Neutron Irradiation Test Results of the RH1028MW Ultralow Noise Precision High Speed Operational Amplifiers

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Part Type Tested: RH1028MW Ultralow Noise Precision High Speed Operational Amplifier

Traceability Information: Fab Lot# W1117814.1; Wafer # 2; Assembly Lot # 675616.3; Date Code 1228A. See photograph of unit under test in Appendix A.

Quantity of Units: 7 units received, 2 units for control, and 5 units for unbiased irradiation. Serial numbers 28-29 and 32-34 were placed in an anti-static foam during irradiation. Serial numbers 35 and 36 were used as control. See Appendix B for the radiation bias connection tables.

Radiation Dose: Total fluence of 1E12 neutron/cm^2.

Radiation Test Standard: MIL-STD-883 TM1017 and Linear Technology RH1028, Spec No. 05-08-5217.

Test Hardware and Software: LTX test program EQBRH1028.02

Facility and Radiation Source: University of Massachusetts, Lowell and Reactor Facility-FNI.

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

SUMMARY

ALL FIVE PARTS PASSED THE ELECTRICAL TEST LIMITS AS SPECIFIED IN THE DATASHEET AFTER IRRADIATION TO 1E12 N/cm^2. ADDITIONAL INFORMATION CAN BE PROVIDED PER REQUEST.

1.0 Overview and Background

Neutron particles incident on semiconductor materials lose energy along their paths. The energy loss produces electron-hole pairs (ionization) and displaces atoms in the material lattice (displacement damage defects or DDD). DDD induces a mixture of isolated and clustered defects or broken bonds. Such defects elevate the energy level of the material and consequently change material and electrical properties. The altering energy level creates the combination of any of the following processes, thermal generation of electron-hole pairs, recombination, trapping, compensation, tunneling, affecting hence the devices' basic features.

Bipolar technology is susceptible to neutron displacement damage around a fluence level of 1E12 neutron/cm^2. The neutron radiation test for the RH1028MW determines the change in device performance as a function of neutrons' fluence.

2.0 Radiation Facility:

Five samples were irradiated unbiased at the University of Massachusetts, Lowell, using the Reactor Facility-FNI. The neutron flux was determined by system S/P-32, method ASTM E-265, to be 4.05E9 N/cm^2-s (1MeV equivalent) for each irradiation step. Refer to Appendix C for the certificate of dosimetry.

3.0 Test Conditions

Five samples and two control units were electrically tested at 25°C prior to irradiation. The testing was performed on the two control units to confirm the operation of the test system prior to the electrical testing of the 7 units (5 irradiated and 2 control). During irradiation, devices were placed into an anti-static bag. Devices were then vertically aligned with the radiation source.

The criteria to pass the neutron displacement damage test is that five irradiated samples 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 in accordance with method 5004, MIL-STD-883, and if valid the lot will be scrapped.

4.0 Tested Parameters

The following parameters were measured pre- and post-irradiations at V_S = +/- 15V, V_{CM} = 0V unless otherwise noted:

- Input Offset Voltage V_{OS} (uV)
- Input Offset Current I_{OS} (nA)
- Positive Bias Current + I_B (nA)
- Negative Bias Current – I_B (nA)
- Positive Slew Rate +SR (V/uS)
- Negative Slew Rate –SR (V/uS)
- Common Mode Rejection Ratio CMRR (dB)
- Power Supply Rejection Ratio PSRR (dB)
- Large-Signal Voltage Gain A_{VOL} (V/uV)
- Positive Output Voltage Swing (V) at R_L = 2KΩ
- Negative Output Voltage Swing (V) at R_L = 2KΩ
- Positive Output Voltage Swing (V) at R_L = 600Ω
- Negative Output Voltage Swing (V) at R_L = 600Ω

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

5.0 Test Results

All five samples passed the post-irradiation electrical tests. All measurements of the thirteen 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:

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

$-K_{TL}$ = mean - (K_{TL}) (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 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 dashed lines with X-markers are the measured data points of five post-irradiated samples. The solid lines with square symbols are the computed KTL values of five post-irradiated samples with the application of the K_{TL} statistics. The orange solid lines with circle markers are the datasheet specification limits.

The post-irradiation test limits are using Linear Technology datasheets 100 Krads(Si) specification limits.

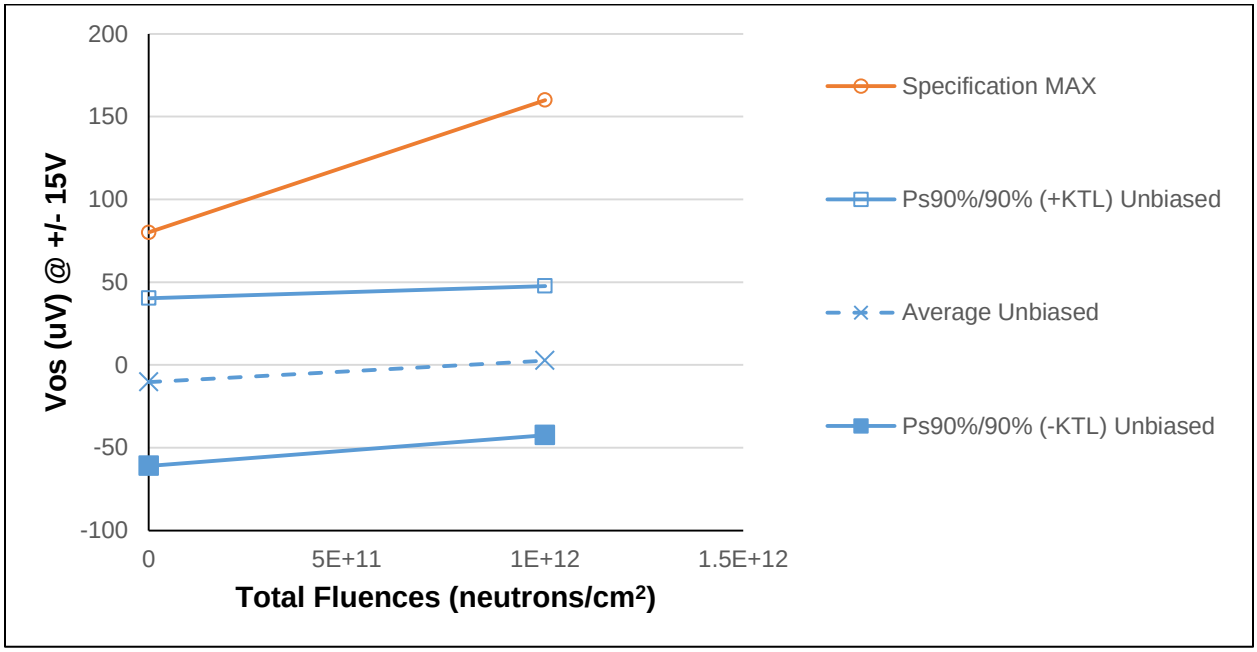

Figure 5.1 Plot of Input Voltage Offset V_{OS} versus Total Fluence

Table 5.1: Raw data table for Input Offset Voltage of pre- and post-irradiation (1E12 N/cm^2) including the statistical calculations, maximum specification, and the status of the test (PASS/FAIL).

Parameter	V_{OS} +/- 15V	Total Fluence (N/cm^2)	
Units	(uV)	0	1E+12
28	Unbiased Irradiation	-15.92250	-4.15021
29	Unbiased Irradiation	-15.80105	-4.25633
32	Unbiased Irradiation	22.33511	31.80490
33	Unbiased Irradiation	-19.77537	-7.64051
34	Unbiased Irradiation	-22.45927	-2.79306
35	Control Unit	-6.85748	-7.51105
36	Control Unit	-3.09044	-4.03001
	Unbiased Irradiation Statistics		
	Average Unbiased	-10.32462	2.59296
	Std Dev Unbiased	18.46992	16.42752
	Ps90%/90% (+KTL) Unbiased	40.31991	47.63722
	Ps90%/90% (-KTL) Unbiased	-60.96914	-42.45130
	Specification MIN		
	Status (Measurements) Unbiased		
	Specification MAX	80	160
	Status (Measurements) Unbiased	PASS	PASS
	Status (-KTL) Unbiased		
	Status (+KTL) Unbiased	PASS	PASS

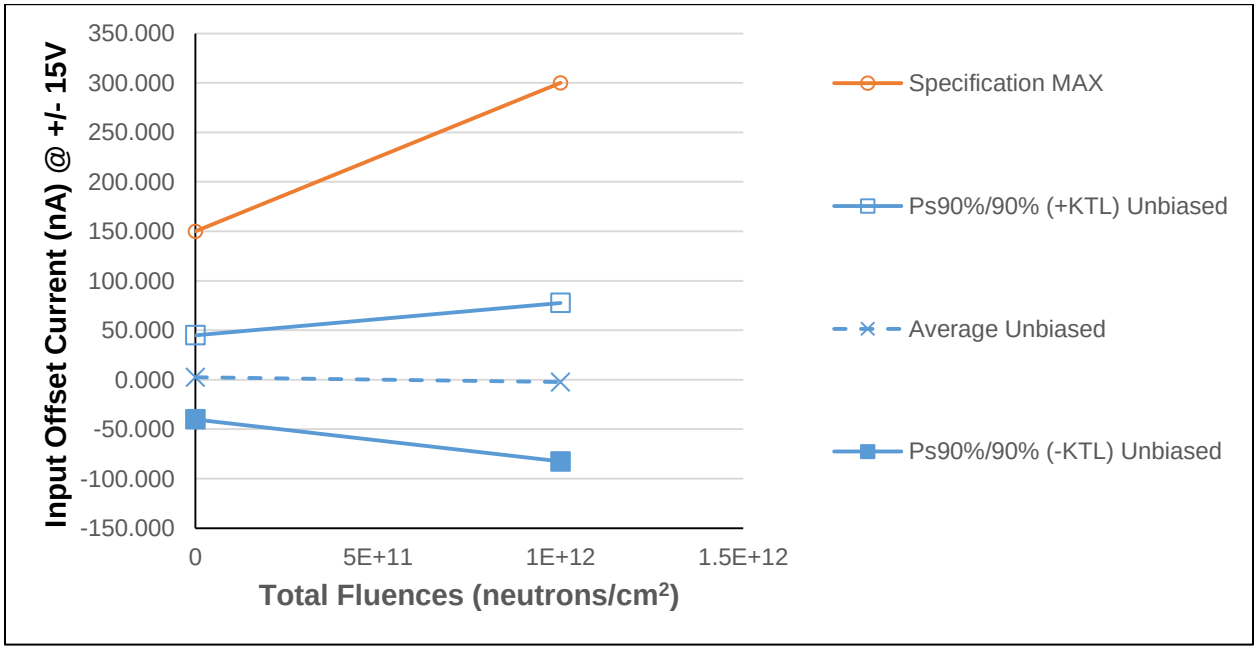

Figure 5.2: Plot of Input Offset Current I_{OS} versus Total Fluence

Table 5.2: Raw data table for Input Offset Current at +/- 15V of pre- and post-irradiation (1E12 N/cm^2) including the statistical calculations, maximum specification, and the status of the test (PASS/FAIL).

Parameter	Input Offset Current @+/-15V	Total Fluence (N/cm^2)	
Units	(nA)	0	1E+12
28	Unbiased Irradiation	3.29649	15.06171
29	Unbiased Irradiation	-16.48244	-40.40946
32	Unbiased Irradiation	23.80797	-7.71453
33	Unbiased Irradiation	9.15691	36.00116
34	Unbiased Irradiation	-7.69181	-15.06171
35	Control Unit	15.74989	15.06171
36	Control Unit	15.74989	13.95963
	Unbiased Irradiation Statistics		
	Average Unbiased	2.41742	-2.42457
	Std Dev Unbiased	15.51733	29.20976
	Ps90%/90% (+KTL) Unbiased	44.96595	77.66859
	Ps90%/90% (-KTL) Unbiased	-40.13110	-82.51772
	Specification MIN		
	Status (Measurements) Unbiased		
	Specification MAX	150	300
	Status (Measurements) Unbiased	PASS	PASS
	Status (-KTL) Unbiased		
	Status (+KTL) Unbiased	PASS	PASS

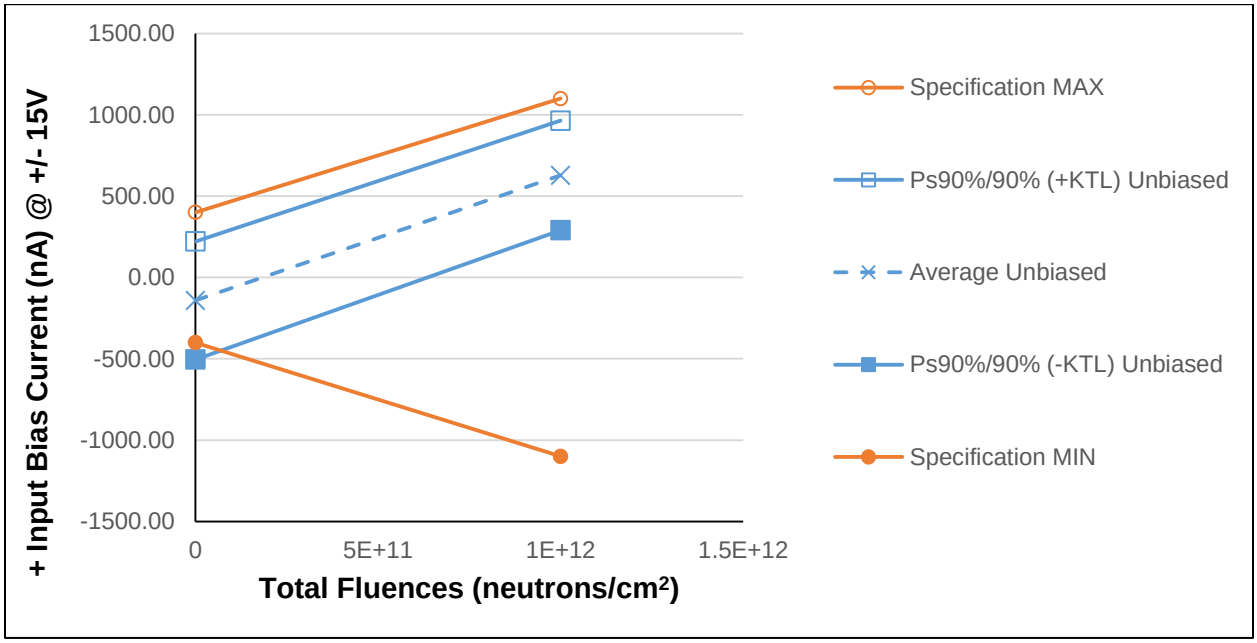

Figure 5.3: Plot of Positive Bias Current versus Total Fluence

Note: the post irradiation +KTL point was marginally higher than the maximum specification limit due to the small 5-piece sample size.

Table 5.3: Raw data table for Positive Bias Current of pre- and post-irradiation (1E12 N/cm^2) including the statistical calculations, minimum specification, maximum specification, and the status of the test (PASS/FAIL).

Parameter	Positive Input Bias Current +/-15V	Total Fluence (N/cm^2)	
Units	(nA)	0	1E+12
28	Unbiased Irradiation	-252.88510	535.96300
29	Unbiased Irradiation	-117.46330	684.73950
32	Unbiased Irradiation	43.98002	732.31120
33	Unbiased Irradiation	-285.50360	459.00320
34	Unbiased Irradiation	-96.20629	723.67860
35	Control Unit	-176.10330	-172.65440
36	Control Unit	-190.58010	-186.61370
	Unbiased Irradiation Statistics		
	Average Unbiased	-141.61565	627.13910
	Std Dev Unbiased	132.45351	122.76157
	Ps90%/90% (+KTL) Unbiased	221.57188	963.75133
	Ps90%/90% (-KTL) Unbiased	-504.80318	290.52687
	Specification MIN	-400	-1100
	Status (Measurements) Unbiased	PASS	PASS
	Specification MAX	400	1100
	Status (Measurements) Unbiased	PASS	PASS
	Status (-KTL) Unbiased	FAIL	PASS
	Status (+KTL) Unbiased	PASS	PASS

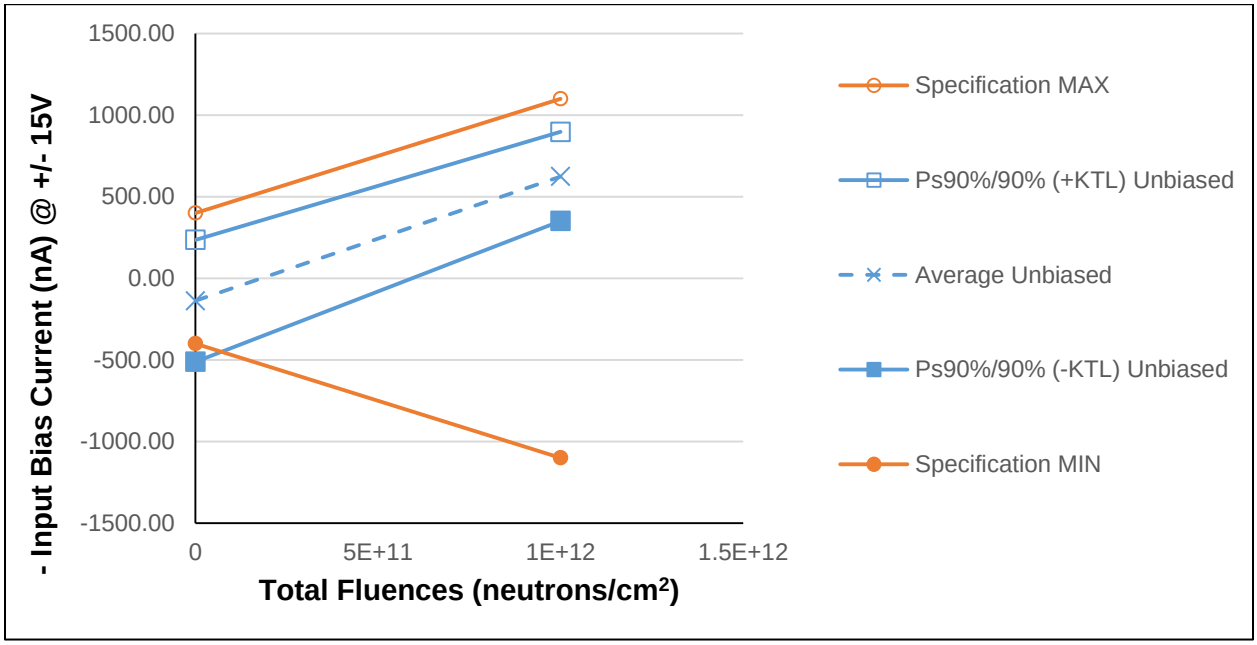

Figure 5.4: Plot of Negative Bias Current versus Total Fluence

Table 5.4: Raw data table for Positive Bias Current of pre- and post-irradiation (1E12 N/cm^2) including the statistical calculations, minimum specification, maximum specification, and the status of the test (PASS/FAIL).

Parameter	Negative Input Bias Current @+/-15V	Total Fluence (N/cm^2)	
Units	(nA)	0	1E+12
28	Unbiased Irradiation	-249.95310	549.73860
29	Unbiased Irradiation	-135.78830	642.86180
32	Unbiased Irradiation	68.90201	724.04610
33	Unbiased Irradiation	-270.47710	494.45280
34	Unbiased Irradiation	-103.90280	708.25020
35	Control Unit	-160.16050	-159.24620
36	Control Unit	-177.20280	-172.47070
	Unbiased Irradiation Statistics		
	Average Unbiased	-138.24386	623.86990
	Std Dev Unbiased	136.06922	99.69984
	Ps90%/90% (+KTL) Unbiased	234.85795	897.24687
	Ps90%/90% (-KTL) Unbiased	-511.34567	350.49293
	Specification MIN	-400	-1100
	Status (Measurements) Unbiased	PASS	PASS
	Specification MAX	400	1100
	Status (Measurements) Unbiased	PASS	PASS
	Status (-KTL) Unbiased	FAIL	PASS
	Status (+KTL) Unbiased	PASS	PASS

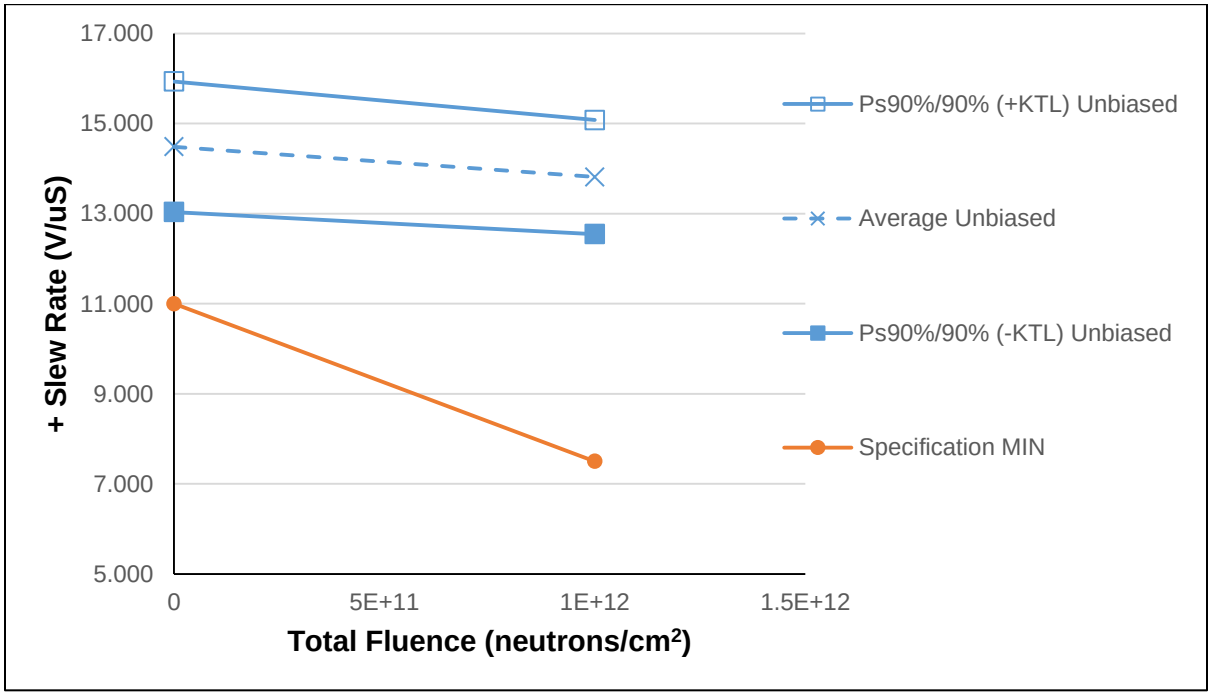

Figure 5.5: Plot of Positive Slew Rate versus Total Fluence

Table 5.5: Raw data table for Positive Slew Rate of pre- and post-irradiation (1E12 N/cm^2) including the statistical calculations, minimum specification, and the status of the test (PASS/FAIL).

Parameter	Positive Slew Rate	Total Fluence (N/cm^2)	
Units	(V/uS)	0	1E+12
28	Unbiased Irradiation	13.98887	13.25790
29	Unbiased Irradiation	14.80586	14.18451
32	Unbiased Irradiation	14.18449	13.61351
33	Unbiased Irradiation	15.25150	14.38572
34	Unbiased Irradiation	14.18449	13.61351
35	Control Unit	15.25150	14.80588
36	Control Unit	15.48460	15.02538
	Unbiased Irradiation Statistics		
	Average Unbiased	14.48304	13.81103
	Std Dev Unbiased	0.52849	0.46199
	Ps90%/90% (+KTL) Unbiased	15.93216	15.07781
	Ps90%/90% (-KTL) Unbiased	13.03392	12.54425
	Specification MIN	11.0	7.5
	Status (Measurements) Unbiased	PASS	PASS
	Specification MAX		
	Status (Measurements) Unbiased		
	Status (-KTL) Unbiased	PASS	PASS
	Status (+KTL) Unbiased		

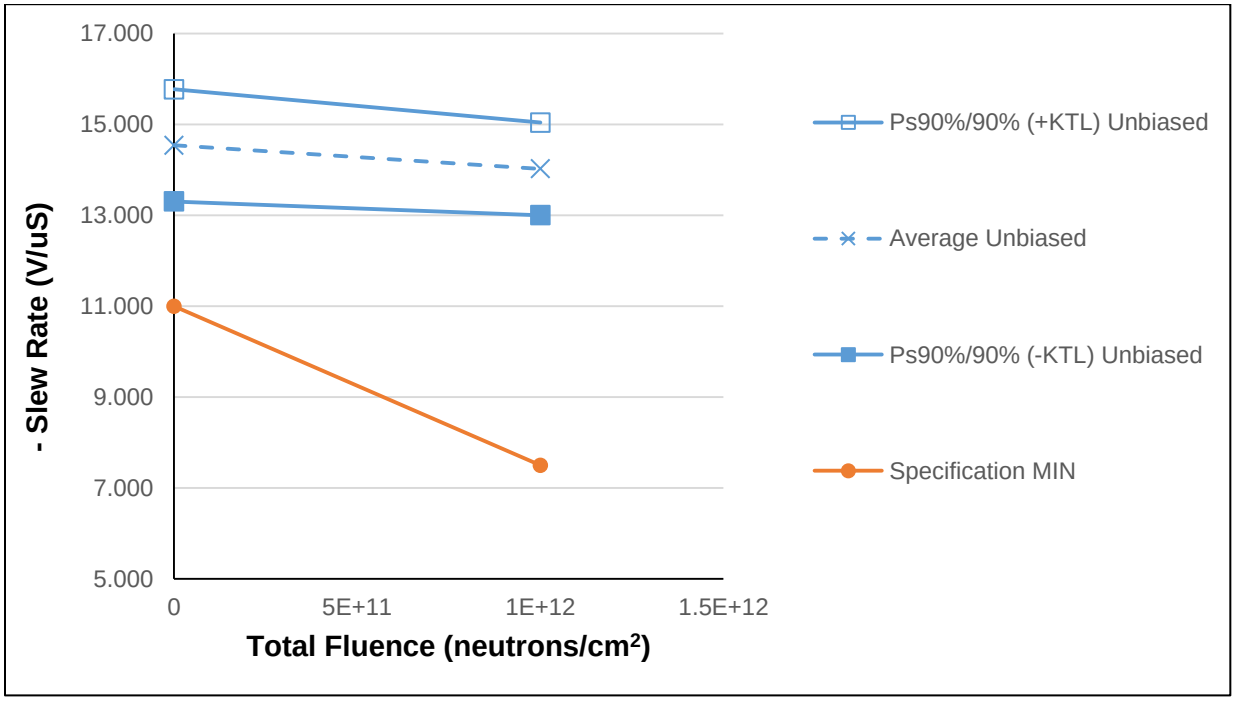

Figure 5.6: Plot of Negative Slew Rate versus Total Fluence

Table 5.6: Raw data table for Negative Slew Rate of pre- and post-irradiation (1E12 N/cm^2) including the statistical calculations, minimum specification, and the status of the test (PASS/FAIL).

Parameter	Negative Slew Rate	Total Fluence (N/cm^2)	
Units	(V/uS)	0	1E+12
28	Unbiased Irradiation	14.08887	13.53333
29	Unbiased Irradiation	14.90586	14.28451
32	Unbiased Irradiation	14.28449	13.89863
33	Unbiased Irradiation	15.12535	14.48572
34	Unbiased Irradiation	14.28449	13.89863
35	Control Unit	14.90586	15.12537
36	Control Unit	15.35149	15.12537
	Unbiased Irradiation Statistics		
	Average Unbiased	14.53781	14.02016
	Std Dev Unbiased	0.45015	0.37188
	Ps90%/90% (+KTL) Unbiased	15.77213	15.03985
	Ps90%/90% (-KTL) Unbiased	13.30349	13.00048
	Specification MIN	11.0	7.5
	Status (Measurements) Unbiased	PASS	PASS
	Specification MAX		
	Status (Measurements) Unbiased		
	Status (-KTL) Unbiased	PASS	PASS
	Status (+KTL) Unbiased		

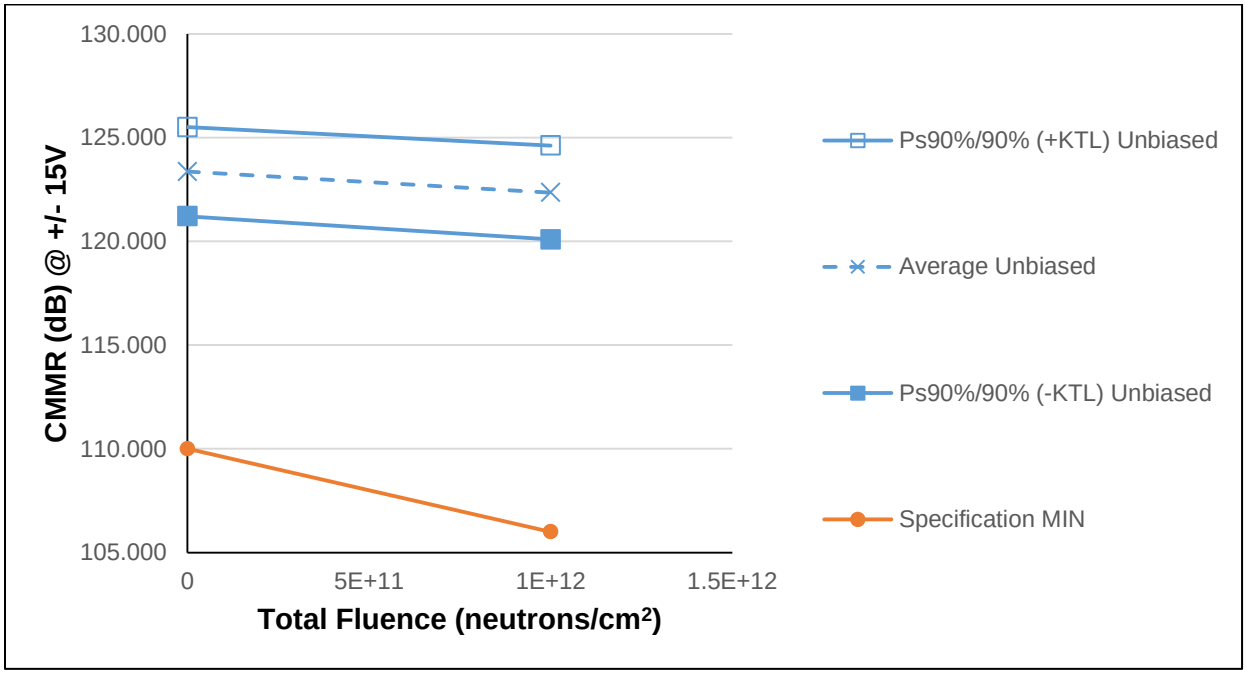

Figure 5.7: Plot of Common Mode Rejection Rate versus Total Fluence

Table 5.7: Raw data table for Common Mode Rejection Rate of pre- and post-irradiation (1E12 N/cm^2) including the statistical calculations, minimum specification, and the status of the test (PASS/FAIL).

Parameter	CMRR @+/-15V; CMR @+/-11.V	Total Fluence (N/cm^2)	
Units	(dB)	0	1E+12
28	Unbiased Irradiation	123.9118	123.3559
29	Unbiased Irradiation	122.6815	121.7427
32	Unbiased Irradiation	124.1027	122.8397
33	Unbiased Irradiation	123.7250	122.5119
34	Unbiased Irradiation	122.3597	121.3119
35	Control Unit	123.5422	123.3559
36	Control Unit	123.0156	123.3559
	Unbiased Irradiation Statistics		
	Average Unbiased	123.3561	122.3524
	Std Dev Unbiased	0.7827	0.8253
	Ps90%/90% (+KTL) Unbiased	125.5022	124.6153
	Ps90%/90% (-KTL) Unbiased	121.2101	120.0895
	Specification MIN	110	106
	Status (Measurements) Unbiased	PASS	PASS
	Specification MAX		
	Status (Measurements) Unbiased		
	Status (-KTL) Unbiased	PASS	PASS
	Status (+KTL) Unbiased		

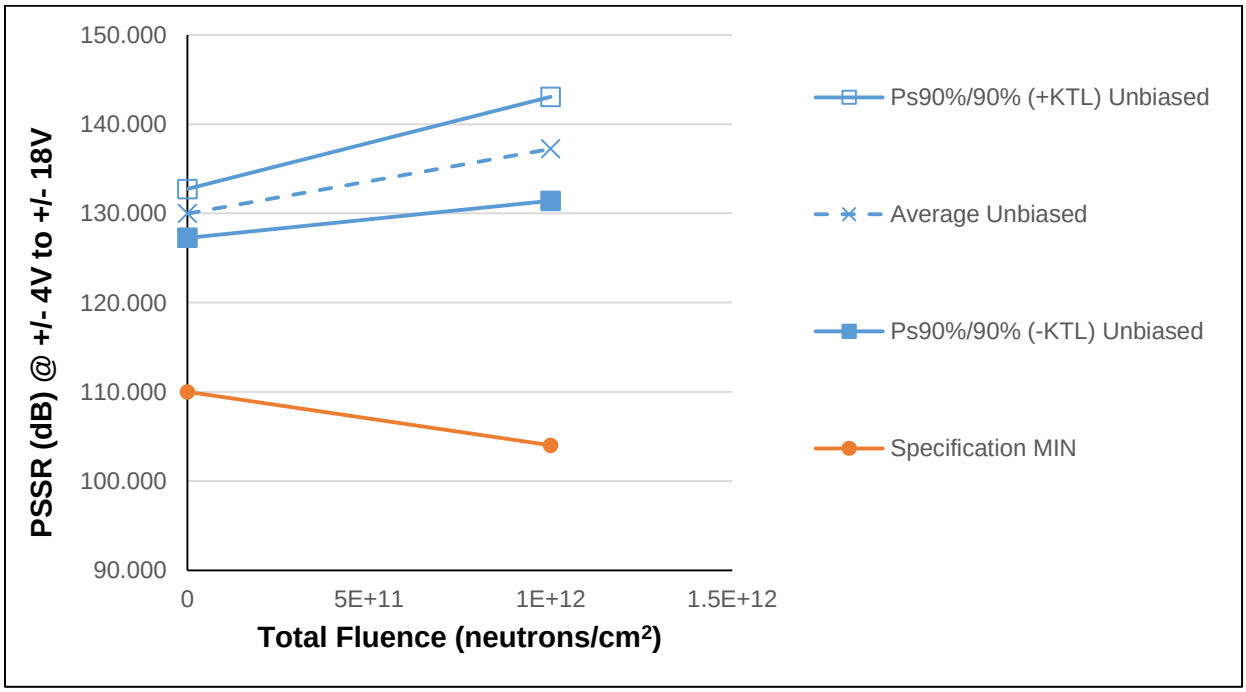

Figure 5.8: Plot of Power Supply Rejection Rate versus Total Fluence

Table 5.8: Raw data table for Power Supply Rejection Rate of pre- and post-irradiation (1E12 N/cm^2) including the statistical calculations, minimum specification, and the status of the test (PASS/FAIL).

Parameter	PSRR,+/-4 TO +/-18	Total Fluence (N/cm^2)	
Units	(dB)	0	1E+12
28	Unbiased Irradiation	131.5675	140.9254
29	Unbiased Irradiation	129.2955	136.1023
32	Unbiased Irradiation	129.5757	135.6606
33	Unbiased Irradiation	130.3574	137.0595
34	Unbiased Irradiation	129.1587	136.4098
35	Control Unit	130.1268	130.7080
36	Control Unit	130.4750	130.2341
	Unbiased Irradiation Statistics		
	Average Unbiased	129.9910	137.2315
	Std Dev Unbiased	0.9961	2.1268
	Ps90%/90% (+KTL) Unbiased	132.7221	143.0631
	Ps90%/90% (-KTL) Unbiased	127.2598	131.3999
	Specification MIN	110	104
	Status (Measurements) Unbiased	PASS	PASS
	Specification MAX		
	Status (Measurements) Unbiased		
	Status (-KTL) Unbiased	PASS	PASS
	Status (+KTL) Unbiased		

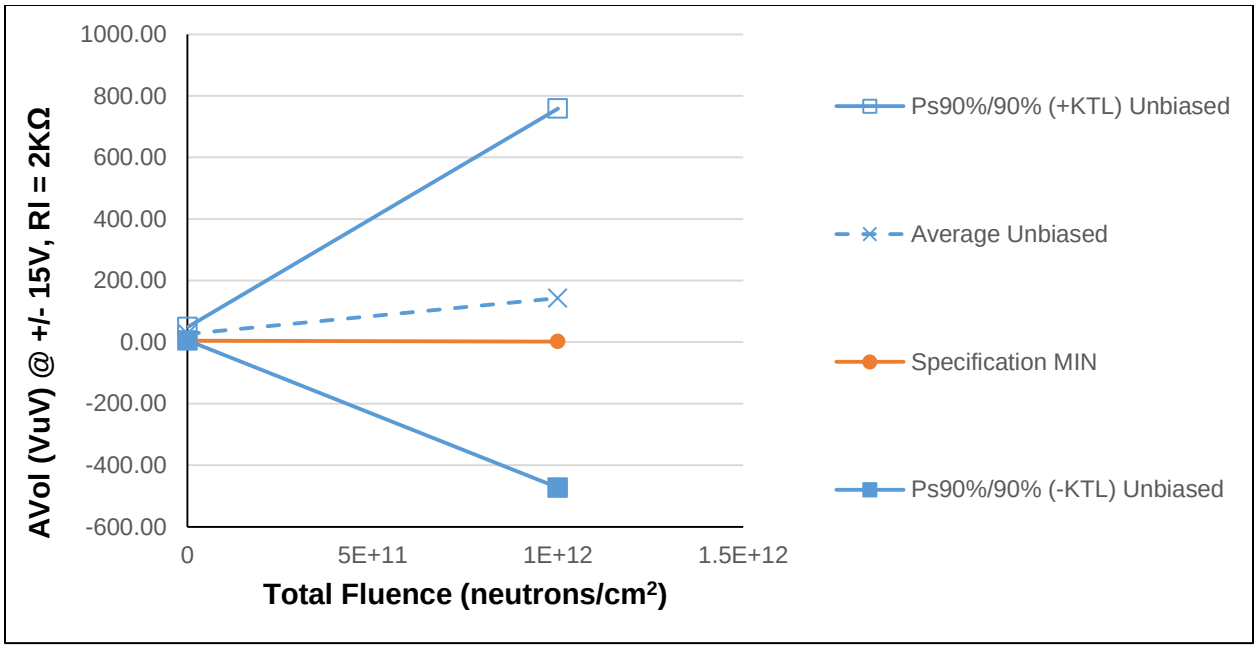

Figure 5.9: Plot of Large Signal Voltage Gain versus Total Fluence

Table 5.9: Raw data table for Large Signal Voltage Gain of pre- and post-irradiation (1E12 N/cm^2) including the statistical calculations, minimum specification, and the status of the test (PASS/FAIL).

Parameter	A_{VOL} @+/-15V; V_O=-10V TO 10V; R_L=2K	Total Fluence (N/cm^2)	
Units	(V/uV)	0	1E+12
28	Unbiased Irradiation	22.53	11.50
29	Unbiased Irradiation	32.77	540.27
32	Unbiased Irradiation	22.53	15.89
33	Unbiased Irradiation	19.31	52.71
34	Unbiased Irradiation	37.95	93.96
35	Control Unit	22.30	33.25
36	Control Unit	23.51	13.26
	Unbiased Irradiation Statistics		
	Average Unbiased	27.02	142.87
	Std Dev Unbiased	7.94	224.63
	Ps90%/90% (+KTL) Unbiased	48.79	758.80
	Ps90%/90% (-KTL) Unbiased	5.25	-473.07
	Specification MIN	5	2
	Status (Measurements) Unbiased	PASS	PASS
	Specification MAX		
	Status (Measurements) Unbiased		
	Status (-KTL) Unbiased	PASS	FAIL
	Status (+KTL) Unbiased		

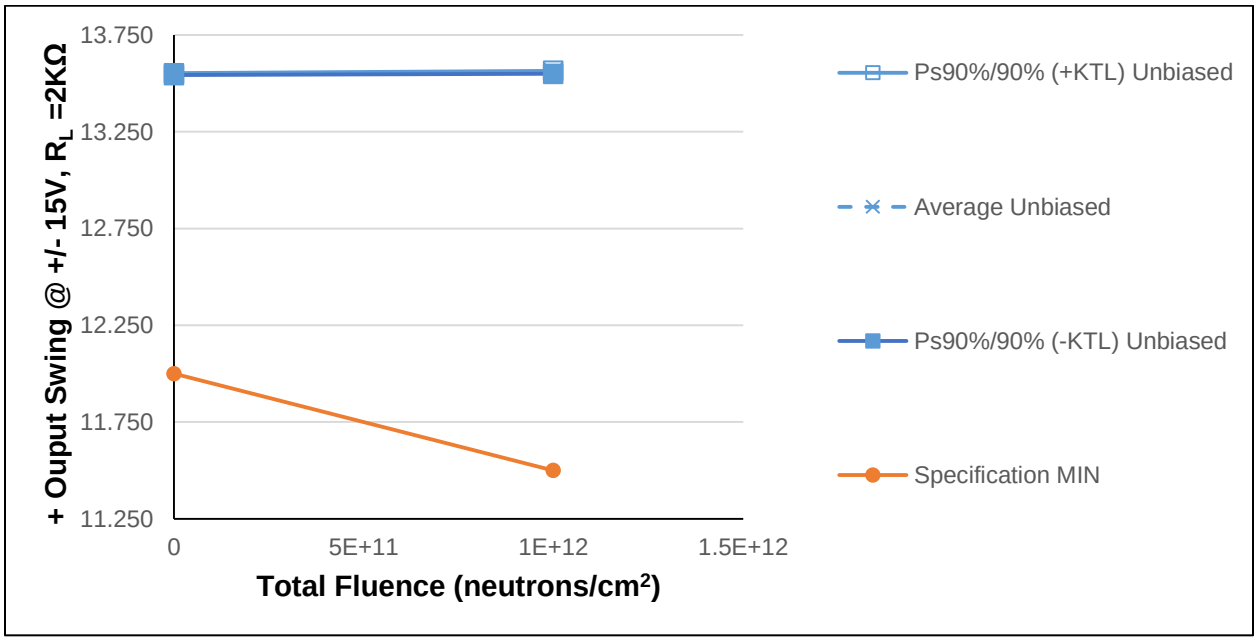

Figure 5.10: Plot of Positive Output Swing @ R_L = 2KΩ versus Total Fluence

Table 5.10: Raw data table for Positive Output Swing at R_L = 2KΩ of pre- and post-irradiation (1E12 N/cm^2) including the statistical calculations, minimum specification, and the status of the test (PASS/FAIL).

Parameter	Pos. Output Swing @+/-15V;R=2K	Total Fluence (N/cm^2)	
Units	(V)	0	1E+12
28	Unbiased Irradiation	13.54872	13.55609
29	Unbiased Irradiation	13.54727	13.55647
32	Unbiased Irradiation	13.54597	13.55465
33	Unbiased Irradiation	13.54903	13.56182
34	Unbiased Irradiation	13.54475	13.55465
35	Control Unit	13.54300	13.54427
36	Control Unit	13.54300	13.54297
	Unbiased Irradiation Statistics		
	Average Unbiased	13.54715	13.55674
	Std Dev Unbiased	0.00181	0.00296
	Ps90%/90% (+KTL) Unbiased	13.55212	13.56485
	Ps90%/90% (-KTL) Unbiased	13.54217	13.54862
	Specification MIN	12.0	11.5
	Status (Measurements) Unbiased	PASS	PASS
	Specification MAX		
	Status (Measurements) Unbiased		
	Status (-KTL) Unbiased	PASS	PASS
	Status (+KTL) Unbiased		

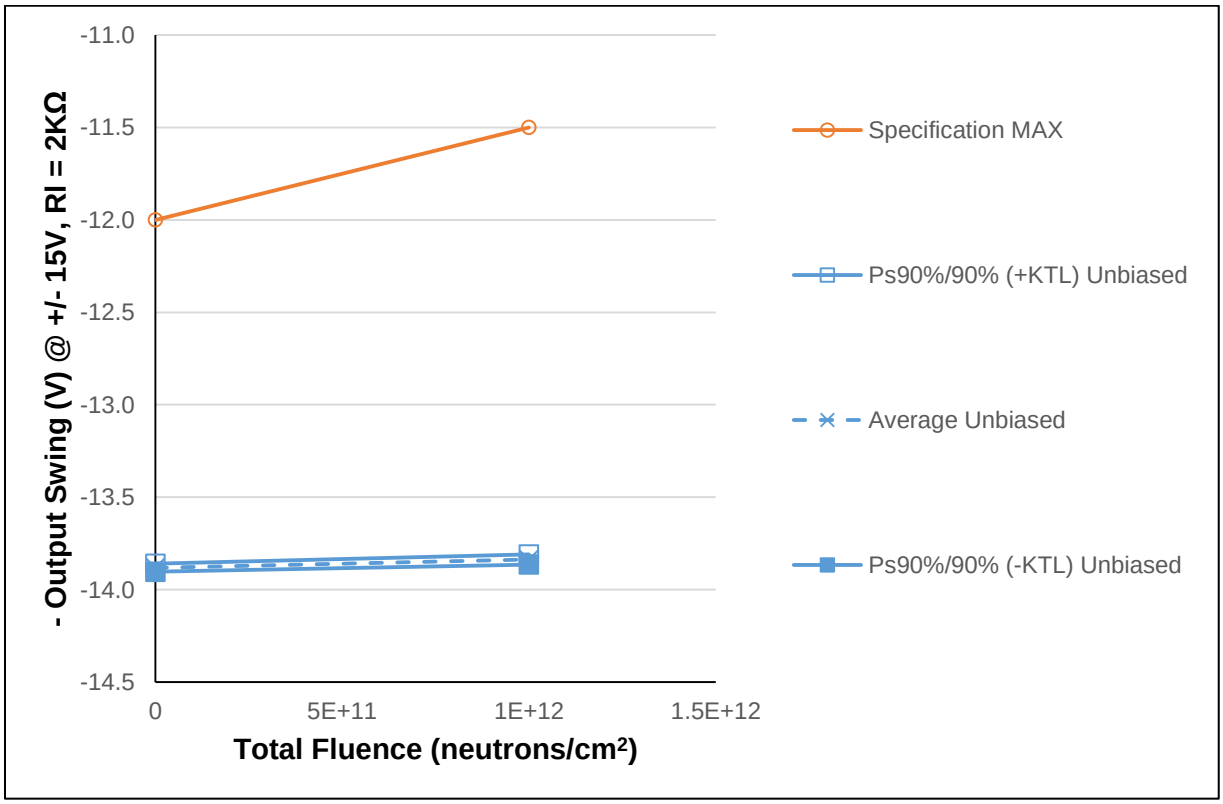

Figure 5.11: Plot of Negative Output Swing @ R_L = 2KΩ versus Total Fluence

Table 5.11: Raw data table for Negative Output Swing at R_L = 2KΩ of pre- and post-irradiation (1E12 N/cm^2) including the statistical calculations, minimum specification, and the status of the test (PASS/FAIL).

Parameter	- OUTPUT SWING @+/-15V; RL=2K	Total Fluence (N/cm^2)	
Units	(V)	0	1E+12
28	Unbiased Irradiation	-13.87552	-13.82982
29	Unbiased Irradiation	-13.88651	-13.84446
32	Unbiased Irradiation	-13.87583	-13.82982
33	Unbiased Irradiation	-13.89230	-13.85057
34	Unbiased Irradiation	-13.87568	-13.82928
35	Control Unit	-13.88438	-13.88873
36	Control Unit	-13.88856	-13.89278
	Unbiased Irradiation Statistics		
	Average Unbiased	-13.88117	-13.83679
	Std Dev Unbiased	0.00779	0.01003
	Ps90%/90% (+KTL) Unbiased	-13.85980	-13.80929
	Ps90%/90% (-KTL) Unbiased	-13.90254	-13.86429
	Specification MIN		
	Status (Measurements) Unbiased		
	Specification MAX	-12.0	-11.5
	Status (Measurements) Unbiased	PASS	PASS
	Status (-KTL) Unbiased		
	Status (+KTL) Unbiased	PASS	PASS

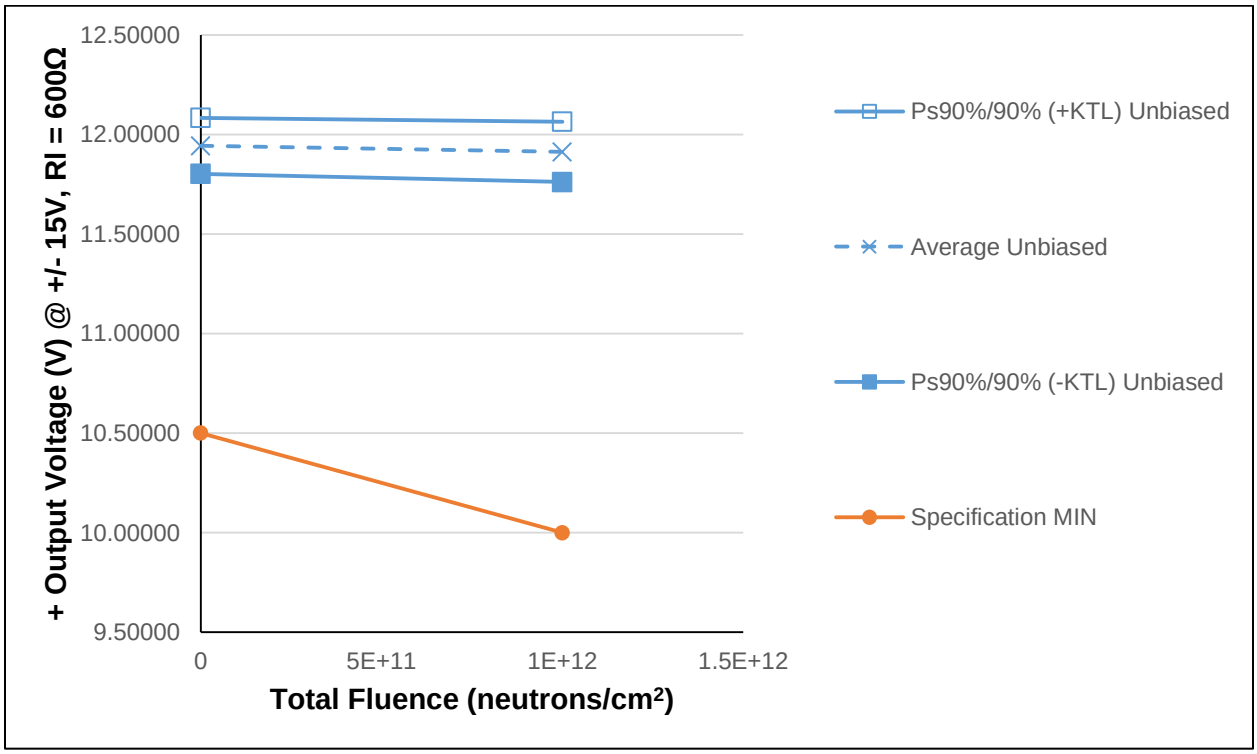

Figure 5.12: Plot of Positive Output Swing Voltage V_{OUT} with R_L = 600Ω versus Total Fluence

Table 5.12: Raw data table for Positive Output Swing at R_L = 600Ω of pre- and post-irradiation (1E12 N/cm^2) including the statistical calculations, minimum specification, and the status of the test (PASS/FAIL).

Parameter	+ OUTPUT VOLTAGE @+/-15V; RL=600	Total Fluence (N/cm^2)	
Units	V	0	1E+12
28	Unbiased Irradiation	11.90738	11.88852
29	Unbiased Irradiation	11.99483	11.97292
32	Unbiased Irradiation	11.89494	11.85434
33	Unbiased Irradiation	12.00208	11.97032
34	Unbiased Irradiation	11.91470	11.87730
35	Control Unit	11.95882	11.94544
36	Control Unit	12.01300	12.00756
	Unbiased Irradiation Statistics		
	Average Unbiased	11.94279	11.91268
	Std Dev Unbiased	0.05137	0.05520
	Ps90%/90% (+KTL) Unbiased	12.08365	12.06405
	Ps90%/90% (-KTL) Unbiased	11.80193	11.76131
	Specification MIN	10.5	10.0
	Status (Measurements) Unbiased	PASS	PASS
	Specification MAX		
	Status (Measurements) Unbiased		
	Status (-KTL) Unbiased	PASS	PASS
	Status (+KTL) Unbiased		

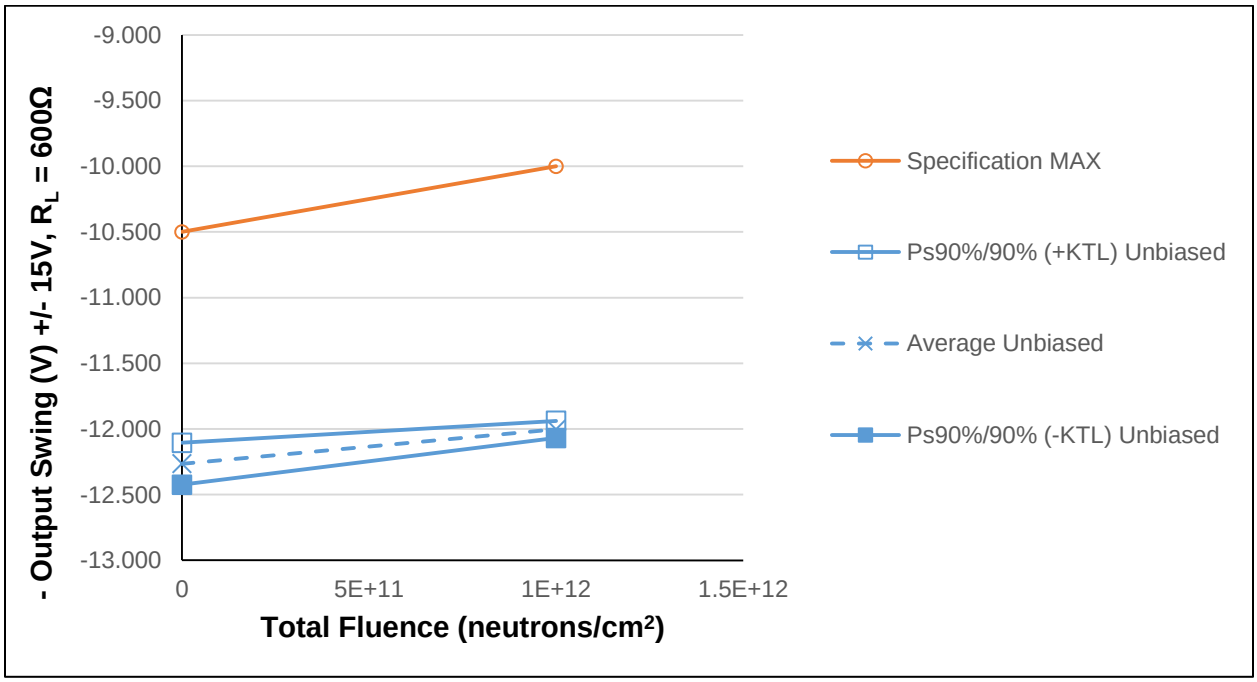

Figure 5.13: Plot of Negative Output Swing Voltage V_{OUT} with R_L = 600Ω versus Total Fluence

Table 5.13: Raw data table for Negative Output Swing at R_L = 600Ω of pre- and post-irradiation (1E12 N/cm^2) including the statistical calculations, minimum specification, and the status of the test (PASS/FAIL).

Parameter	- OUTPUT SWING @+/-15V; RL=600	Total Fluence (N/cm^2)	
Units	(V)	0	1E+12
28	Unbiased Irradiation	-12.20846	-11.99352
29	Unbiased Irradiation	-12.31561	-12.02069
32	Unbiased Irradiation	-12.21532	-11.98162
33	Unbiased Irradiation	-12.33612	-12.03648
34	Unbiased Irradiation	-12.24821	-11.98520
35	Control Unit	-12.29942	-12.29112
36	Control Unit	-12.34957	-12.34728
	Unbiased Irradiation Statistics		
	Average Unbiased	-12.26474	-12.00350
	Std Dev Unbiased	0.05824	0.02396
	Ps90%/90% (+KTL) Unbiased	-12.10506	-11.93780
	Ps90%/90% (-KTL) Unbiased	-12.42443	-12.06920
	Specification MIN		
	Status (Measurements) Unbiased		
	Specification MAX	-10.5	-10.0
	Status (Measurements) Unbiased	PASS	PASS
	Status (-KTL) Unbiased		
	Status (+KTL) Unbiased	PASS	PASS

Appendix A

Pictures of one among five samples used in the test.

Figure A1: Top View showing date code

Figure A2: Bottom View showing serial number

Appendix B

Radiation Bias Connection Table

Table B1: Unbias condition

Pin	Function	Connection
1	NC	Float
2	V_{OS} TRIM	Float
3	-IN	Float
4	+IN	Float
5	V^-	Float
6	Overcomp	Float
7	V_{OUT}	Float
8	V^+	Float
9	V_{OS} TRIM	Float
10	NC	Float

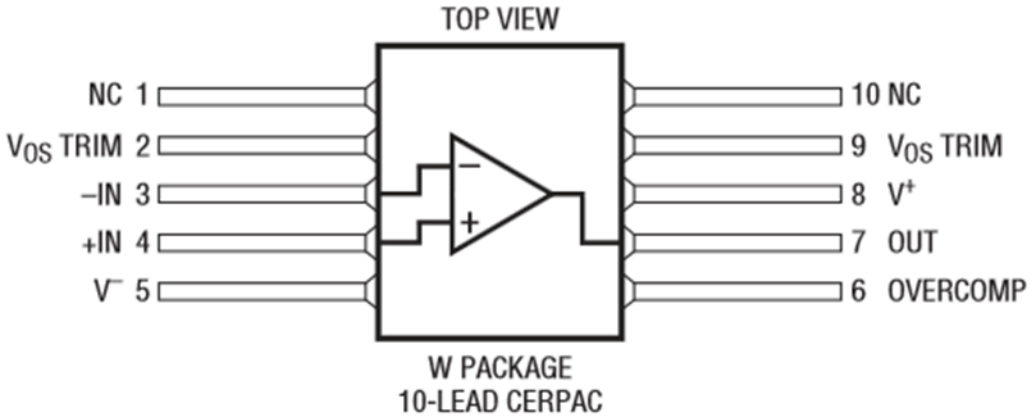

Figure B1: Pin-Out

Appendix C

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Thomas Regan
Reactor Engineering

University of Massachusetts
UMASS Lowell

RADIATION LABORATORY

7/2/2012
Linear Technology Corporation
Attention: Sana Rezgui
1530 Buckeye Drive
Milpitas, CA 95035

Subject: **Certificate of Neutron Exposure**

Product: Multiple products see attached table

Irradiation Date: June, 27th, 2012
Irradiation Facility: Reactor Facility- FNI
Dosimetry system: S/P-32, ASTM E-265

Neutron Dosimetry Results:

Irradiation	Requested Fluence (n/cm^2)	Reactor Power (kW)	Time (s)	Fluence Rate (n/cm^2-s)(2,3)	Gamma Dose rad (Si) (1)	Measured Fluence (n/cm^2)(4)	Total Integral Fluence (n/cm^2)
Group 1	1.00E+12	45.0	228	4.05E+09	117	1.03E+12	1.03E+12
Group 2	1.00E+12	45.0	228	4.05E+09	117	9.41E+11	9.41E+11
Group 3	1.00E+13	475	234	4.28E+10	1266	9.22E+12	9.22E+12
Group 4	1.00E+13	90	1235	8.10E+09	1266	9.03E+12	9.03E+12

(1) Based on reactor power at 1,000kW, the gamma dose is 41+/- 5.3% krad(Si)/hr as mapped by TLD-based dosimetry
(2) Dosimetry method: ASTM E-265
(3) The neutron fluence rate is determined from "Initial Testing of the New Ex-Core Fast Neutron Irradiator at UMass Lowell " (6/18/02)
(4) Validated by S-32 flux monitors

The neutron fluence for this irradiation was determined using the previously measured neutron radiation field for this facility, measured with ASTM E-265 "Measuring Reaction Rates and Fast Neutron Fluence by Radioactivation of Sulfur-32" and correlated to the measured reactor power level.

Group 1 Average Integrated Neutron Fluence (1 MeV Si Eq.) =1.03E12 n/cm^2
Group 2 Average Integrated Neutron Fluence (1 MeV Si Eq.) =9.41E11 n/cm^2
Group 3 Average Integrated Neutron Fluence (1 MeV Si Eq.) =9.22E12 n/cm^2
Group 4 Average Integrated Neutron Fluence (1 MeV Si Eq.) =9.03E12 n/cm^2

Reviewed by Thomas M Regan
Thomas Regan
Reactor Engineer

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	200 Krad(Si) MIN	200 Krad(Si) MAX	Units
Input Offset Voltage		80		100		120		140		160		180	uV
Input Offset Current		150		200		200		200		300		500	nA
+ Input Bias Current		+/-400		+/-600		+/-700		+/-950		+/-1100		+/-1700	nA
- Input Bias Current		+/-400		+/-600		+/-700		+/-950		+/-1100		+/-1700	nA
+ Slew Rate	11		7.5		7.5		7.5		7.5		7.5		V/uS
- Slew Rate	11		7.5		7.5		7.5		7.5		7.5		V/uS
CMRR	110		106		106		106		106		106		dB
PSRR	110		104		104		104		104		104		dB
A_{VOL} (R_L = 2 KΩ)	5		2		2		2		2		2		V/uV
V_{OUT} (+) (R_L = 2 KΩ)	12		11.5		11.5		11.5		11.5		11.5		V
V_{OUT} (-) (R_L = 2 KΩ)		-12		-11.5		-11.5		-11.5		-11.5		-11.5	V
V_{OUT} (+) (R_L = 600 Ω)	10.5		10		10		10		10		10		V
V_{OUT} (-) (R_L = 600 Ω)		-10.5		-10		-10		-10		-10		-10	V