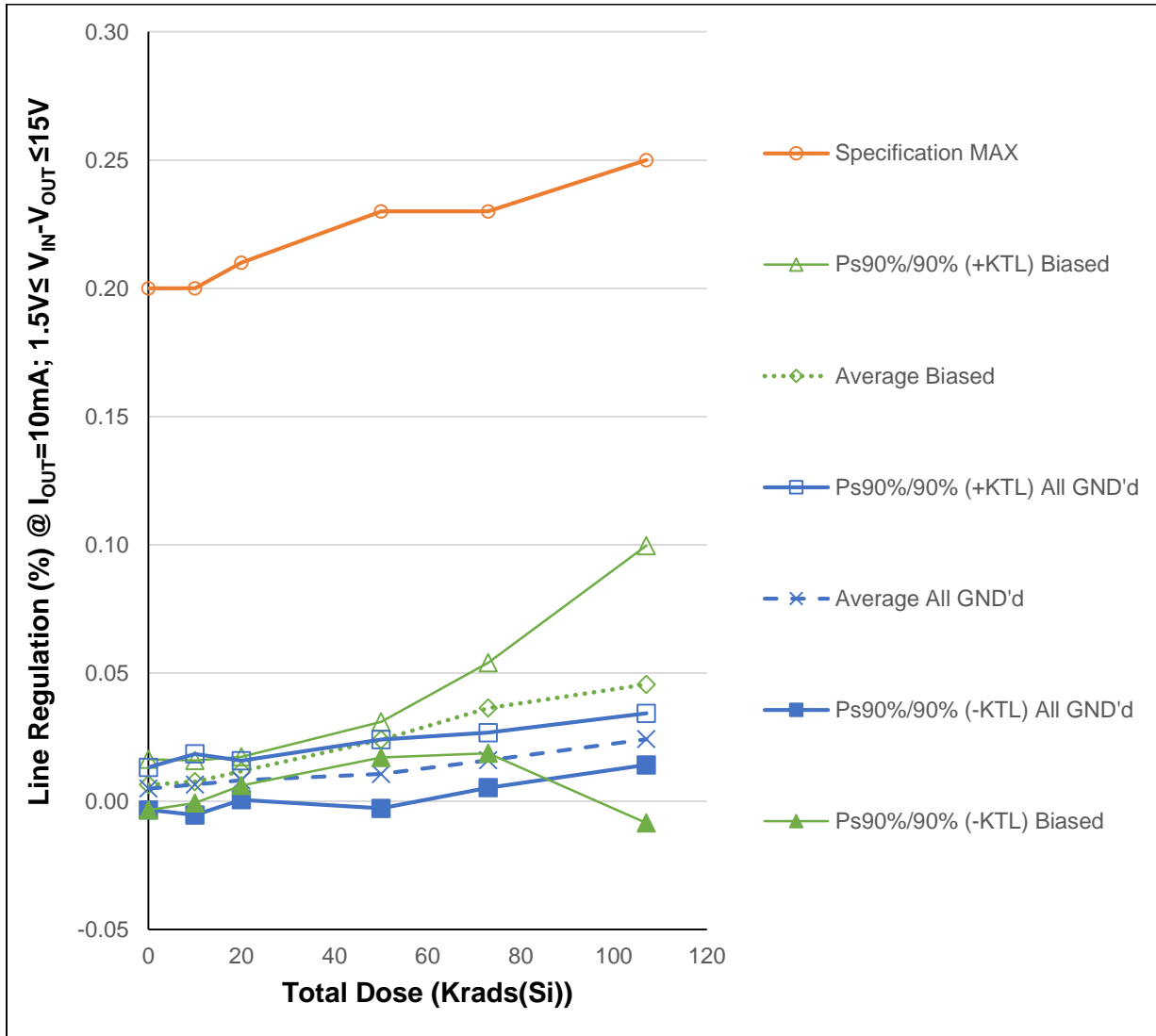


Figure 5.2: Plot of Line Regulation versus Total Dose



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

Parameter	Line Reg @ $I_{OUT}=10mA$ ; $1.5V \leq V_{IN} - V_{OUT} \leq 15V$	Total Dose (Krad(Si)) @ 10 mrads(Si)/s					
		0	10	20	50	73	107
Units	(%)						
667	All GND'd Irradiation	0.00533	0.00533	0.00686	0.01677	0.01678	0.02373
668	All GND'd Irradiation	0.00076	0.01225	0.00685	0.00990	0.01372	0.03035
669	All GND'd Irradiation	0.00404	0.00912	0.00601	0.00685	0.01827	0.02133
670	All GND'd Irradiation	0.00918	0.00532	0.01293	0.00533	0.01066	0.02423
671	All GND'd Irradiation	0.00533	0.00076	0.00838	0.01449	0.02068	0.02147
662	Biased Irradiation	0.01139	0.00305	0.01076	0.02461	0.03925	0.01217
663	Biased Irradiation	0.00683	0.00770	0.00924	0.02465	0.02929	0.04658
664	Biased Irradiation	0.00129	0.00763	0.01452	0.02390	0.04552	0.06196
665	Biased Irradiation	0.00685	0.01150	0.01297	0.02693	0.03160	0.05803
666	Biased Irradiation	0.00616	0.00844	0.01143	0.01998	0.03610	0.04932
660	Control Unit	0.01291	0.00000	0.00608	0.01749	0.00837	0.00836
661	Control Unit	0.00531	0.00914	0.00531	0.00228	0.00911	0.01017
All GND'd Irradiation Statistics							
	Average All GND'd	0.00493	0.00656	0.00820	0.01067	0.01602	0.02422
	Std Dev All GND'd	0.00302	0.00435	0.00278	0.00489	0.00392	0.00366
	Ps90%/90% (+KTL) All GND'd	0.01322	0.01847	0.01582	0.02407	0.02676	0.03427
	Ps90%/90% (-KTL) All GND'd	-0.00336	-0.00536	0.00059	-0.00274	0.00528	0.01417
Biased Irradiation Statistics							
	Average Biased	0.00651	0.00766	0.01178	0.02401	0.03635	0.04561
	Std Dev Biased	0.00358	0.00303	0.00203	0.00253	0.00642	0.01972
	Ps90%/90% (+KTL) Biased	0.01633	0.01597	0.01736	0.03095	0.05396	0.09967
	Ps90%/90% (-KTL) Biased	-0.00332	-0.00064	0.00621	0.01707	0.01874	-0.00845
Specification MIN							
	Status (Measurements) All GND'd						
	Status (Measurements) Biased						
Specification MAX		0.20	0.20	0.21	0.23		0.25
	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

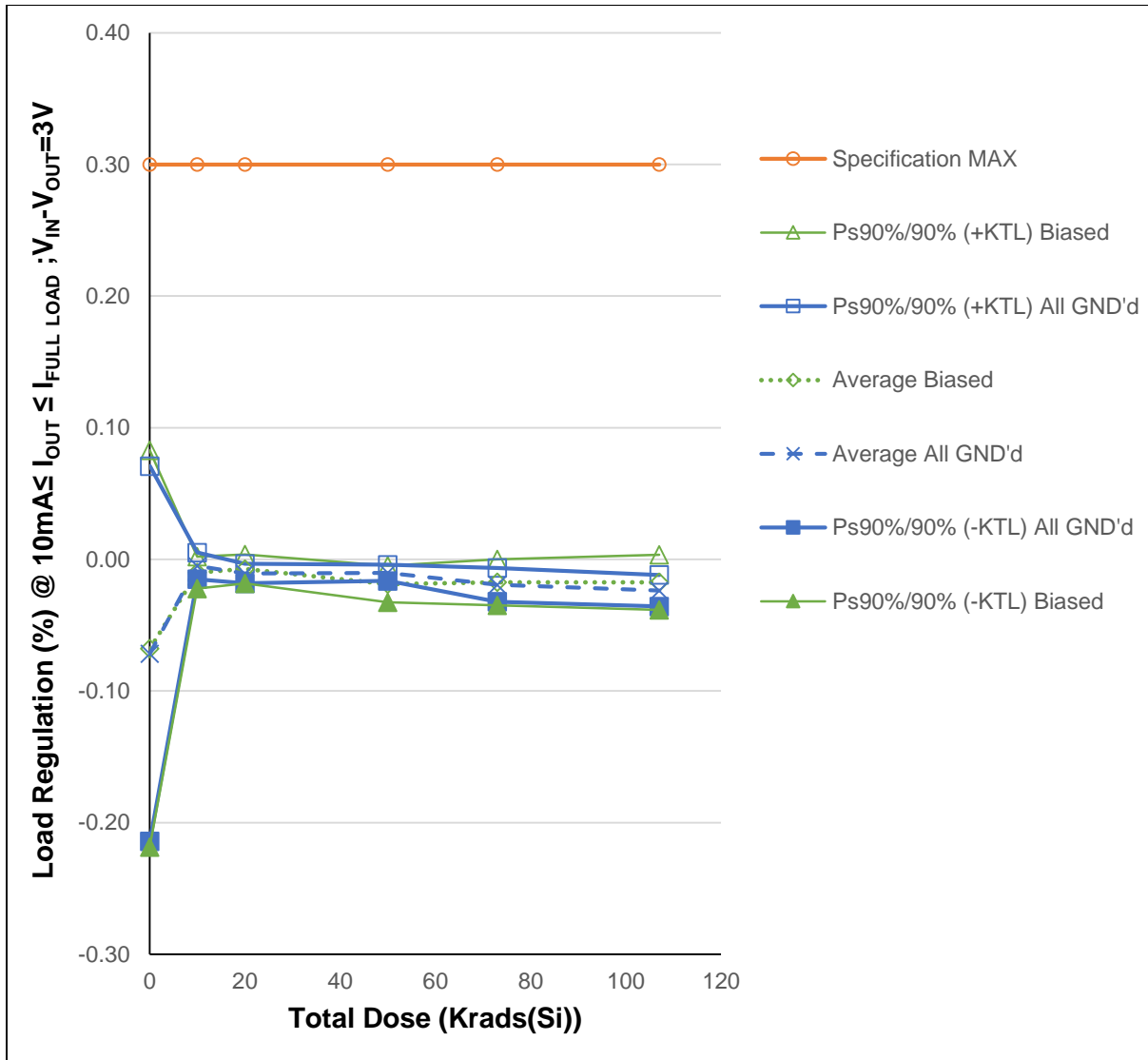


Figure 5.3: Plot of Load Regulation versus Total Dose

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

Parameter	Load Reg @ 10mA ≤ I <sub>OUT</sub> ≤ I <sub>FULL LOAD</sub> , V <sub>IN</sub> -V <sub>OUT</sub> =3V	Total Dose (Krad(Si)) @ 10 mrads(Si)/s					
		0	10	20	50	73	107
Units	(%)						
667	All GND'd Irradiation	-0.10728	-0.00564	-0.01135	-0.00839	-0.02136	-0.02122
668	All GND'd Irradiation	-0.11767	-0.01065	-0.01294	-0.01066	-0.02591	-0.02371
669	All GND'd Irradiation	-0.10048	-0.00152	-0.01368	-0.00989	-0.01447	-0.02971
670	All GND'd Irradiation	-0.00092	-0.00182	-0.00837	-0.00830	-0.01523	-0.01836
671	All GND'd Irradiation	-0.03196	-0.00533	-0.00762	-0.01380	-0.01984	-0.02605
662	Biased Irradiation	-0.07579	-0.01615	-0.01061	-0.02078	-0.02616	-0.00608
663	Biased Irradiation	-0.05237	-0.00541	-0.01153	-0.01082	-0.01310	-0.02410
664	Biased Irradiation	-0.12704	-0.01305	-0.00688	-0.02151	-0.02083	-0.01783
665	Biased Irradiation	-0.10111	-0.00769	-0.00153	-0.01696	-0.01002	-0.01448
666	Biased Irradiation	0.01689	-0.00768	-0.00609	-0.02372	-0.01690	-0.02454
660	Control Unit	0.00008	-0.01072	-0.01285	-0.00304	-0.00844	-0.00608
661	Control Unit	-0.02360	-0.00564	-0.00531	-0.01214	-0.01139	-0.01708
All GND'd Irradiation Statistics							
	Average All GND'd	-0.07166	-0.00499	-0.01079	-0.01021	-0.01936	-0.02381
	Std Dev All GND'd	0.05195	0.00370	0.00270	0.00225	0.00469	0.00437
	Ps90%/90% (+KTL) All GND'd	0.07080	0.00514	-0.00338	-0.00405	-0.00649	-0.01184
	Ps90%/90% (-KTL) All GND'd	-0.21412	-0.01513	-0.01821	-0.01637	-0.03223	-0.03578
Biased Irradiation Statistics							
	Average Biased	-0.06788	-0.01000	-0.00733	-0.01876	-0.01740	-0.01741
	Std Dev Biased	0.05499	0.00444	0.00399	0.00506	0.00636	0.00763
	Ps90%/90% (+KTL) Biased	0.08289	0.00217	0.00362	-0.00488	0.00003	0.00350
	Ps90%/90% (-KTL) Biased	-0.21866	-0.02217	-0.01828	-0.03264	-0.03484	-0.03831
	Specification MIN						
	Status (Measurements) All GND'd						
	Status (Measurements) Biased						
	Specification MAX	0.3	0.3	0.3	0.3		0.3
	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

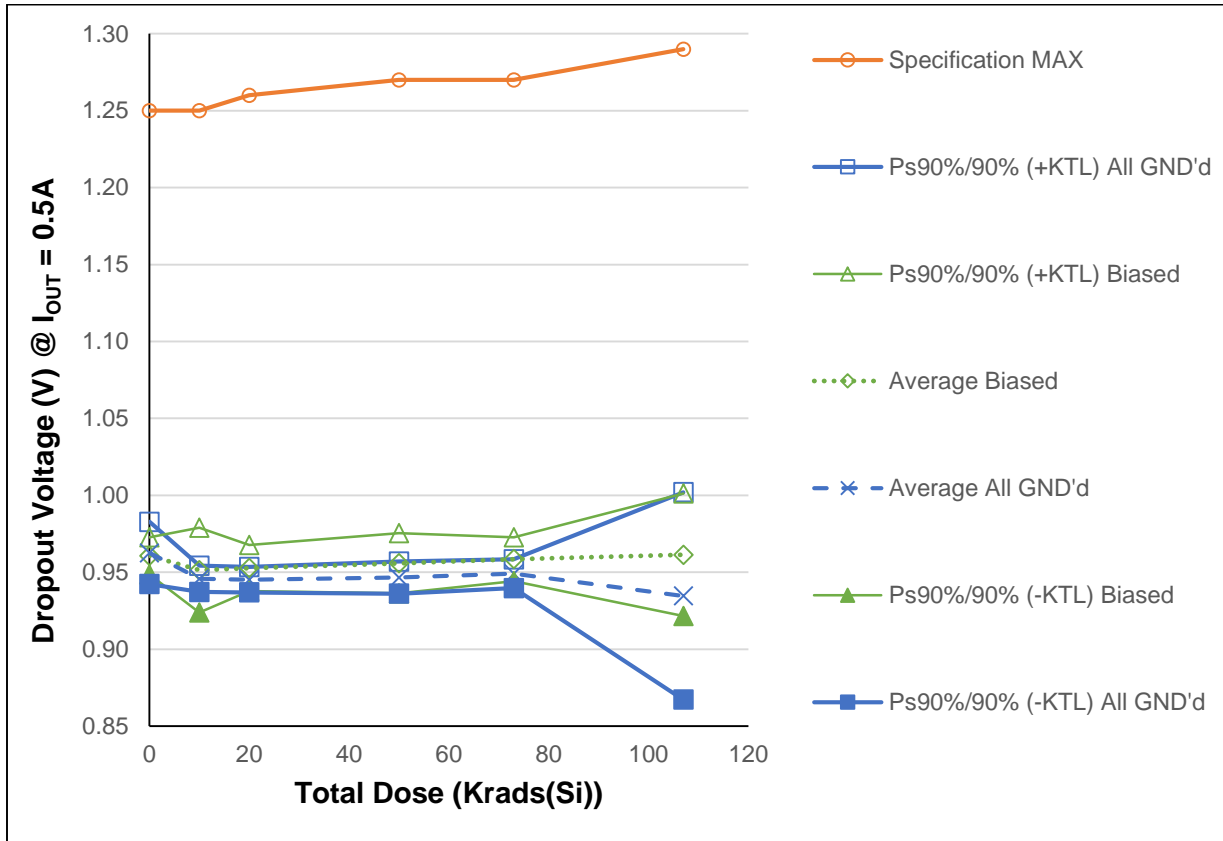


Figure 5.4: Plot of Dropout Voltage versus Total Dose

Table 5.4: Raw data for dropout voltage versus total dose including the statistical calculations, maximum specification, and the status of the test (PASS/FAIL).

Parameter	Dropout Voltage @ $I_{OUT} = 0.5A$	Total Dose (Krad(Si)) @ 10 mrads(Si)/s					
Units	(V)	0	10	20	50	73	107
667	All GND'd Irradiation	0.95429	0.94160	0.94231	0.94365	0.94524	0.94335
668	All GND'd Irradiation	0.96995	0.94842	0.94895	0.95059	0.95245	0.95869
669	All GND'd Irradiation	0.96002	0.94865	0.94765	0.95033	0.95276	0.91632
670	All GND'd Irradiation	0.97070	0.94659	0.94418	0.94578	0.94833	0.95290
671	All GND'd Irradiation	0.95784	0.94339	0.94255	0.94222	0.94650	0.90158
662	Biased Irradiation	0.96438	0.93989	0.94948	0.95632	0.95795	0.93707
663	Biased Irradiation	0.96148	0.94958	0.95286	0.95434	0.95654	0.96606
664	Biased Irradiation	0.96517	0.94431	0.94582	0.94465	0.95128	0.95968
665	Biased Irradiation	0.95503	0.96401	0.95510	0.96067	0.96194	0.97113
666	Biased Irradiation	0.95735	0.95912	0.96020	0.96312	0.96485	0.97281
660	Control Unit	0.96246	0.92021	0.92577	0.93924	0.94273	0.93831
661	Control Unit	0.96399	0.95474	0.93904	0.93908	0.93731	0.93276
All GND'd Irradiation Statistics							
	Average All GND'd	0.96256	0.94573	0.94513	0.94651	0.94906	0.93457
	Std Dev All GND'd	0.00738	0.00312	0.00302	0.00382	0.00342	0.02458
	Ps90%/90% (+KTL) All GND'd	0.98280	0.95429	0.95341	0.95698	0.95844	1.00196
	Ps90%/90% (-KTL) All GND'd	0.94232	0.93716	0.93684	0.93605	0.93968	0.86718
Biased Irradiation Statistics							
	Average Biased	0.96068	0.95138	0.95269	0.95582	0.95851	0.96135
	Std Dev Biased	0.00440	0.01006	0.00547	0.00714	0.00521	0.01450
	Ps90%/90% (+KTL) Biased	0.97275	0.97895	0.96770	0.97540	0.97279	1.00112
	Ps90%/90% (-KTL) Biased	0.94861	0.92381	0.93769	0.93624	0.94423	0.92158
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

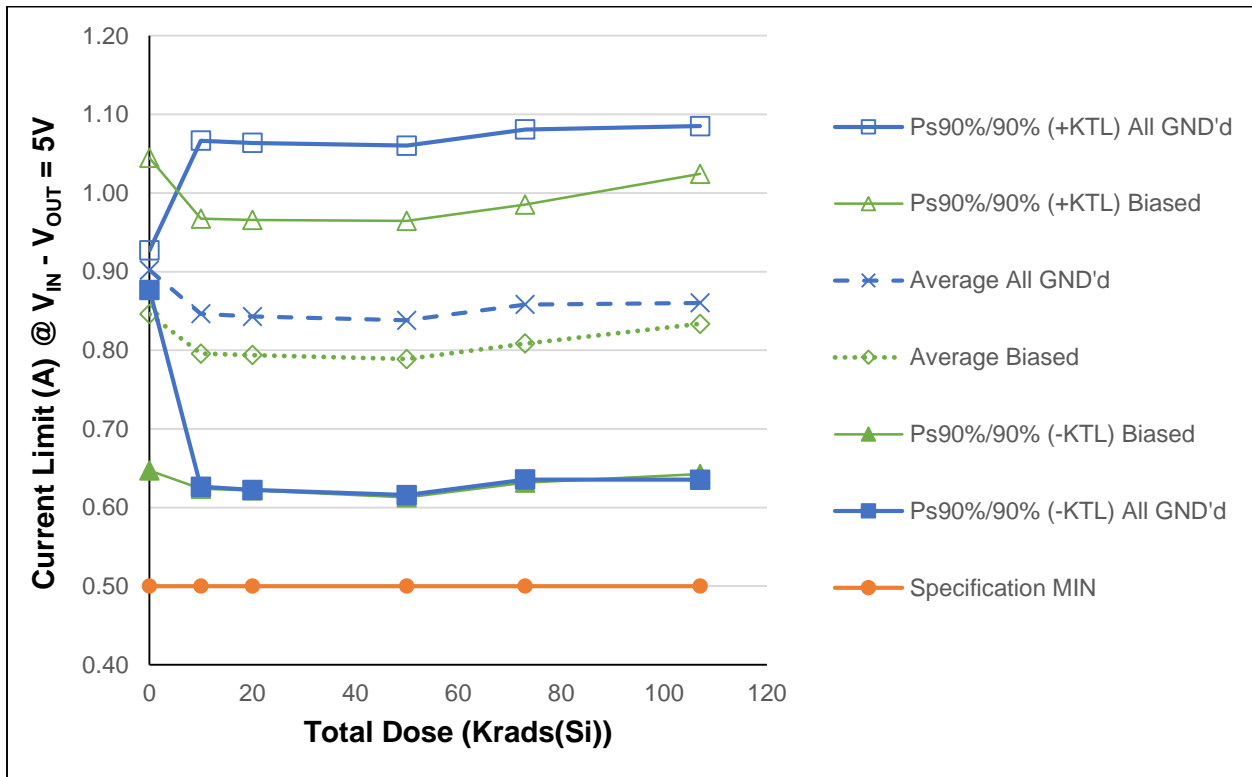


Figure 5.5: Plot of Current Limit versus Total Dose

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

Parameter	Current Limit (A) @ $V_{IN} - V_{OUT} = 5V$	Total Dose (Krad(Si)) @ 10 mrad(Si)/s					
Units	(A)	0	10	20	50	73	107
667	All GND'd Irradiation	0.90094	0.90733	0.90406	0.89946	0.91953	0.92311
668	All GND'd Irradiation	0.88998	0.90337	0.90065	0.89646	0.91638	0.92448
669	All GND'd Irradiation	0.91463	0.75427	0.75119	0.74592	0.76637	0.76301
670	All GND'd Irradiation	0.89800	0.76303	0.75867	0.75274	0.77222	0.77847
671	All GND'd Irradiation	0.90634	0.90438	0.90065	0.89571	0.91649	0.91201
662	Biased Irradiation	0.89635	0.76702	0.76764	0.76347	0.78303	0.88726
663	Biased Irradiation	0.89857	0.77043	0.76852	0.76280	0.78201	0.78774
664	Biased Irradiation	0.76807	0.76628	0.76593	0.75642	0.77681	0.78184
665	Biased Irradiation	0.90205	0.76729	0.76135	0.75795	0.77703	0.78209
666	Biased Irradiation	0.76528	0.90774	0.90594	0.90340	0.92379	0.92892
660	Control Unit	0.75971	0.88028	0.87549	0.86815	0.88825	0.88786
661	Control Unit	0.89711	0.77171	0.89779	0.88597	0.90136	0.90272
All GND'd Irradiation Statistics							
	Average All GND'd	0.90198	0.84648	0.84304	0.83805	0.85820	0.86022
	Std Dev All GND'd	0.00922	0.08025	0.08049	0.08104	0.08119	0.08200
	Ps90%/90% (+KTL) All GND'd	0.92725	1.06651	1.06375	1.06028	1.08083	1.08507
	Ps90%/90% (-KTL) All GND'd	0.87670	0.62644	0.62233	0.61583	0.63557	0.63536
Biased Irradiation Statistics							
	Average Biased	0.84606	0.79575	0.79388	0.78881	0.80853	0.83357
	Std Dev Biased	0.07251	0.06263	0.06271	0.06413	0.06449	0.06964
	Ps90%/90% (+KTL) Biased	1.04487	0.96747	0.96582	0.96466	0.98537	1.02453
	Ps90%/90% (-KTL) Biased	0.64725	0.62403	0.62193	0.61296	0.63170	0.64261
	Specification MIN	0.5	0.5	0.5	0.5		0.5
	Status (Measurements) All GND'd	PASS	PASS	PASS	PASS		PASS
	Status (Measurements) Biased	PASS	PASS	PASS	PASS		PASS
	Specification MAX						
	Status (Measurements) All GND'd						
	Status (Measurements) Biased						
	Status (-KTL) All GND'd	PASS	PASS	PASS	PASS		PASS
	Status (+KTL) All GND'd						
	Status (-KTL) Biased	PASS	PASS	PASS	PASS		PASS
	Status (+KTL) Biased						

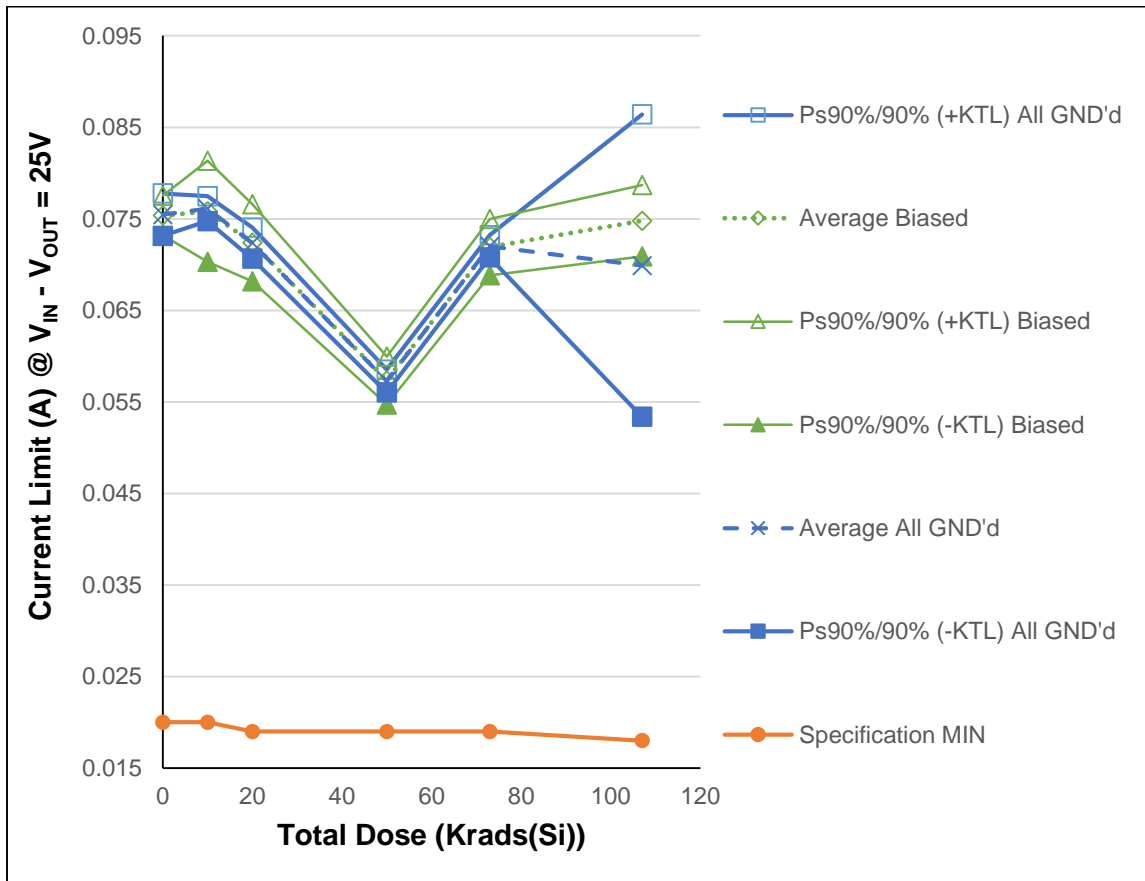


Figure 5.6: Plot of Current Limit @ 25V versus Total Dose



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

Parameter	Current Limit (A) @ $V_{IN} - V_{OUT} = 25V$	Total Dose (Krad(Si)) @ 10 mrads(Si)/s					
Units	(A)	0	10	20	50	73	107
667	All GND'd Irradiation	0.07617	0.07663	0.07331	0.05801	0.07247	0.07362
668	All GND'd Irradiation	0.07455	0.07562	0.07205	0.05729	0.07134	0.07458
669	All GND'd Irradiation	0.07628	0.07571	0.07185	0.05681	0.07193	0.06379
670	All GND'd Irradiation	0.07457	0.07594	0.07190	0.05702	0.07191	0.07463
671	All GND'd Irradiation	0.07569	0.07665	0.07263	0.05729	0.07234	0.06285
662	Biased Irradiation	0.07475	0.07299	0.07155	0.05782	0.07198	0.07318
663	Biased Irradiation	0.07453	0.07714	0.07428	0.05873	0.07371	0.07653
664	Biased Irradiation	0.07611	0.07636	0.07348	0.05665	0.07158	0.07565
665	Biased Irradiation	0.07628	0.07801	0.07218	0.05713	0.07167	0.07503
666	Biased Irradiation	0.07518	0.07462	0.07042	0.05636	0.07063	0.07350
660	Control Unit	0.07456	0.06957	0.06771	0.05672	0.07300	0.07381
661	Control Unit	0.07399	0.07667	0.07145	0.05663	0.07126	0.07264
All GND'd Irradiation Statistics							
Average All GND'd		0.07545	0.07611	0.07235	0.05728	0.07200	0.06989
Std Dev All GND'd		0.00084	0.00050	0.00062	0.00045	0.00044	0.00602
Ps90%/90% (+KTL) All GND'd		0.07777	0.07748	0.07405	0.05852	0.07321	0.08641
Ps90%/90% (-KTL) All GND'd		0.07314	0.07475	0.07065	0.05604	0.07079	0.05338
Biased Irradiation Statistics							
Average Biased		0.07537	0.07582	0.07238	0.05734	0.07191	0.07478
Std Dev Biased		0.00079	0.00202	0.00153	0.00096	0.00112	0.00142
Ps90%/90% (+KTL) Biased		0.07754	0.08135	0.07659	0.05996	0.07499	0.07868
Ps90%/90% (-KTL) Biased		0.07320	0.07029	0.06818	0.05472	0.06883	0.07088
Specification MIN		0.02	0.02	0.019	0.019		0.018
Status (Measurements) All GND'd		PASS	PASS	PASS	PASS		PASS
Status (Measurements) Biased		PASS	PASS	PASS	PASS		PASS
Specification MAX							
Status (Measurements) All GND'd							
Status (Measurements) Biased							
Status (-KTL) All GND'd		PASS	PASS	PASS	PASS		PASS
Status (+KTL) All GND'd							
Status (-KTL) Biased		PASS	PASS	PASS	PASS		PASS
Status (+KTL) Biased							

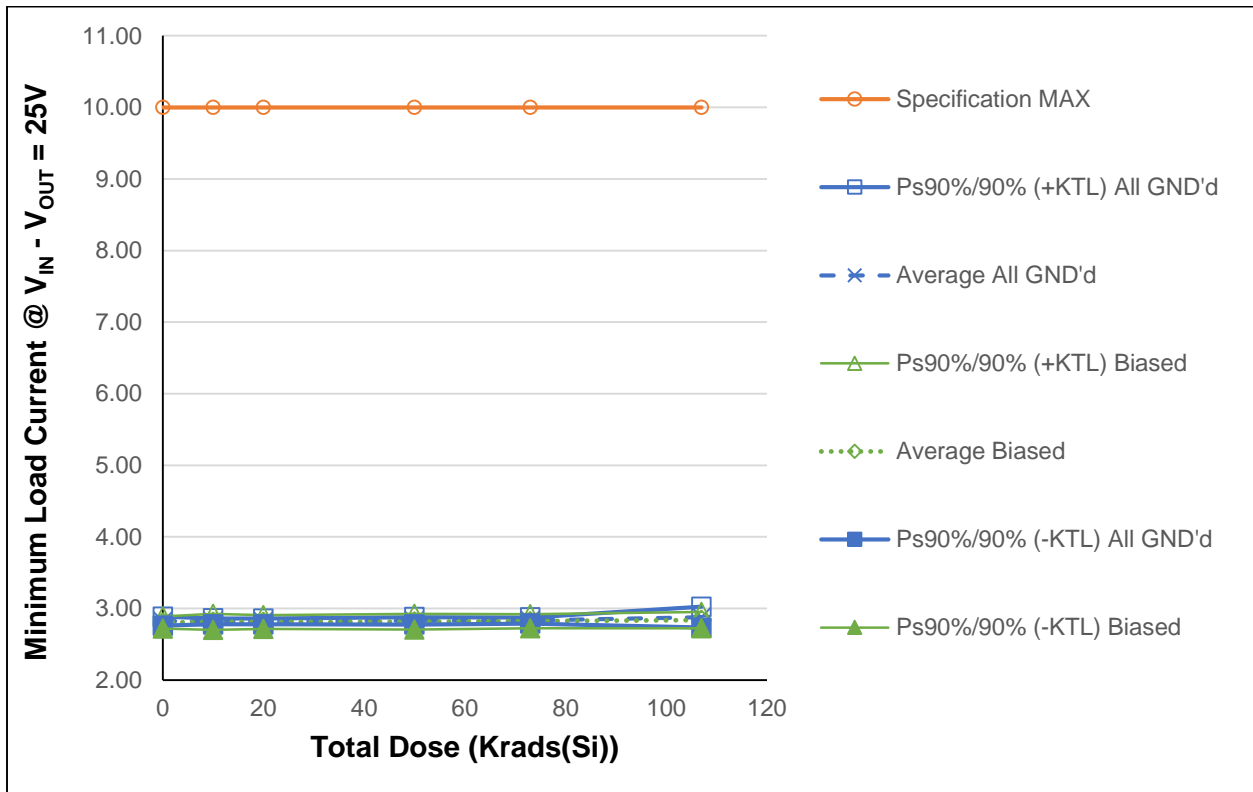


Figure 5.7: Plot of Minimum Load Current versus Total Dose

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

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

Parameter	Minimum Load Current @ $V_{IN} - V_{OUT} = 25V$	Total Dose (Krad(Si)) @ 10 mrad(Si)/s					
Units	(mA)	0	10	20	50	73	107
667	All GND'd Irradiation	2.82694	2.83624	2.82941	2.84471	2.84865	2.86407
668	All GND'd Irradiation	2.81329	2.80123	2.79928	2.80581	2.81266	2.81375
669	All GND'd Irradiation	2.85721	2.80508	2.80569	2.80581	2.81571	2.91134
670	All GND'd Irradiation	2.79644	2.82557	2.83201	2.83310	2.83707	2.84881
671	All GND'd Irradiation	2.81352	2.82404	2.82094	2.83921	2.83836	2.94824
662	Biased Irradiation	2.78401	2.82680	2.80943	2.80688	2.80420	2.87748
663	Biased Irradiation	2.77815	2.87314	2.86000	2.87863	2.87862	2.88244
664	Biased Irradiation	2.81543	2.81598	2.81004	2.81809	2.82174	2.82374
665	Biased Irradiation	2.84959	2.78265	2.80996	2.80124	2.81884	2.82007
666	Biased Irradiation	2.77884	2.76954	2.76175	2.77005	2.78133	2.78340
660	Control Unit	2.78371	2.91422	2.90089	2.86375	2.86429	2.87437
661	Control Unit	2.78890	2.78934	2.86915	2.86666	2.87115	2.89083
All GND'd Irradiation Statistics							
Average All GND'd		2.82148	2.81843	2.81747	2.82572	2.83049	2.87724
Std Dev All GND'd		0.02272	0.01478	0.01445	0.01864	0.01558	0.05295
Ps90%/90% (+KTL) All GND'd		2.88376	2.85896	2.85710	2.87684	2.87322	3.02244
Ps90%/90% (-KTL) All GND'd		2.75920	2.77791	2.77783	2.77461	2.78777	2.73205
Biased Irradiation Statistics							
Average Biased		2.80120	2.81362	2.81023	2.81498	2.82094	2.83743
Std Dev Biased		0.03111	0.04069	0.03474	0.03979	0.03599	0.04195
Ps90%/90% (+KTL) Biased		2.88650	2.92520	2.90549	2.92409	2.91964	2.95244
Ps90%/90% (-KTL) Biased		2.71590	2.70204	2.71498	2.70586	2.72225	2.72241
Specification MIN							
Status (Measurements) All GND'd							
Status (Measurements) Biased							
Specification MAX		10	10	10	10		10
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

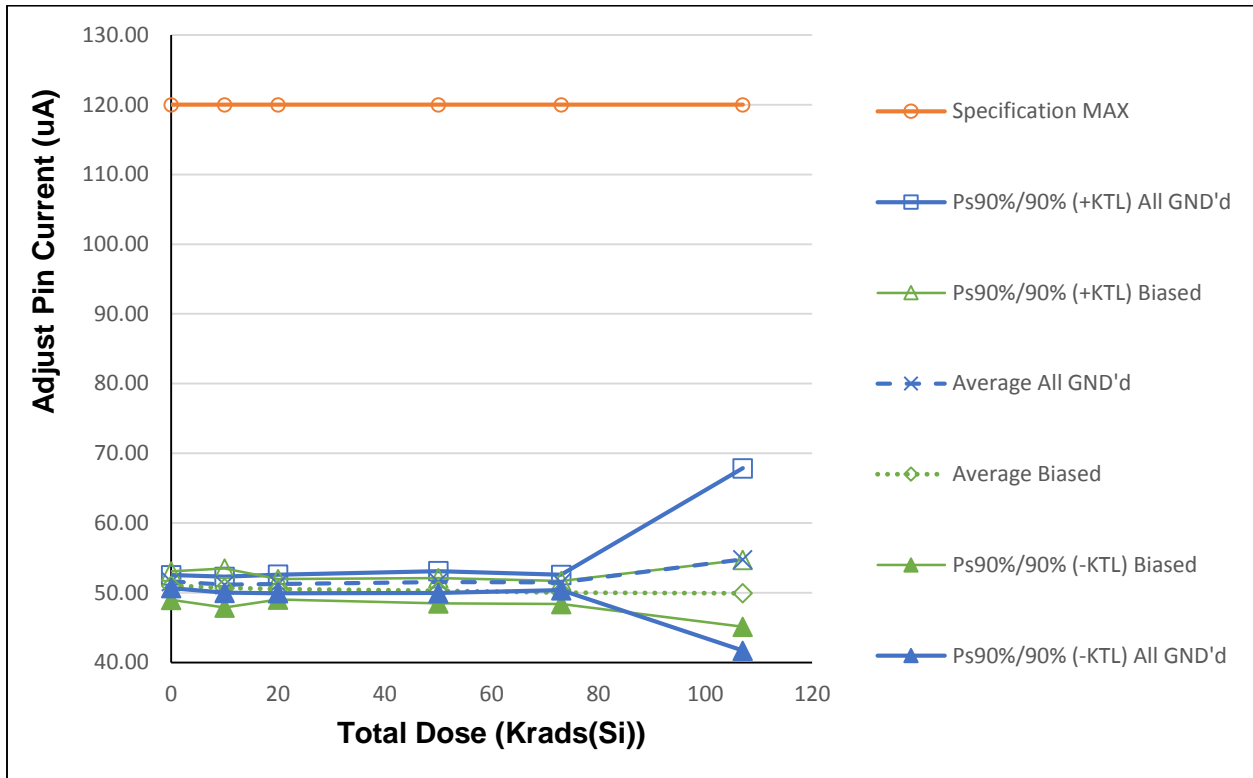


Figure 5.8: Plot of Adjust Pin Current versus Total Dose

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

Parameter	Adjust Pin Current	Total Dose (Krad(Si)) @ 10 mrads(Si)/s					
Units	(uA)	0	10	20	50	73	107
667	All GND'd Irradiation	51.46739	51.16077	51.13360	51.35074	51.49332	52.10466
668	All GND'd Irradiation	51.54274	50.68806	50.64878	50.89056	51.09520	50.56190
669	All GND'd Irradiation	52.17214	50.89416	51.09883	51.21584	51.10828	58.76696
670	All GND'd Irradiation	51.53872	51.16346	51.47364	51.77897	51.59667	51.42087
671	All GND'd Irradiation	51.26912	51.80642	51.95401	52.38297	52.07212	61.01048
662	Biased Irradiation	50.51411	51.81381	50.50613	49.85899	49.70883	52.93249
663	Biased Irradiation	50.75986	51.66335	51.31272	51.14656	51.04864	50.00793
664	Biased Irradiation	51.45809	50.47853	50.27752	50.80077	49.93206	49.09832
665	Biased Irradiation	52.05428	49.61465	50.52639	50.07566	49.97163	49.01781
666	Biased Irradiation	50.22866	49.83895	49.84284	49.55891	49.47996	48.61651
660	Control Unit	50.69638	55.99811	54.86282	52.67405	52.26501	52.76613
661	Control Unit	50.86432	49.90421	53.07209	53.18373	53.24805	53.96946
	All GND'd Irradiation Statistics						
	Average All GND'd	51.59802	51.14257	51.26177	51.52382	51.47312	54.77297
	Std Dev All GND'd	0.33964	0.42123	0.48549	0.57643	0.40324	4.76833
	Ps90%/90% (+KTL) All GND'd	52.52932	52.29760	52.59300	53.10438	52.57880	67.84775
	Ps90%/90% (-KTL) All GND'd	50.66672	49.98755	49.93055	49.94326	50.36744	41.69820
	Biased Irradiation Statistics						
	Average Biased	51.00300	50.68186	50.49312	50.28818	50.02822	49.93461
	Std Dev Biased	0.74331	1.01679	0.53441	0.66347	0.60339	1.75142
	Ps90%/90% (+KTL) Biased	53.04115	53.46988	51.95847	52.10741	51.68271	54.73702
	Ps90%/90% (-KTL) Biased	48.96485	47.89383	49.02777	48.46894	48.37374	45.13221
	Specification MIN						
	Status (Measurements) All GND'd						
	Status (Measurements) Biased						
	Specification MAX	120	120	120	120		120
	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

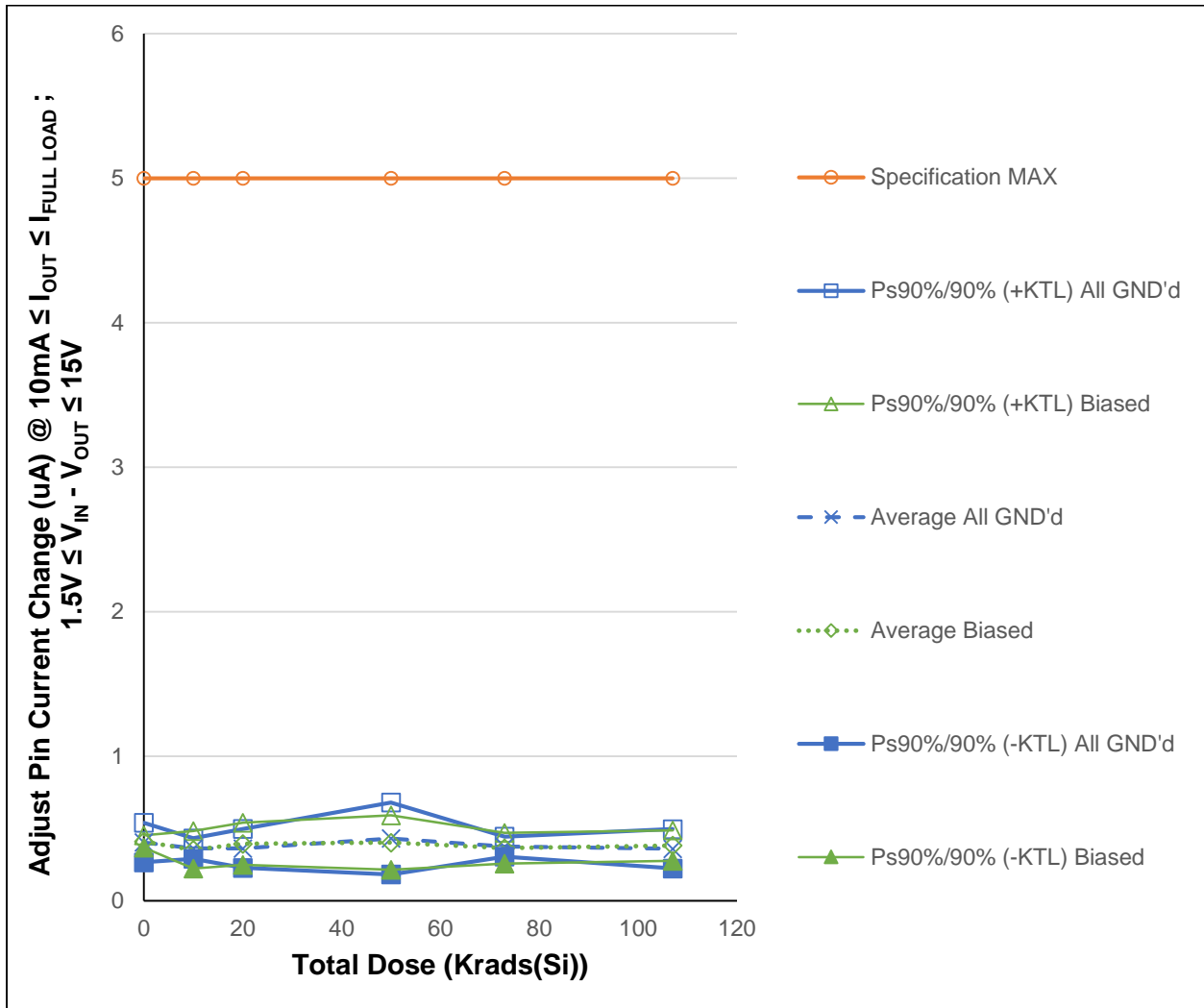


Figure 5.9: Plot of Adjust Pin Current Change versus Total Dose

Table 5.9: Raw data table for adjust pin current change versus total dose including the statistical calculations, maximum specification, and the status of the test (PASS/FAIL)

Parameter	Adj Pin I Change @ 10mA <sub>I<sub>OUT</sub>≤I<sub>FULL LOAD</sub></sub> ; 1.5V≤V <sub>IN</sub> -V <sub>OUT</sub> ≤15V	Total Dose (Krad(Si)) @ 10 mrads(Si)/s					
Units	(uA)	0	10	20	50	73	107
667	All GND'd Irradiation	0.48135	0.34583	0.42368	0.28232	0.38013	0.42720
668	All GND'd Irradiation	0.41860	0.38151	0.40238	0.49347	0.37982	0.37144
669	All GND'd Irradiation	0.35140	0.35920	0.31177	0.40681	0.34519	0.33960
670	All GND'd Irradiation	0.38688	0.39203	0.35283	0.49311	0.41106	0.37104
671	All GND'd Irradiation	0.37788	0.32857	0.32147	0.48036	0.35751	0.29150
662	Biased Irradiation	0.43090	0.39632	0.40865	0.41517	0.36377	0.40536
663	Biased Irradiation	0.41442	0.33062	0.35594	0.28197	0.33462	0.31876
664	Biased Irradiation	0.40064	0.39657	0.43047	0.44817	0.42177	0.38200
665	Biased Irradiation	0.39054	0.28453	0.32294	0.42327	0.32362	0.38609
666	Biased Irradiation	0.41349	0.35550	0.45191	0.44575	0.37478	0.41783
660	Control Unit	0.39923	0.44516	0.41310	0.44669	0.34369	0.43880
661	Control Unit	0.44066	0.33420	0.42321	0.37922	0.38192	0.42305
All GND'd Irradiation Statistics							
Average All GND'd		0.40322	0.36143	0.36242	0.43121	0.37474	0.36016
Std Dev All GND'd		0.04984	0.02583	0.04920	0.09067	0.02522	0.04969
Ps90%/90% (+KTL) All GND'd		0.53988	0.43224	0.49734	0.67984	0.44390	0.49641
Ps90%/90% (-KTL) All GND'd		0.26657	0.29061	0.22751	0.18259	0.30559	0.22391
Biased Irradiation Statistics							
Average Biased		0.41000	0.35271	0.39398	0.40287	0.36371	0.38201
Std Dev Biased		0.01528	0.04735	0.05338	0.06906	0.03856	0.03823
Ps90%/90% (+KTL) Biased		0.45191	0.48255	0.54035	0.59222	0.46944	0.48683
Ps90%/90% (-KTL) Biased		0.36809	0.22287	0.24762	0.21352	0.25798	0.27719
Specification MIN							
Status (Measurements) All GND'd							
Status (Measurements) Biased							
Specification MAX		5	5	5	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

## Appendix A



Figure A1: Top View showing ID and Date Code



## Appendix B

### Radiation Bias Connection Tables

Table B1: Biased Conditions

PIN	FUNCTION	CONNECTION / BIAS
1	INPUT	+ 15V
2	ADJUST	-15V To Pin 3 via 150Ω resistor
3 CASE	OUTPUT	To pin 2 via 150Ω resistor to - 15V

Table B2: All GND'd

PIN	FUNCTION	CONNECTION / BIAS
1	INPUT	Ground
2	ADJUST	Ground
3	OUTPUT	Ground

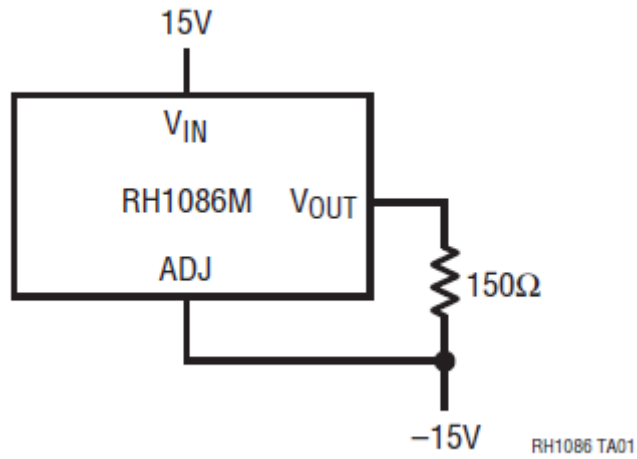


Figure B1: Total Dose Bias Circuit

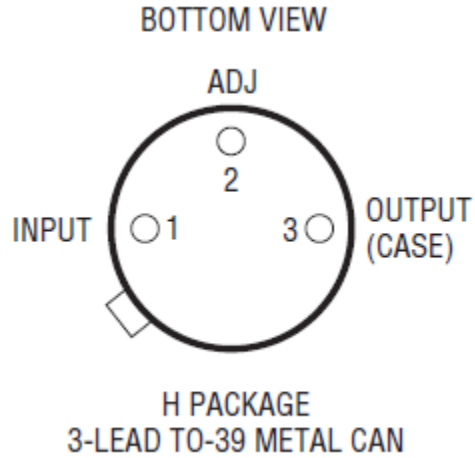


Figure B2: Pin-Out



Figure B3: Bias Board (top view)

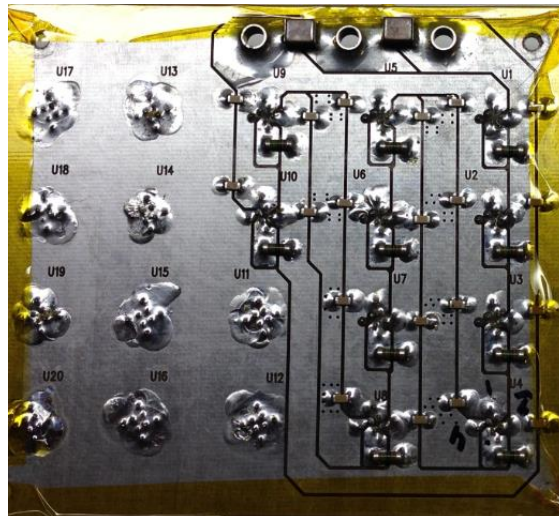


Figure B4: Bias Board (bottom view)

## Appendix C

**TEST CERTIFICATE**

Defense Microelectronics Activity  
Science and Engineering Gamma Irradiation Test Facility  
DMEA/MEBC  
4234 54<sup>th</sup> 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

**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.**

REQUEST FOR AND RESULTS OF TESTS					PAGE NO. 1	NO. OF PAGES 2
<b>SECTION A - REQUEST FOR TEST</b>						
1. TO: (Include ZIP Code) Defense Microelectronics Activity Science and Engineering Gamma Irradiation Test Facility 4234 54th Street McClellan, CA 95652-2100			2. FROM: (Include ZIP Code) Dr. Sana Rezgui Linear Technology Corp. 1630 McCarthy Blvd. Milpitas, CA 95035 Phone: (408) 432-1900 Email: srezgui@linear.com			
3. PRIME CONTRACTOR AND ADDRESS (Include ZIP Code) Same as block 2  CONTRACT NUMBER CRADA CR-08-17			4. MANUFACTURING PLANT NAME AND ADDRESS (Include ZIP Code) Linear Technology Corp. 1630 McCarthy Blvd. Milpitas, CA 95035  P.O. NUMBER TBD			
5. END ITEM AND/OR PROJECT N/A		6. SAMPLE NUMBER N/A	7. LOT NO. See below	8. REASON FOR SUBMITTAL Total Ionizing Dose (TID) Testing		9. DATE SUBMITTED 2014-02-24
10. MATERIAL TO BE TESTED Various biased/unbiased devices - see below	10a. QUANTITY SUBMITTED See below	11. QUANTITY REPRESENTED N/A	12. SPEC. & AMEND AND/OR DRAWING NO. & REV. FOR SAMPLE & DATE N/A			
13. PURCHASED FROM OR SOURCE Linear Technology Corp.		14. SHIPMENT METHOD Hand carry	15. DATE SAMPLED AND SUBMITTED BY 2014-02-25 by Tom Shepherd			
16. REMARKS AND/OR SPECIAL INSTRUCTIONS AND/OR WAIVERS. Dose Rate: 3000 ±10% rad/(SiO <sub>2</sub> )/min      Irradiation Steps: 22      Type of Test: Customer-Performed Total Dose: see below ±10% krad/(SiO <sub>2</sub> )      Requested Test Start Date: 2014-02-25      Dimensions: various Security Requirements, Safety or Handling Precautions: Customer to perform pre- and post-irradiation electrical testing. Parts may be packed by customer in dry ice for transport. Irradiation portion of testing to be conducted per MIL-STD-883H, Test Method 1019.8, Condition A. Customer reserves right to modify parameters, devices, etc. to suit test requirements.  Description of parts to be irradiated is as follows: MSK196RH (6RH6105BK#1B*01), fab lot #WDS4907E.1, ass'y lot #N/A, WFR #2: 10, 30, 50, 100 and 200 krad/(SiO <sub>2</sub> ), 10 devices per dose level, biased/GND'd RH1086MH (6RH1086BHK), fab lot #W1231270.1, ass'y lot #719601.1, WFR #4: 10, 30, 50 and 100 krad/(SiO <sub>2</sub> ), 10 devices per dose level, biased/GND'd RH1084MK-CS, fab lot #WD41450E.1, ass'y lot #N/A, WFR #5: 10, 30, 50, 100 and 200 krad/(SiO <sub>2</sub> ), 10 devices per dose level, biased/GND'd RH1021BMH-10 (6RH1021-10K*14), fab lot #W1245822.1, ass'y lot #724755.1, WFR #1: 10, 30, 50 and 100 krad/(SiO <sub>2</sub> ), 10 devices per dose level, biased/GND'd RH1021CMH-5450289 (RH1021-5K*08), fab lot #10214210.1, ass'y lot #697997.1, WFR #10: 10, 30, 50 and 100 krad/(SiO <sub>2</sub> ), 10 devices per dose level, biased/GND'd						
Experiment #: 2014-NRC-024	DMEA Approval:	 <small>SHEPHERD, THOMAS AD J 1255235946 Date: 2014-02-26 10:48:01 -0800</small>	 <small>ARSHAD, MOHAMMAD MAD 1231956693 Date: 2014-02-26 14:04:00 -0800</small>	 <small>MELINE, CARY W 1231854033 Date: 2014-02-26 14:04:00 -0800</small>		
17. SEND REPORT OF TEST TO Individual identified in Block 2						
<b>SECTION B - RESULTS OF TEST (Continue on plain white paper if more space is required)</b>						
1. DATE SAMPLE RECEIVED 2014-02-25		2. DATE RESULTS REPORTED 2014-02-26		3. LAB REPORT NUMBER N/A		
4. TEST PERFORMED	RESULTS OF TEST	SAMPLE RESULT		REQUIREMENTS		
Please see next page.						
DATE 2014-02-26 2014-02-26	TYPED NAME AND TITLE OF PERSON CONDUCTING TEST Thomas J. Shepherd, SEGIT Technical Manager Mohammad Arshad, Alt. SEGIT Facility Supervisor		SIGNATURE SHEPHERD, THOMAS, J. 1255235946 6 ARSHAD, MOHAMMAD, 1231956693			

DD FORM 1222, FEB 62 (EF)

REPLACES DD FORM 1222, 1 JUL 58, WHICH IS OBSOLETE.

Continuation of DD Form 1222

Experiment #: 2014-NRC-024 Page 2 of 2

Test Performed		Results of Test			Sample Result	Requirements	Step No.
20140225 10:12:30	to 20140225 10:15:44	1.000E+04	rad(SiO2) at	3.085E+03	rad(SiO2)/min	RH1086MH (6RH1086BHK), WFR #4, S/Ns 620-629: 10 krad TD	1
20140225 10:12:30	to 20140225 10:15:44	1.000E+04	rad(SiO2) at	3.085E+03	rad(SiO2)/min	RH1021BMH-10 (6RH1021-10K*14), WFR #1, S/Ns 93-97, 99-103: 10 krad TD	1
20140225 10:12:30	to 20140225 10:15:44	1.000E+04	rad(SiO2) at	3.085E+03	rad(SiO2)/min	RH1021CMH-5#50289 (RH1021-5K*08), WFR #10, S/Ns 267-276: 10 krad TD	1
20140225 10:44:00	to 20140225 10:53:43	3.000E+04	rad(SiO2) at	3.085E+03	rad(SiO2)/min	RH1086MH (6RH1086BHK), WFR #4, S/Ns 630-639: 30 krad TD	2
20140225 10:44:00	to 20140225 10:53:43	3.000E+04	rad(SiO2) at	3.085E+03	rad(SiO2)/min	RH1021BMH-10 (6RH1021-10K*14), WFR #1, S/Ns 105-109: 30 krad TD	2
20140225 10:44:00	to 20140225 10:53:43	3.000E+04	rad(SiO2) at	3.085E+03	rad(SiO2)/min	RH1021CMH-5#50289 (RH1021-5K*08), WFR #10, S/Ns 277-286: 30 krad TD	2
20140225 11:09:00	to 20140225 11:18:43	3.000E+04	rad(SiO2) at	3.085E+03	rad(SiO2)/min	RH1021BMH-10 (6RH1021-10K*14), WFR #1, S/Ns 110-114: 30 krad TD	3
20140225 11:34:00	to 20140225 11:50:12	5.000E+04	rad(SiO2) at	3.085E+03	rad(SiO2)/min	RH1086MH (6RH1086BHK), WFR #4, S/Ns 640-649: 50 krad TD	4
20140225 11:34:00	to 20140225 11:50:12	5.000E+04	rad(SiO2) at	3.085E+03	rad(SiO2)/min	RH1021BMH-10 (6RH1021-10K*14), WFR #1, S/Ns 116, 118-120, 180, 182-186: 50 krad TD	4
20140225 11:34:00	to 20140225 11:50:12	5.000E+04	rad(SiO2) at	3.085E+03	rad(SiO2)/min	RH1021CMH-5#50289 (RH1021-5K*08), WFR #10, S/Ns 287-296: 50 krad TD	4
20140225 12:07:00	to 20140225 12:39:25	1.000E+05	rad(SiO2) at	3.085E+03	rad(SiO2)/min	MSK196RH (6RH6105BK#IB*01), WFR #4, S/Ns 650-659: 100 krad TD	5
20140225 12:07:00	to 20140225 12:39:25	1.000E+05	rad(SiO2) at	3.085E+03	rad(SiO2)/min	RH1021BMH-10 (6RH1021-10K*14), WFR #1, S/Ns 187-193, 196-198: 100 krad TD	5
20140225 12:07:00	to 20140225 12:39:25	1.000E+05	rad(SiO2) at	3.085E+03	rad(SiO2)/min	RH1021CMH-5#50289 (RH1021-5K*08), WFR #10, S/Ns 297-300, 316-317, 319-322: 100 krad TD	5
20140225 14:46:00	to 20140225 14:49:14	1.000E+04	rad(SiO2) at	3.085E+03	rad(SiO2)/min	MSK196RH (6RH6105BK#IB*01), WFR #2, S/Ns 1020-1027, 1029-1030: 10 krad TD	6
20140225 14:46:00	to 20140225 14:49:14	1.000E+04	rad(SiO2) at	3.085E+03	rad(SiO2)/min	RH1084MK-CS, WFR #5, S/Ns 13-22: 10 krad TD	6
20140225 15:00:20	to 20140225 15:10:03	3.000E+04	rad(SiO2) at	3.085E+03	rad(SiO2)/min	MSK196RH (6RH6105BK#IB*01), WFR #2, S/Ns 1031, 1042-1050: 30 krad TD	7
20140225 15:00:20	to 20140225 15:10:03	3.000E+04	rad(SiO2) at	3.085E+03	rad(SiO2)/min	RH1084MK-CS, WFR #5, S/Ns 23-32: 30 krad TD	7
20140225 15:19:40	to 20140225 15:35:52	5.000E+04	rad(SiO2) at	3.085E+03	rad(SiO2)/min	MSK196RH (6RH6105BK#IB*01), WFR #2, S/Ns 1051-1056, 1058-1059, 1061-1062: 50 krad TD	8
20140225 15:19:40	to 20140225 15:35:52	5.000E+04	rad(SiO2) at	3.085E+03	rad(SiO2)/min	RH1084MK-CS, WFR #5, S/Ns 33, 35-37, 39-44: 50 krad TD	8
20140225 15:45:10	to 20140225 16:17:35	1.000E+05	rad(SiO2) at	3.085E+03	rad(SiO2)/min	MSK196RH (6RH6105BK#IB*01), WFR #2, S/Ns 1064-1065, 1067-1074: 100 krad TD	9
20140225 15:45:10	to 20140225 16:17:35	1.000E+05	rad(SiO2) at	3.085E+03	rad(SiO2)/min	RH1084MK-CS, WFR #5, S/Ns 45-47, 49-55: 100 krad TD	9
20140225 16:27:20	to 20140225 17:15:57	1.500E+05	rad(SiO2) at	3.085E+03	rad(SiO2)/min	MSK196RH (6RH6105BK#IB*01), WFR #2, S/Ns 1075-1084: 150 krad TD	10
20140225 16:27:20	to 20140225 17:15:57	1.500E+05	rad(SiO2) at	3.085E+03	rad(SiO2)/min	RH1084MK-CS, WFR #5, S/Ns 56-60, 62, 64-67: 150 krad SD, 150 krad TD	10
20140225 17:22:20	to 20140225 17:38:32	5.000E+04	rad(SiO2) at	3.085E+03	rad(SiO2)/min	RH1084MK-CS, WFR #5, S/Ns 56-60, 62, 64-67: 50 krad SD, 200 krad TD	11

Uncertainty: Total Doses reported are ± 16.02%

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

//

NOTES:

- ASTM = American Society for Testing and Materials.
- DUT = Device Under Test.
- S/N = Serial Number.
- SD = Step Dose.
- TD = Total Dose.
- Dose rate uniformity across target area: ± 9.76%
- All irradiation steps met the requirements of MIL-STD-883H, Test Method 1019.8, Condition A.
- After the original Test Request (DD Form 1222) was approved, the following changes were made:
  - Total number of irradiation steps was 11 instead of 22. The board configuration allowed the irradiation of 2 boards simultaneously.
  - The MSK196RH (6RH6105BK#IB\*01) highest TD level was incorrect on the original Test Request; it should have been 150 krad(SiO2) instead of 200 krad(SiO2). The 150 krad(SiO2) TD was executed correctly during Step No. 10.
- Latitude to change test parameters to suit customer requirements was included in the original Test Request; no Customer Order Change Request (SEGIT Form QP03-4, Rev. 5) was required/issued.
- Source information:
  - Irradiator = J.L. Shepherd & Associates Model 81-22/484 self-contained irradiation facility, S/Ns 7125/50016.
  - Source selection = two large Co-60 sources.
- Dosimeter system:
  - Radcal Model No. 9010 Radiation Monitor Controller, S/N 90-1313.
  - Radcal Model No. 90X5-018 Electrometer/Ion Chamber, S/Ns 95-0478/9771.
  - This dosimeter system was calibrated per ISO/IEC 17025:2005 by University of Wisconsin Medical Radiation Research Center on 3 Feb 2014 (Report No. ION14426). This calibration is effective for two years.
- Irradiation geometry: in accordance with section 7.3.2 of ASTM E1249-00 (2005), the DUT's semiconductor chip plane was perpendicular to the incident radiation beam.
- Filter box: a DMEA Dose Enhancement Chamber (DEC) was used for all testing/dosimetry involved with this experiment. The DEC's Pb and Al layers are compliant with section 7.2.2 of ASTM E1249-00 (2005) with respect to thickness and geometry.



## Appendix D

Table D1: Pre-Irradiation Electrical Characteristics of Device-Under-Test

PARAMETER	CONDITIONS	NOTES	$T_A = 25^\circ\text{C}$			SUB-GROUP	$-55^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$			SUB-GROUP	UNITS
			MIN	TYP	MAX		MIN	TYP	MAX		
Reference Voltage	$I_{\text{OUT}} = 10\text{mA}$ , $(V_{\text{IN}} - V_{\text{OUT}}) = 3\text{V}$ (K)		1.238	1.262		1					V
	$10\text{mA} \leq I_{\text{OUT}} \leq I_{\text{FULL LOAD}}$ , $1.5\text{V} \leq (V_{\text{IN}} - V_{\text{OUT}}) \leq 25\text{V}$	6	1.225	1.270			1.225	1.270	2,3		V
Line Regulation	$I_{\text{LOAD}} = 10\text{mA}$ , $1.5\text{V} \leq (V_{\text{IN}} - V_{\text{OUT}}) \leq 15\text{V}$	2, 3		0.2		1		0.2	2,3		%
Load Regulation	$(V_{\text{IN}} - V_{\text{OUT}}) = 3\text{V}$ , $10\text{mA} \leq I_{\text{OUT}} \leq I_{\text{FULL LOAD}}$	2, 3, 6		0.3		1		0.4	2,3		%
Dropout Voltage	$\Delta V_{\text{REF}} = 1\%$ , $I_{\text{OUT}} = 1.5\text{A}$ (K)	4		1.5		1		1.5	2,3		V
	$\Delta V_{\text{REF}} = 1\%$ , $I_{\text{OUT}} = 0.5\text{A}$ (H)	4		1.25		1		1.25	2,3		V
Current Limit	$(V_{\text{IN}} - V_{\text{OUT}}) = 5\text{V}$ (K)		1.5			1	1.5		2,3		A
	$(V_{\text{IN}} - V_{\text{OUT}}) = 5\text{V}$ (H)		0.5			1	0.5		2,3		A
	$(V_{\text{IN}} - V_{\text{OUT}}) = 25\text{V}$ (K)		0.05			1	0.05		2,3		A
	$(V_{\text{IN}} - V_{\text{OUT}}) = 25\text{V}$ (H)		0.020			1	0.020		2,3		A
Minimum Load Current	$(V_{\text{IN}} - V_{\text{OUT}}) = 25\text{V}$			10		1		10	2,3		mA
Thermal Regulation	$T_A = 25^\circ\text{C}$ , 30ms Pulse			0.04		4					%/W
Ripple Rejection	$f = 120\text{Hz}$ , $C_{\text{ADJ}} = 25\mu\text{F}$ , $C_{\text{OUT}} = 25\mu\text{F}$ Tantalum, $I_{\text{OUT}} = I_{\text{FULL LOAD}}$ , $(V_{\text{IN}} - V_{\text{OUT}}) = 3\text{V}$	6	60			4	60		5,6		dB
Adjust Pin Current	$T_J = 25^\circ\text{C}$			55 120		1		120	2,3		$\mu\text{A}$
Adjust Pin Current Change	$10\text{mA} \leq I_{\text{OUT}} \leq I_{\text{FULL LOAD}}$ , $1.5\text{V} \leq (V_{\text{IN}} - V_{\text{OUT}}) \leq 15\text{V}$	6		5		1		5	2,3		$\mu\text{A}$
Temperature Stability				0.5				0.5			%
Long Term Stability	$T_A = 125^\circ\text{C}$ , 1000 Hours	5		0.3							%
RMS Output Noise (% of $V_{\text{OUT}}$ )	$10\text{Hz} \leq f \leq 10\text{kHz}$			0.003							%
Thermal Resistance Junction-to-Case	Control Circuitry (K)	5		1.7							$^\circ\text{C}/\text{W}$
	Control Circuitry (H)	5		15.0							$^\circ\text{C}/\text{W}$
	Power Transistor (K)	5		4.0							$^\circ\text{C}/\text{W}$
	Power Transistor (H)	5		20.0							$^\circ\text{C}/\text{W}$

Table D2: Post-Irradiation Electrical Characteristics of Device-Under-Test

PARAMETER	CONDITIONS	10KRAD (Si)		20KRAD (Si)		50KRAD (Si)		100KRAD (Si)		200KRAD (Si)		UNITS
		MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
Reference Voltage (Note 6)	$I_{OUT} = 10\text{mA}$ ( $V_{IN} - V_{OUT} = 3\text{V}$ (K))	1.234	1.262	1.230	1.262	1.225	1.262	1.220	1.262	1.205	1.262	V
	$10\text{mA} \leq I_{OUT} \leq I_{FULL\ LOAD}$ $1.5\text{V} \leq (V_{IN} - V_{OUT}) \leq 15\text{V}$	1.220	1.275	1.219	1.275	1.215	1.275	1.210	1.275	1.20	1.275	V
Line Regulation (Notes 2, 3)	$I_{OUT} = 10\text{mA}$ $1.5\text{V} \leq (V_{IN} - V_{OUT}) \leq 15\text{V}$		0.2		0.21		0.23		0.25		0.3	%
Load Regulation (Notes 2, 3, 6)	$(V_{IN} - V_{OUT}) = 3\text{V}$ $10\text{mA} \leq I_{OUT} \leq I_{FULL\ LOAD}$		0.3		0.3		0.3		0.3		0.3	%
Dropout Voltage (Note 4)	$\Delta V_{REF} = 1\%$ , $I_{OUT} = 1.5\text{A}$ (K)		1.5		1.51		1.52		1.55		1.575	V
	$\Delta V_{REF} = 1\%$ , $I_{OUT} = 0.5\text{A}$ (H)		1.25		1.26		1.27		1.29		1.32	V
Current Limit	$(V_{IN} - V_{OUT}) = 5\text{V}$ (K)	1.5		1.5		1.5		1.5		1.5		A
	$(V_{IN} - V_{OUT}) = 25\text{V}$ (K)	0.05		0.049		0.048		0.047		0.045		A
	$(V_{IN} - V_{OUT}) = 5\text{V}$ (H)	0.5		0.5		0.5		0.5		0.5		A
	$(V_{IN} - V_{OUT}) = 25\text{V}$ (H)	0.020		0.019		0.019		0.018		0.017		A
Minimum Load Current	$(V_{IN} - V_{OUT}) = 25\text{V}$		10		10		10		10		10	mA
Adjust Pin Current			120		120		120		120		120	$\mu\text{A}$
Adjust Pin Current Change (Note 6)	$10\text{mA} \leq I_{OUT} \leq I_{FULL\ LOAD}$ $1.5\text{V} \leq (V_{IN} - V_{OUT}) \leq 15\text{V}$		5		5		5		5		5	$\mu\text{A}$

**Note 1:** Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

**Note 2:** See thermal regulation specifications for changes in output voltage due to heating effects. Line and load regulation are measured at a constant junction temperature by low duty cycle pulse testing.

**Note 3:** Line and load regulation are guaranteed up to the maximum power dissipation of 15W for RH1086MK and 3W for the RH1086MH. Power dissipation is determined by the input/output differential voltage and the output current. Guaranteed maximum power dissipation will not be available over the full input/output voltage range.

**Note 4:** Dropout voltage is specified over the full output current range of the device. Test points and limits are shown on the Dropout Voltage curve in the LT<sup>®</sup>1086 data sheet.

**Note 5:** Guaranteed by design, characterization, or correlation to other tested parameters.

**Note 6:**  $I_{FULL\ LOAD}$  is defined in the Current Limit curves in the standard data sheet. For compliance with 883 revision C current density specifications, the RH1086MK is derated to 1A.