Neutron Irradiation Test Results of the RH3080MK Adjustable 0.9A Single Resistor Low Dropout Regulator

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Acknowledgements

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Neutron Radiation Testing of the RH3080MK Adjustable 0.9A Single Resistor Low Dropout Regulator

Part Type Tested: RH3080MK Adjustable 0.9A Single Resistor Low Dropout Regulator, SPEC NO. 05-08-5246 REV. 0

Traceability Information: Fab Lot# H0923840.4; Wafer # 3; Assembly Lot # 589490.2. 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. Leads of devices, serial numbers 1 to 5, were shorted together using anti-static foam during irradiation. Serial numbers 11 and 12 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 RH3080MH SPEC NO. 05-08-5246 REV. C and RH3080MK DICE/DWF

Test Hardware and Software: LTX test program EFCR3080R.00.

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. We run the electrical tests after we had made sure that the parts are not radioactive anymore to be shipped to LTC.

Bipolar technology is susceptible to neutron displacement damage around a fluence level of 1E12 neutron/cm^2. The neutron radiation test for the RH3080MK 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 leads were shorted together using anti-static foam and devices then 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 5003, MIL-STD-883, and if valid the lot will be scrapped.

4.0 Tested Parameters

The following parameters were measured pre- and post-irradiations:

- SET Pin Current (uA) @ V_{IN} = 1V, $V_{CONTROL}$ = 2V, I_{LOAD} = 1mA
- Output Offset Voltage (V_{OUT} – V_{SET}) (mV) @ V_{IN} = 1V, $V_{CONTROL}$ = 2V, I_{LOAD} = 1mA
- Load Regulation, I_{SET} (nA) @ I_{LOAD} = 1mA to 0.9A
- Load Regulation, V_{OS} (mV) @ I_{LOAD} = 1mA to 0.9A
- Line Regulation, I_{SET} (nA/V) @ V_{IN} = 1V to 26V, $V_{CONTROL}$ = 2V to 26V, I_{LOAD} = 1mA
- Line Regulation, V_{OS} (mV/V) @ V_{IN} = 1V to 26V, $V_{CONTROL}$ = 2V to 26V, I_{LOAD} = 1mA
- Minimum Load Current (mA) @ V_{IN} = 10V, $V_{CONTROL}$ = 10V
- Minimum Load Current (mA) @ V_{IN} = 26V, $V_{CONTROL}$ = 26V
- $V_{CONTROL}$ Dropout Voltage (V) @ V_{IN} = 1V, I_{LOAD} = 0.1A
- $V_{CONTROL}$ Dropout Voltage (V) @ V_{IN} = 1V, I_{LOAD} = 0.9A
- V_{IN} Dropout Voltage (V) @ $V_{CONTROL}$ = 2V, I_{LOAD} = 0.1A
- V_{IN} Dropout Voltage (V) @ $V_{CONTROL}$ = 2V, I_{LOAD} = 0.8A
- $V_{CONTROL}$ Pin Current (mA) @ V_{IN} = 1V, $V_{CONTROL}$ = 2V, I_{LOAD} = 0.1A
- $V_{CONTROL}$ Pin Current (mA) @ V_{IN} = 1V, $V_{CONTROL}$ = 2V, I_{LOAD} = 0.9A
- Current Limit (A) @ V_{IN} = 5V, $V_{CONTROL}$ = 5V, V_{SET} = 0V, V_{OUT} = - 0.1V

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 fifteen 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 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 10 Krads(Si) specification limits.

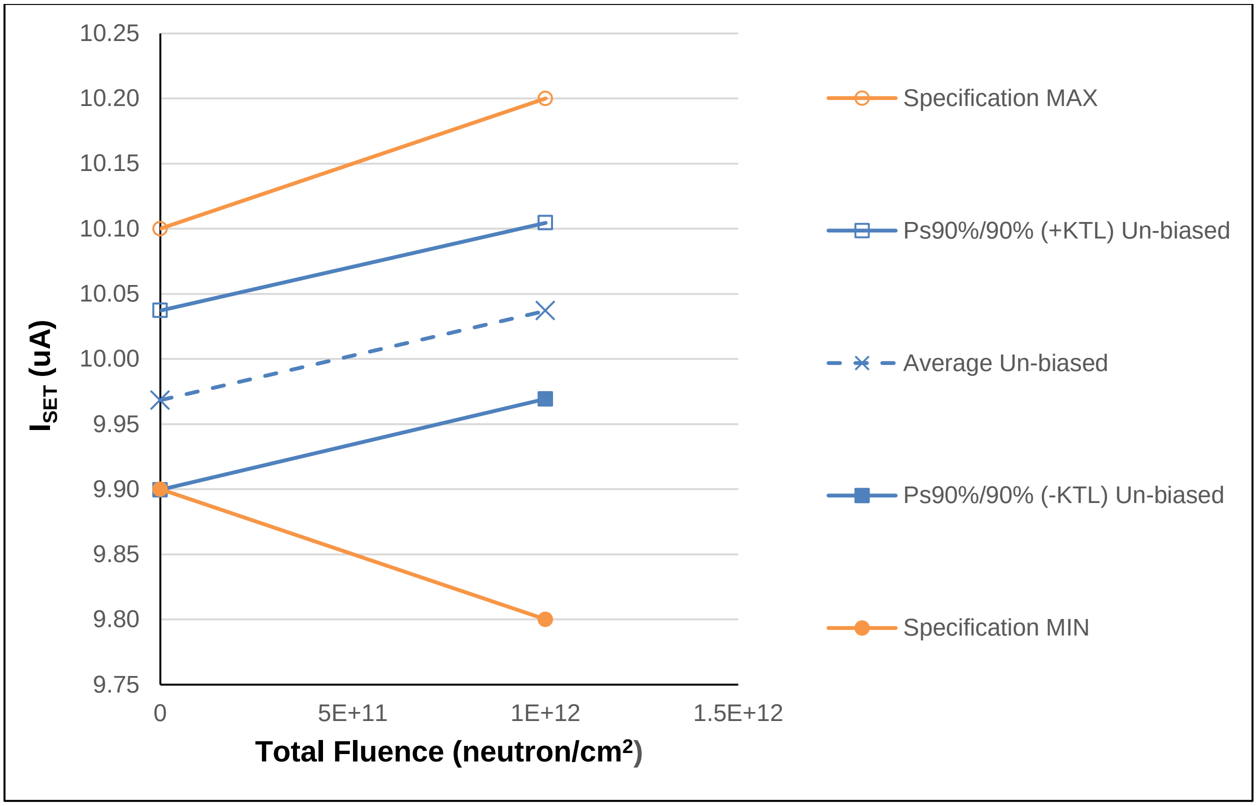

Figure 5.1 Plot of SET Pin Current versus Total Fluence

All five samples pass the SET Pin Current parameter. Notice the –KTL point of pre-irradiation is right at the minimum specification limit due to the small 5-piece sample size.

Table 5.1: Raw data table for SET Pin Current of pre- and post-irradiation (1E12 N/cm^2)

Parameter	I_{SET}	Total Fluence (neutron/cm^2)	
Units	(uA)	0	1.E+12
1	Un-biased Irradiation	9.9432	10.0165
2	Un-biased Irradiation	9.9539	10.0219
3	Un-biased Irradiation	9.9638	10.0333
4	Un-biased Irradiation	9.9718	10.0341
5	Un-biased Irradiation	10.0089	10.0790
11	Control Unit	9.9364	9.9311
12	Control Unit	9.9852	9.9875
	Un-biased Irradiation Statistics		
	Average Un-biased	9.9683	10.0370
	Std Dev Un-biased	0.0251	0.0247
	Ps90%/90% (+KTL) Un-biased	10.0372	10.1046
	Ps90%/90% (-KTL) Un-biased	9.8995	9.9693
	Specification MIN	9.90	9.80
	Status (Measurements)	PASS	PASS
	Specification MAX	10.10	10.20
	Status (Measurements)	PASS	PASS
	Status (-KTL) Un-biased	FAIL	PASS
	Status (+KTL) Un-biased	PASS	PASS

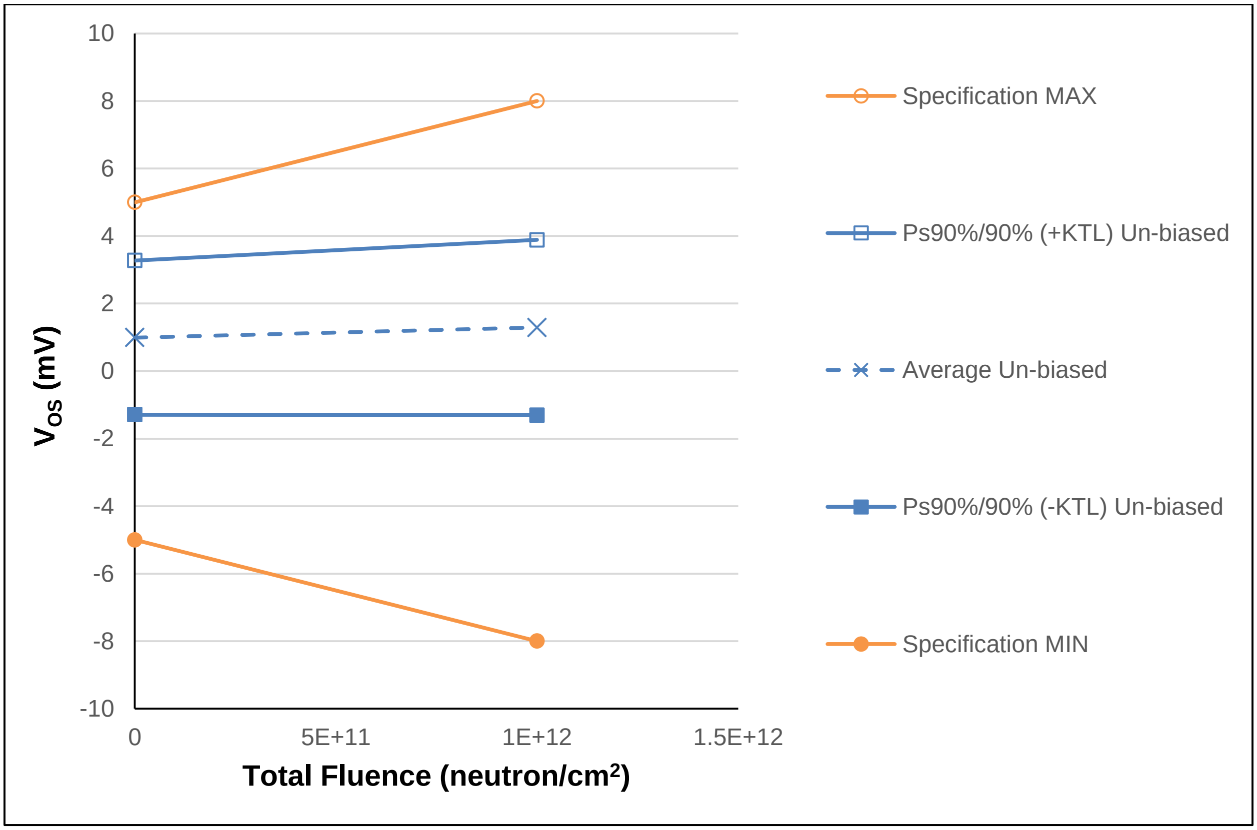

Figure 5.2: Plot of Output Offset Voltage versus Total Fluence

All measured data are within the datasheet specification limits.

Table 5.2: Raw data table for Output Offset Voltage of pre- and post-irradiation (1E12 N/cm^2)

Parameter	V_{OS}	Total Fluence (neutron/cm^2)	
Units	(mV)	0	1.E+12
1	Un-biased Irradiation	0.8622	1.2100
2	Un-biased Irradiation	1.7056	2.3800
3	Un-biased Irradiation	1.1254	1.5000
4	Un-biased Irradiation	1.6301	1.5800
5	Un-biased Irradiation	-0.3578	-0.2140
11	Control Unit	0.2691	0.3231
12	Control Unit	-0.5725	-0.5018
	Un-biased Irradiation Statistics		
	Average Un-biased	0.9931	1.2912
	Std Dev Un-biased	0.8326	0.9467
	Ps90%/90% (+KTL) Un-biased	3.2761	3.8870
	Ps90%/90% (-KTL) Un-biased	-1.2899	-1.3046
	Specification MIN	-5	-8
	Status (Measurements)	PASS	PASS
	Specification MAX	5	8
	Status (Measurements)	PASS	PASS
	Status (-KTL) Un-biased	PASS	PASS
	Status (+KTL) Un-biased	PASS	PASS

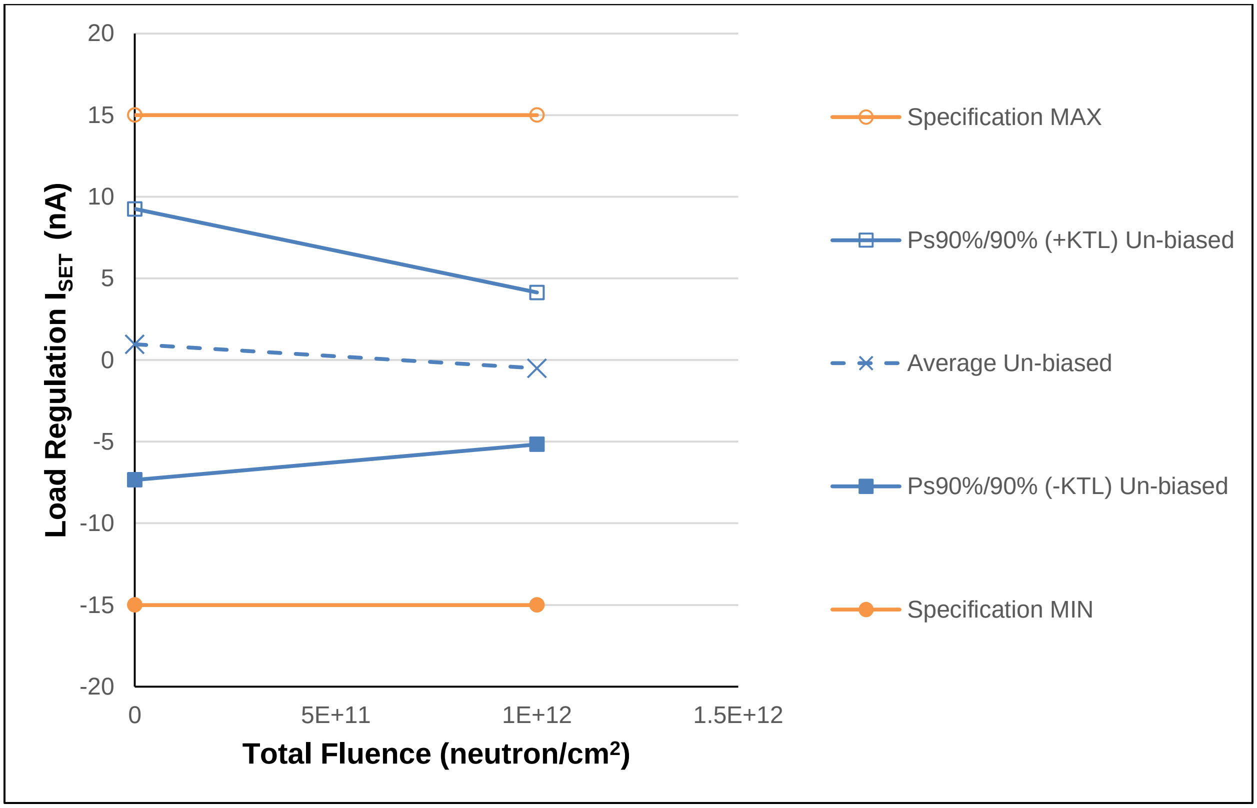

Figure 5.3: Plot of Load Regulation I_{SET} versus Total Fluence

All measured data points of Load Regulation I_{SET} parameter are within datasheet specification limits.

Table 5.3: Raw data table for Load Regulation I_{SET} of pre- and post-irradiation (1E12 N/cm^2)

Parameter	Load Regulation I_{SET}	Total Fluence (neutron/cm^2)	
Units	(nA)	0	1.E+12
1	Un-biased Irradiation	4.5820	-2.3800
2	Un-biased Irradiation	-1.6225	-2.2900
3	Un-biased Irradiation	0.0000	1.1400
4	Un-biased Irradiation	-1.9090	0.7630
5	Un-biased Irradiation	3.7289	0.1910
11	Control Unit	0.3820	6.3965
12	Control Unit	3.8181	-1.4315
	Un-biased Irradiation Statistics		
	Average Un-biased	0.9559	-0.5152
	Std Dev Un-biased	3.0252	1.6956
	Ps90%/90% (+KTL) Un-biased	9.2511	4.1340
	Ps90%/90% (-KTL) Un-biased	-7.3393	-5.1644
	Specification MIN	-15	-15
	Status (Measurements)	PASS	PASS
	Specification MAX	15	15
	Status (Measurements)	PASS	PASS
	Status (-KTL) Un-biased	PASS	PASS
	Status (+KTL) Un-biased	PASS	PASS

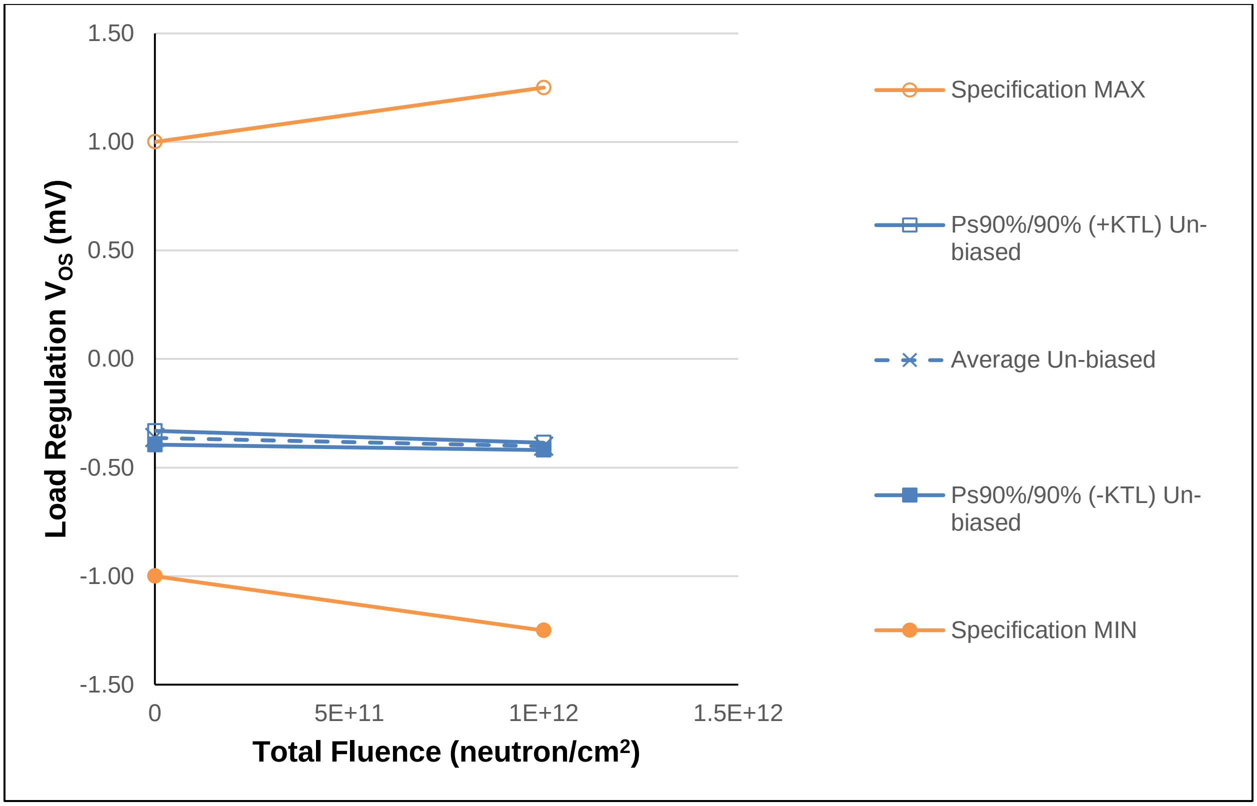

Figure 5.4: Plot of Load Regulation V_{OS} versus Total Fluence

All post-irradiation measured values of Load Regulation V_{OS} are within datasheet specification limits.

Table 5.4: Raw data table for Load Regulation V_{OS} of pre- and post-irradiation (1E12 N/cm^2)

Parameter	Load Regulation V_{OS}	Total Fluence (neutron/cm^2)	
Units	(mV)	0	1.E+12
1	Un-biased Irradiation	-0.3701	-0.4070
2	Un-biased Irradiation	-0.3677	-0.4030
3	Un-biased Irradiation	-0.3450	-0.4040
4	Un-biased Irradiation	-0.3592	-0.4040
5	Un-biased Irradiation	-0.3740	-0.3910
11	Control Unit	-0.3400	-0.3780
12	Control Unit	-0.3391	-0.3618
	Un-biased Irradiation Statistics		
	Average Un-biased	-0.3632	-0.4018
	Std Dev Un-biased	0.0115	0.0062
	Ps90%/90% (+KTL) Un-biased	-0.3316	-0.3847
	Ps90%/90% (-KTL) Un-biased	-0.3948	-0.4189
	Specification MIN	-1.00	-1.25
	Status (Measurements)	PASS	PASS
	Specification MAX	1.00	1.25
	Status (Measurements)	PASS	PASS
	Status (-KTL) Un-biased	PASS	PASS
	Status (+KTL) Un-biased	PASS	PASS

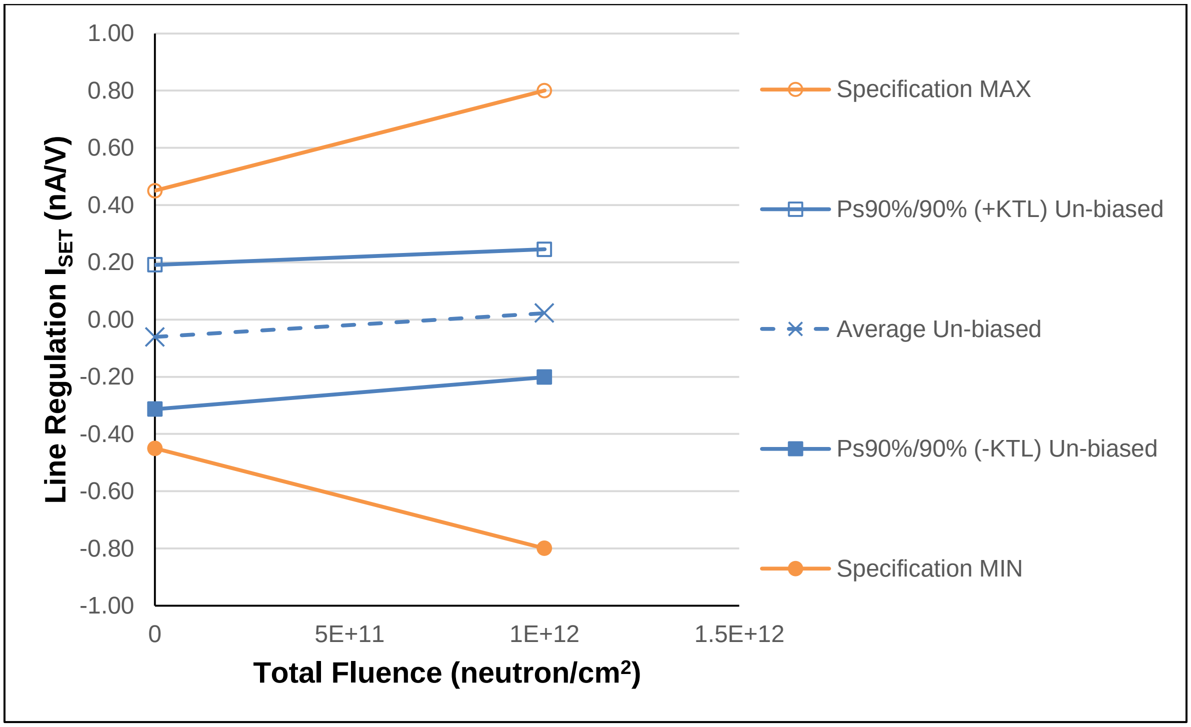

Figure 5.5: Plot of Line Regulation versus Total Fluence

All measured post-irradiation data points are within datasheet specification limits.

Table 5.5: Raw data table for Line Regulation I_{SET} of pre- and post-irradiation (1E12 N/cm²)

Parameter	Line Regulation I_{SET}	Total Fluence (neutron/cm²)	
Units	(nA/V)	0	1.E+12
1	Un-biased Irradiation	0.0955	0.0000
2	Un-biased Irradiation	-0.1313	-0.0953
3	Un-biased Irradiation	-0.0991	0.1230
4	Un-biased Irradiation	-0.1154	0.0159
5	Un-biased Irradiation	-0.0553	0.0676
11	Control Unit	-0.0676	0.3182
12	Control Unit	0.0875	-0.0795
	Un-biased Irradiation Statistics		
	Average Un-biased	-0.0611	0.0222
	Std Dev Un-biased	0.0920	0.0815
	Ps90%/90% (+KTL) Un-biased	0.1912	0.2457
	Ps90%/90% (-KTL) Un-biased	-0.3134	-0.2012
	Specification MIN	-0.45	-0.80
	Status (Measurements)	PASS	PASS
	Specification MAX	0.45	0.80
	Status (Measurements)	PASS	PASS
	Status (-KTL) Un-biased	PASS	PASS
	Status (+KTL) Un-biased	PASS	PASS

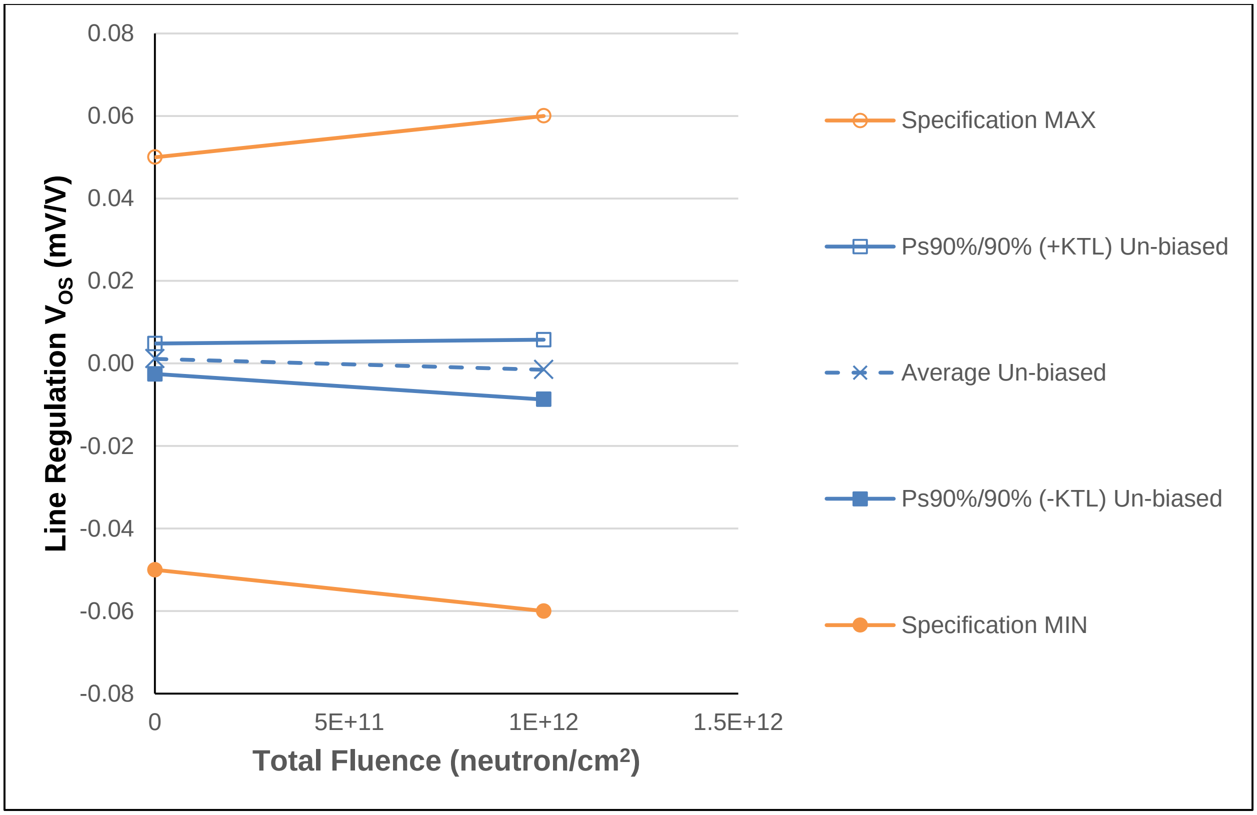

Figure 5.6: Plot of Line Regulation V_{OS} versus Total Fluence

All five samples pass the Line Regulation V_{OS} post-irradiation test.

Table 5.6: Raw data table for Line Regulation V_{OS} of pre- and post-irradiation (1E12 N/cm^2)

Parameter	Line Regulation V_{OS}	Total Fluence (neutron/cm^2)	
Units	(mV/V)	0	1.E+12
1	Un-biased Irradiation	0.0002	-0.0013
2	Un-biased Irradiation	0.0013	-0.0004
3	Un-biased Irradiation	0.0023	-0.0018
4	Un-biased Irradiation	0.0025	0.0016
5	Un-biased Irradiation	-0.0006	-0.0056
11	Control Unit	0.0022	0.0014
12	Control Unit	-0.0009	-0.0020
	Un-biased Irradiation Statistics		
	Average Un-biased	0.0011	-0.0015
	Std Dev Un-biased	0.0013	0.0026
	Ps90%/90% (+KTL) Un-biased	0.0048	0.0057
	Ps90%/90% (-KTL) Un-biased	-0.0025	-0.0087
	Specification MIN	-0.05	-0.06
	Status (Measurements)	PASS	PASS
	Specification MAX	0.05	0.06
	Status (Measurements)	PASS	PASS
	Status (-KTL) Un-biased	PASS	PASS
	Status (+KTL) Un-biased	PASS	PASS

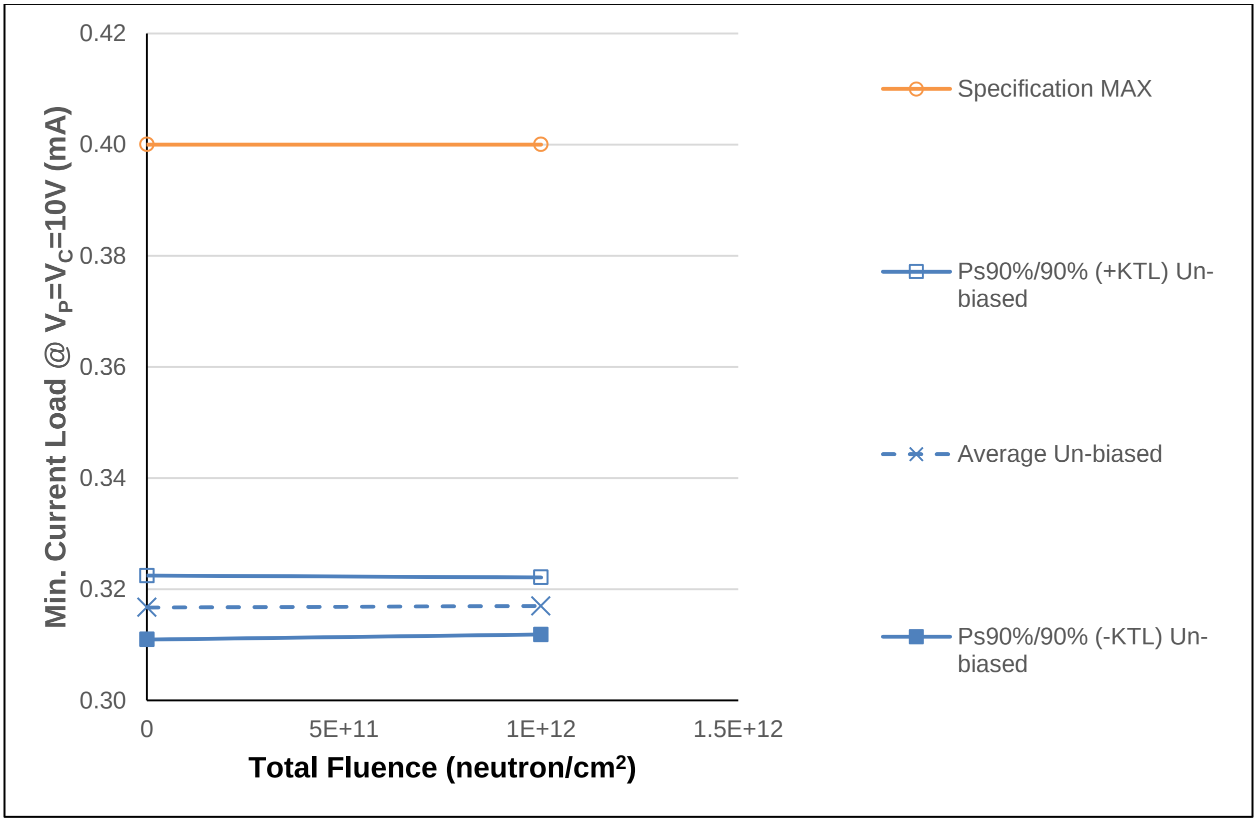

Figure 5.7: Plot of Minimum Load with V_{IN} and $V_{CONTROL}$ = 10V versus Total Fluence

All measured data points are well under datasheet upper limits.

Table 5.7: Raw data table for Minimum Load Current of pre- and post-irradiation (1E12 N/cm^2)

Parameter	Miin Current Load @V_P=V_C=10V	Total Fluence (neutron/cm^2)	
Units	(mA)	0	1.E+12
1	Un-biased Irradiation	0.3176	0.3160
2	Un-biased Irradiation	0.3193	0.3200
3	Un-biased Irradiation	0.3157	0.3170
4	Un-biased Irradiation	0.3137	0.3150
5	Un-biased Irradiation	0.3172	0.3170
11	Control Unit	0.3260	0.3276
12	Control Unit	0.3182	0.3214
	Un-biased Irradiation Statistics		
	Average Un-biased	0.3167	0.3170
	Std Dev Un-biased	0.0021	0.0019
	Ps90%/90% (+KTL) Un-biased	0.3225	0.3221
	Ps90%/90% (-KTL) Un-biased	0.3110	0.3119
	Specification MIN		
	Status (Measurements)		
	Specification MAX	0.40	0.40
	Status (Measurements)	PASS	PASS
	Status (-KTL) Un-biased		
	Status (+KTL) Un-biased	PASS	PASS

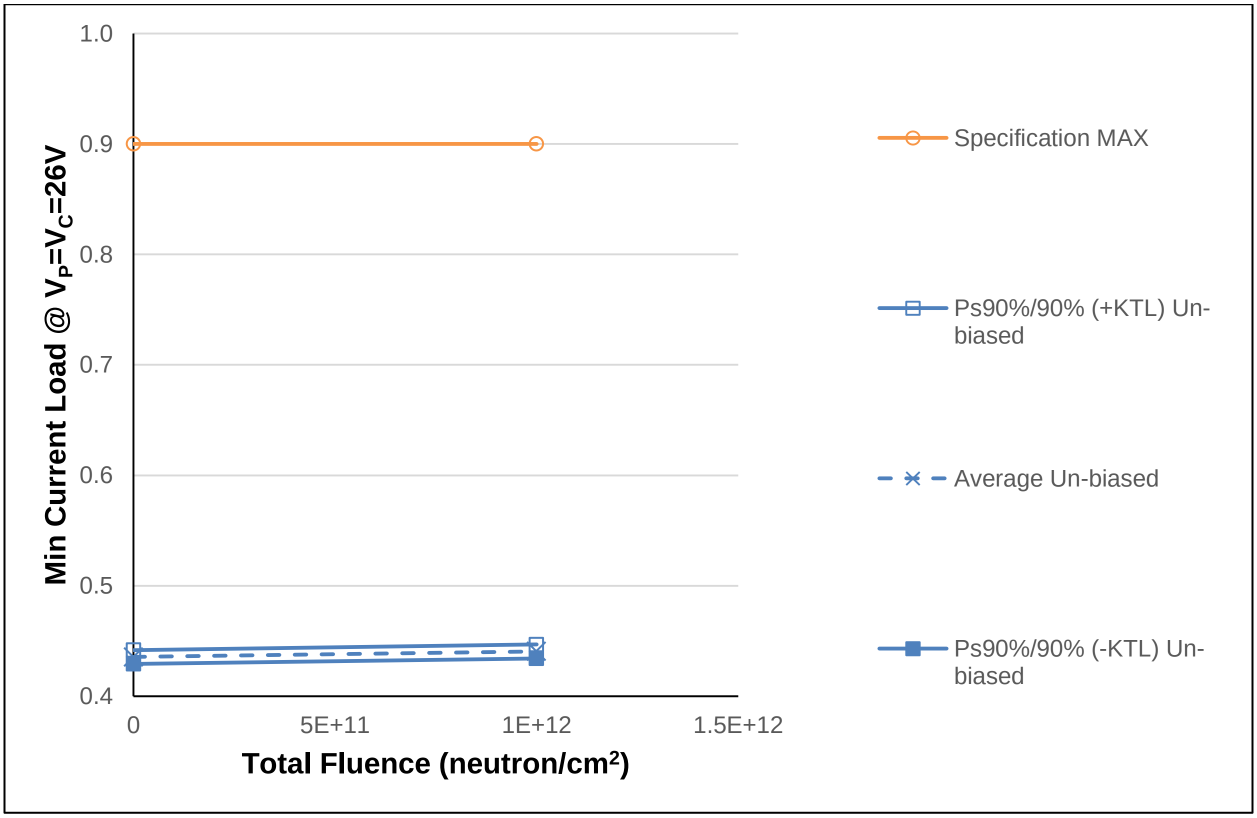

Figure 5.8: Plot of Minimum Load Current with V_{IN} = $V_{CONTROL}$ = 26V versus Total Fluence

Table 5.8: Raw data table for Minimum Load Current of pre- and post-irradiation (1E12 N/cm^2)

Parameter	Min Current Load @VP=V_C=26V	Total Fluence (neutron/cm^2)	
Units	(mA)	0	1.E+12
1	Un-biased Irradiation	0.4372	0.4410
2	Un-biased Irradiation	0.4380	0.4430
3	Un-biased Irradiation	0.4345	0.4400
4	Un-biased Irradiation	0.4323	0.4370
5	Un-biased Irradiation	0.4359	0.4420
11	Control Unit	0.4515	0.4545
12	Control Unit	0.4359	0.4405
	Un-biased Irradiation Statistics		
	Average Un-biased	0.4356	0.4406
	Std Dev Un-biased	0.0023	0.0023
	Ps90%/90% (+KTL) Un-biased	0.4418	0.4469
	Ps90%/90% (-KTL) Un-biased	0.4293	0.4343
	Specification MIN		
	Status (Measurements)		
	Specification MAX	0.90	0.90
	Status (Measurements)	PASS	PASS
	Status (-KTL) Un-biased		
	Status (+KTL) Un-biased	PASS	PASS

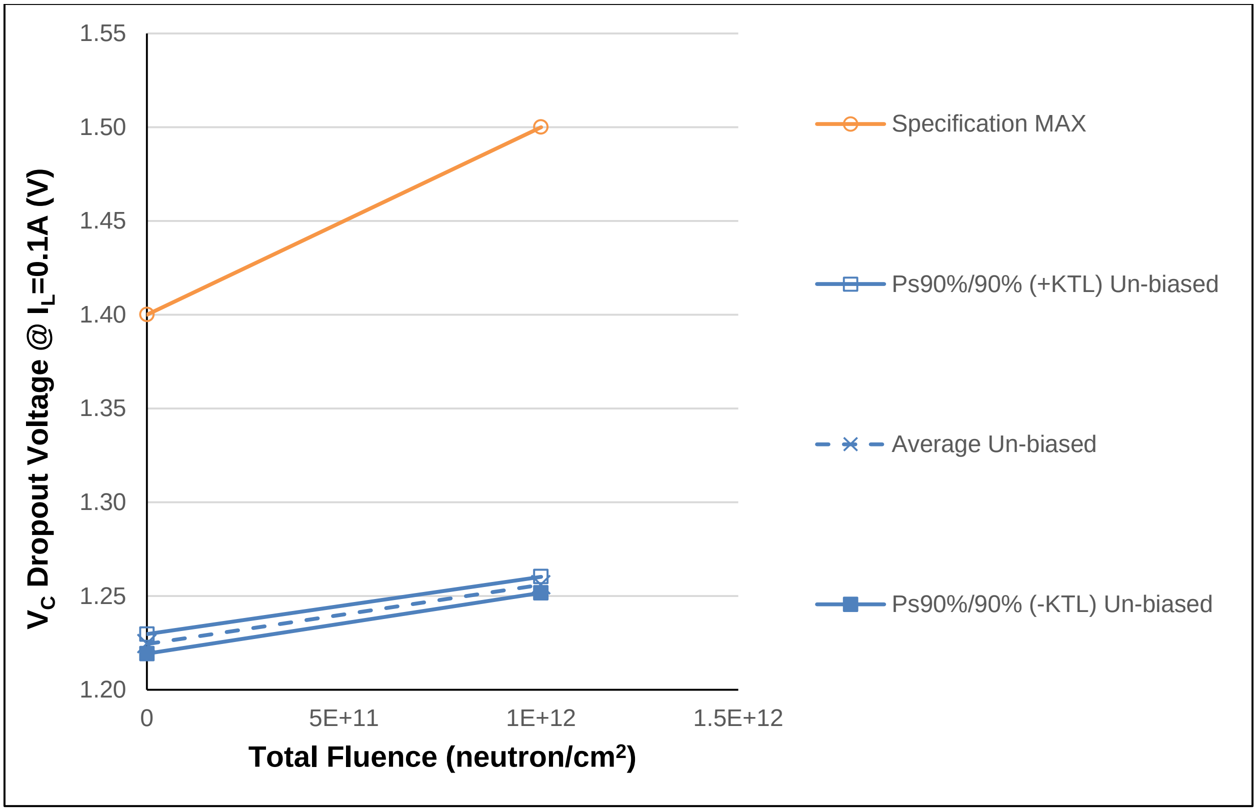

Figure 5.9: Plot of V_C Dropout Voltage (@V_{IN}=1V, I_{LOAD}= 0.1A) versus Total Fluence

The measured parameters are well under the specification maximum limit.

Table 5.9: Raw data table for Dropout Voltage Control of pre- and post-irradiation (1E12 N/cm^2)

Parameter	V_C Dropout Voltage @ I_L = 0.1A	Total Fluence (neutron/cm^2)	
Units	(V)	0	1.E+12
1	Un-biased Irradiation	1.2262	1.2558
2	Un-biased Irradiation	1.2254	1.2552
3	Un-biased Irradiation	1.2233	1.2543
4	Un-biased Irradiation	1.2257	1.2560
5	Un-biased Irradiation	1.2217	1.2585
11	Control Unit	1.2541	1.2483
12	Control Unit	1.2257	1.2088
	Un-biased Irradiation Statistics		
	Average Un-biased	1.2244	1.2560
	Std Dev Un-biased	0.0019	0.0016
	Ps90%/90% (+KTL) Un-biased	1.2297	1.2603
	Ps90%/90% (-KTL) Un-biased	1.2192	1.2517
	Specification MIN		
	Status (Measurements)		
	Specification MAX	1.40	1.50
	Status (Measurements)	PASS	PASS
	Status (-KTL) Un-biased		
	Status (+KTL) Un-biased	PASS	PASS

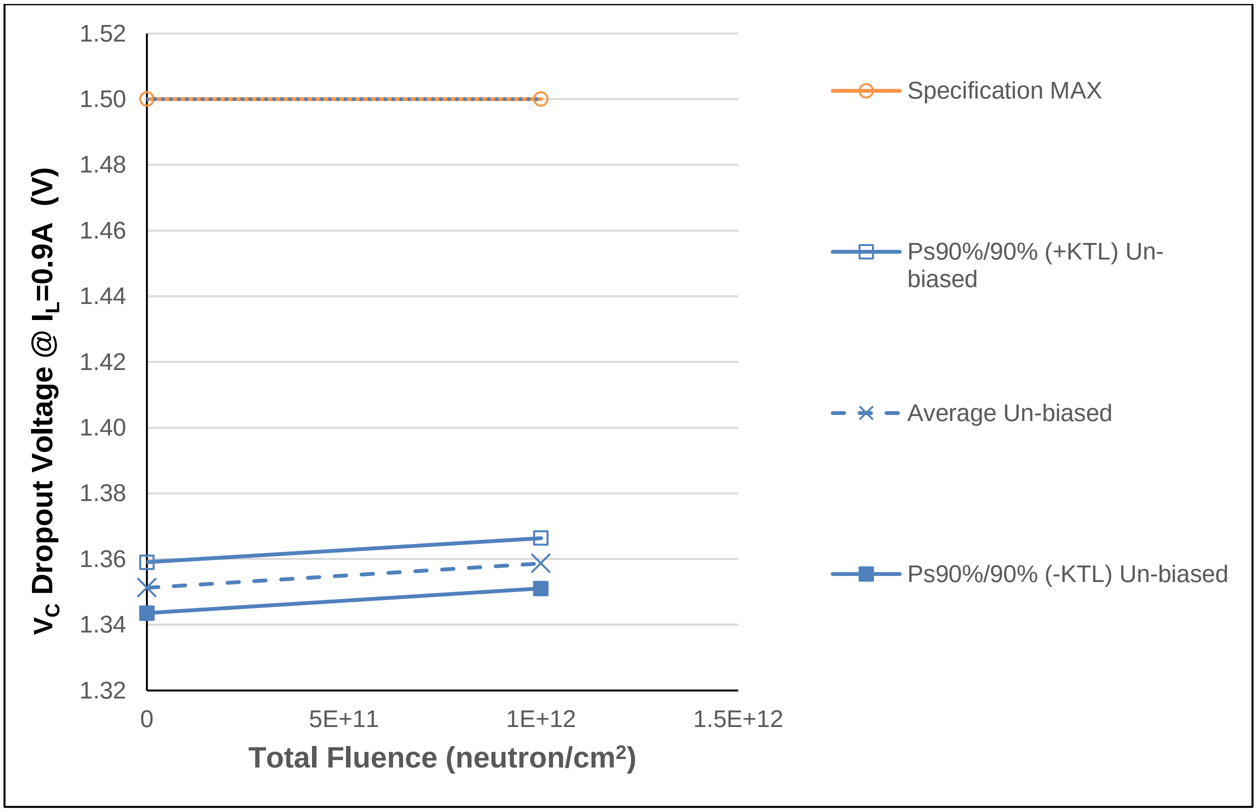

Figure 5.10: Plot of V_C Dropout Voltage (@ V_{IN} = 1V, I_{LOAD} = 0.9A) versus Total Fluence

Table 5.10: Raw data table for Dropout Voltage Control of pre- and post-irradiation (1E12 N/cm^2)

Parameter	V_C Dropout Volrage @ IL=.9A	Total Fluence (neutron/cm^2)	
Units		0	1.E+12
1	Un-biased Irradiation	1.3512	1.3591
2	Un-biased Irradiation	1.3504	1.3586
3	Un-biased Irradiation	1.3482	1.3550
4	Un-biased Irradiation	1.3506	1.3579
5	Un-biased Irradiation	1.3559	1.3628
11	Control Unit	1.3809	1.3741
12	Control Unit	1.3508	1.3395
	Un-biased Irradiation Statistics		
	Average Un-biased	1.3513	1.3587
	Std Dev Un-biased	0.0028	0.0028
	Ps90%/90% (+KTL) Un-biased	1.3590	1.3664
	Ps90%/90% (-KTL) Un-biased	1.3435	1.3510
	Specification MIN		
	Status (Measurements)		
	Specification MAX	1.50	1.50
	Status (Measurements)	PASS	PASS
	Status (-KTL) Un-biased		
	Status (+KTL) Un-biased	PASS	PASS

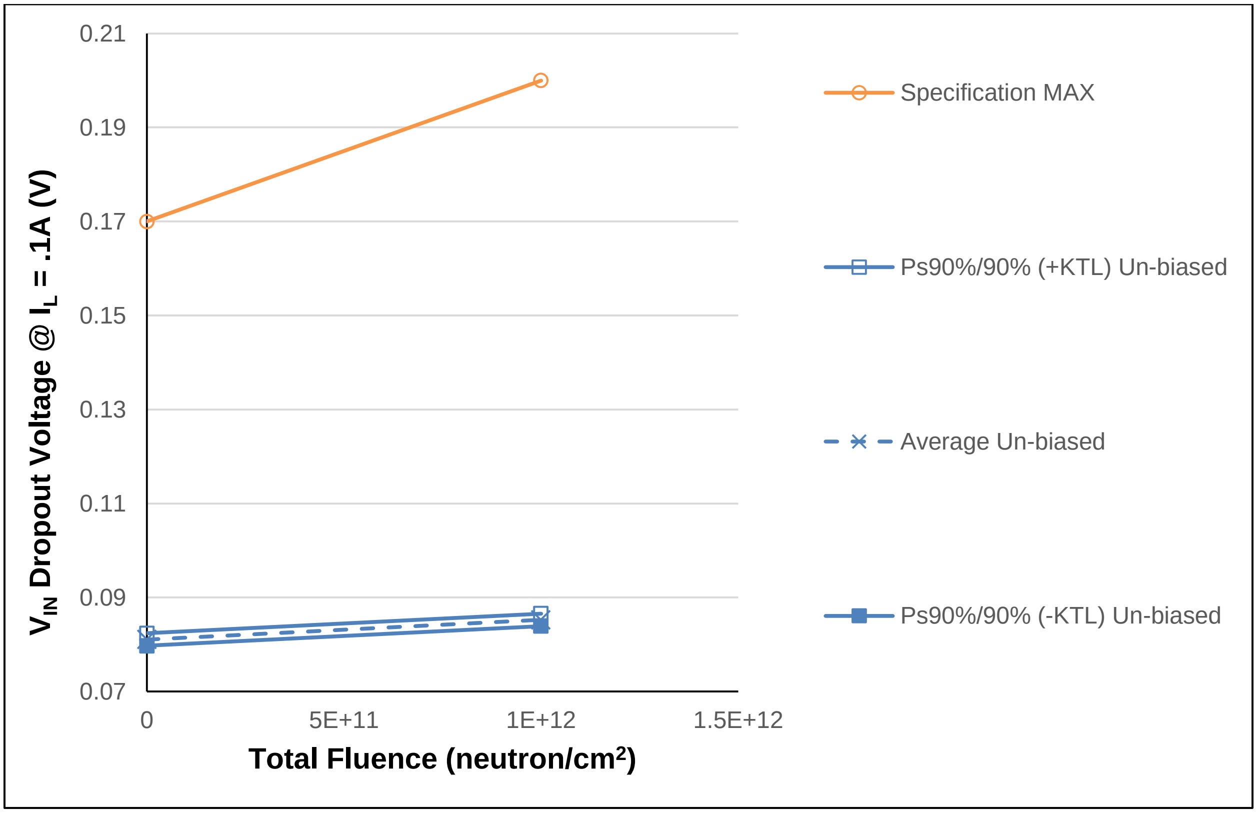

Figure 5.11: Plot of V_{IN} Dropout Voltage (@ $V_{CONTROL}$ = 2V I_{LOAD} = 0.1A) versus Total Fluence

Table 5.11: Raw data table for V_{IN} Dropout Voltage of pre- and post-irradiation (1E12 N/cm^2)

Parameter	V_{IN} Dropout Voltage @ IL=.1A	Total Fluence (neutron/cm^2)	
Units	(V)	0	1.E+12
1	Un-biased Irradiation	0.0807	0.0854
2	Un-biased Irradiation	0.0811	0.0855
3	Un-biased Irradiation	0.0811	0.0853
4	Un-biased Irradiation	0.0818	0.0856
5	Un-biased Irradiation	0.0805	0.0844
11	Control Unit	0.0809	0.0809
12	Control Unit	0.0807	0.0808
	Un-biased Irradiation Statistics		
	Average Un-biased	0.0810	0.0852
	Std Dev Un-biased	0.0005	0.0005
	Ps90%/90% (+KTL) Un-biased	0.0824	0.0866
	Ps90%/90% (-KTL) Un-biased	0.0797	0.0839
	Specification MIN		
	Status (Measurements)		
	Specification MAX	0.17	0.20
	Status (Measurements)	PASS	PASS
	Status (-KTL) Un-biased		
	Status (+KTL) Un-biased	PASS	PASS

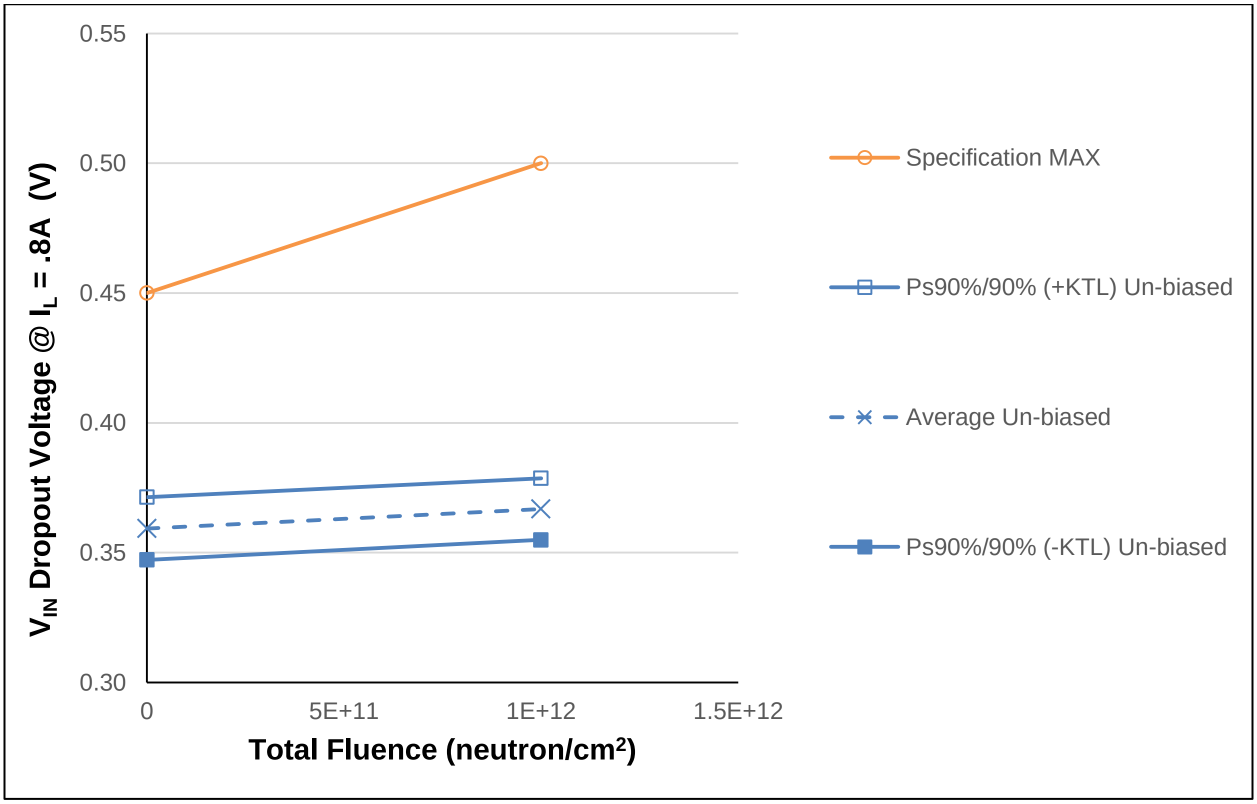

Figure 5.12: Plot of V_{IN} Dropout Voltage (@ $V_{CONTROL}$ = 2V I_{LOAD} = 0.8A) versus Total Fluence

Table 5.12: Raw data table for V_{IN} Dropout Voltage of pre- and post-irradiation (1E12 N/cm^2)

Parameter	V_{IN} Dropout Voltage @ I_L =.8A	Total Fluence (neutron/cm^2)	
Units	(V)	0	1.E+12
1	Un-biased Irradiation	0.3586	0.3670
2	Un-biased Irradiation	0.3633	0.3710
3	Un-biased Irradiation	0.3579	0.3660
4	Un-biased Irradiation	0.3637	0.3700
5	Un-biased Irradiation	0.3530	0.3600
11	Control Unit	0.3554	0.3572
12	Control Unit	0.3583	0.3624
	Un-biased Irradiation Statistics		
	Average Un-biased	0.3593	0.3668
	Std Dev Un-biased	0.0044	0.0043
	Ps90%/90% (+KTL) Un-biased	0.3714	0.3787
	Ps90%/90% (-KTL) Un-biased	0.3472	0.3549
	Specification MIN		
	Status (Measurements)		
	Specification MAX	0.45	0.50
	Status (Measurements)	PASS	PASS
	Status (-KTL) Un-biased		
	Status (+KTL) Un-biased	PASS	PASS

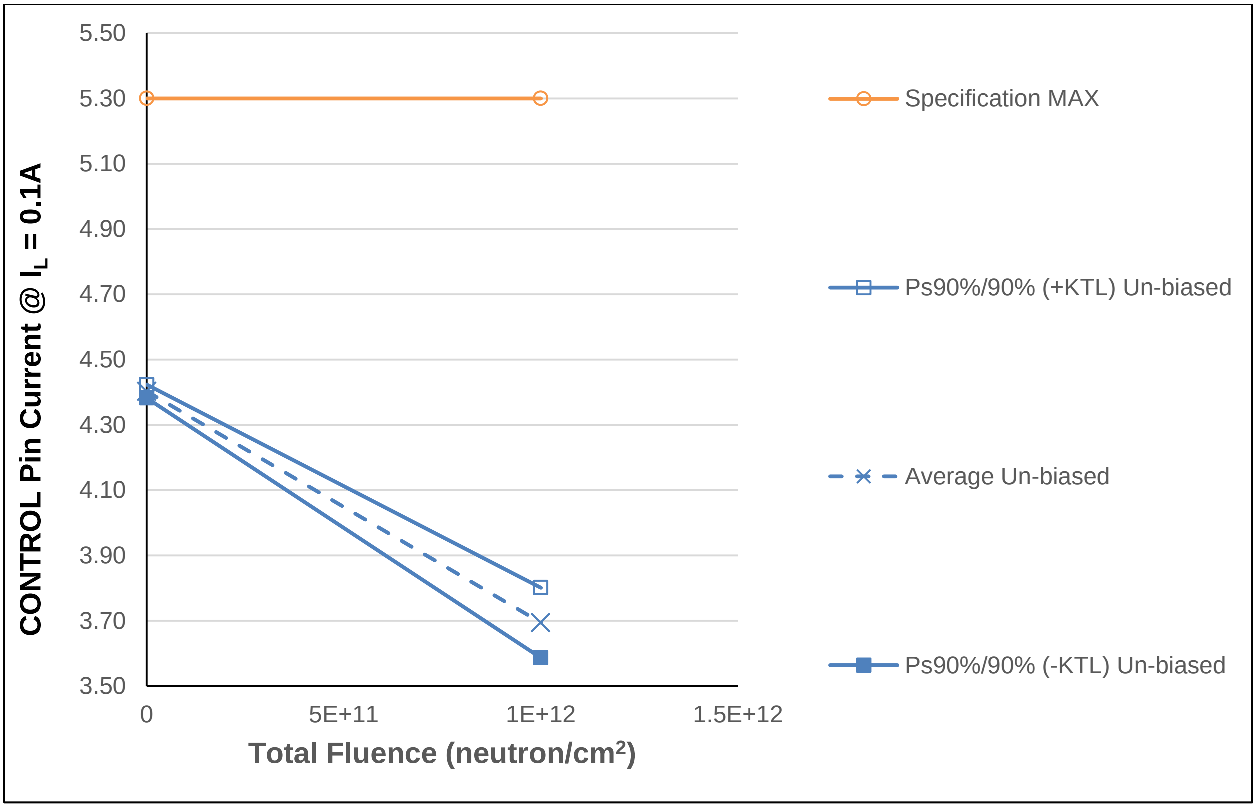

Figure 5.13: Plot of CONTROL Pin Current (@ I_{LOAD} = 0.1A) versus Total Fluence

Table 5.13: Raw data table for CONTROL Pin Current of pre- and post-irradiation (1E12 N/cm^2)

Parameter	CONTROL Pin Current @I_L=.1A	Total Fluence (neutron/cm^2)	
Units	(mA)	0	1.E+12
1	Un-biased Irradiation	4.4008	3.6500
2	Un-biased Irradiation	4.4095	3.6700
3	Un-biased Irradiation	4.3936	3.6800
4	Un-biased Irradiation	4.3986	3.7400
5	Un-biased Irradiation	4.4111	3.7300
11	Control Unit	4.3883	4.3763
12	Control Unit	4.4111	4.3906
	Un-biased Irradiation Statistics		
	Average Un-biased	4.4027	3.6940
	Std Dev Un-biased	0.0074	0.0391
	Ps90%/90% (+KTL) Un-biased	4.4231	3.8013
	Ps90%/90% (-KTL) Un-biased	4.3824	3.5867
	Specification MIN		
	Status (Measurements)		
	Specification MAX	5.30	5.30
	Status (Measurements)	PASS	PASS
	Status (-KTL) Un-biased		
	Status (+KTL) Un-biased	PASS	PASS

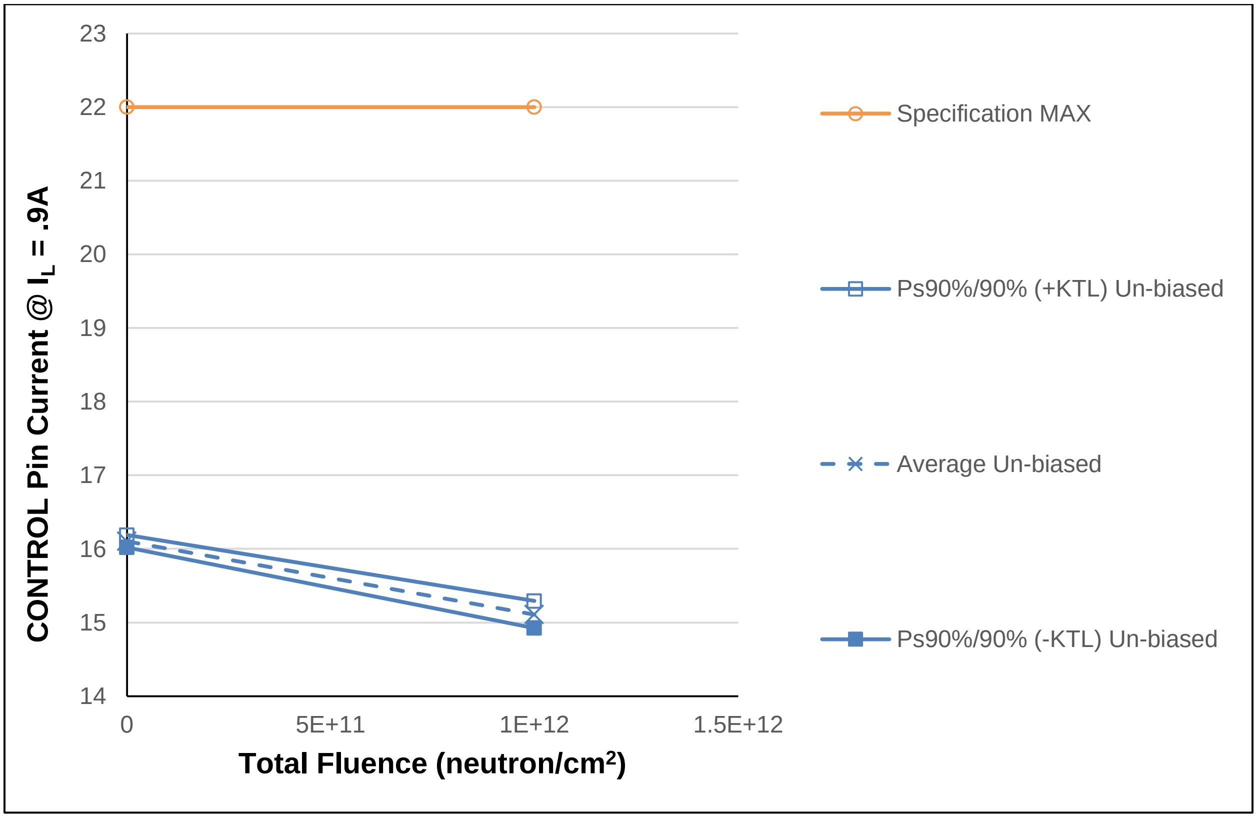

Figure 5.14: Plot of CONTROL Pin Current (@ I_{LOAD} = 0.9A) versus Total Fluence

Table 5.14: Raw data table for $V_{CONTROL}$ Pin Current of pre- and post-irradiation (1E12 N/cm^2)

Parameter	CONTROL Pin Current @I_L=.9A	Total Fluence (neutron/cm^2)	
Units	(mA)	0	1.E+12
1	Un-biased Irradiation	16.0540	15.0400
2	Un-biased Irradiation	16.1292	15.0900
3	Un-biased Irradiation	16.0952	15.0550
4	Un-biased Irradiation	16.1126	15.1790
5	Un-biased Irradiation	16.1254	15.1795
11	Control Unit	15.9669	15.7206
12	Control Unit	16.1560	15.7566
	Un-biased Irradiation Statistics		
	Average Un-biased	16.1033	15.1087
	Std Dev Un-biased	0.0306	0.0669
	Ps90%/90% (+KTL) Un-biased	16.1872	15.2922
	Ps90%/90% (-KTL) Un-biased	16.0194	14.9252
	Specification MIN		
	Status (Measurements)		
	Specification MAX	22	22
	Status (Measurements)	PASS	PASS
	Status (-KTL) Un-biased		
	Status (+KTL) Un-biased	PASS	PASS

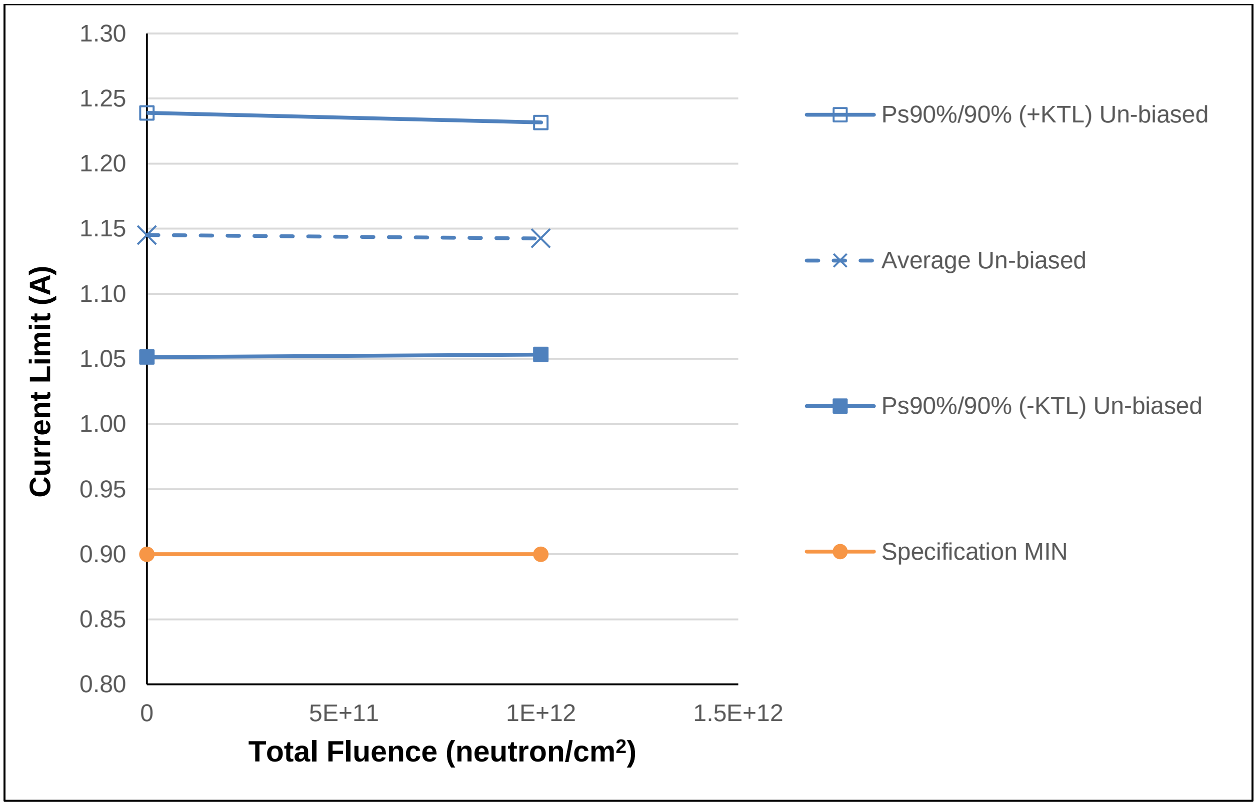

Figure 5.15: Plot of Current Limit versus Total Fluence

Table 5.15: Raw data table for Current Limit of pre- and post-irradiation (1E12 N/cm^2)

Parameter	Current Limit	Total Fluence (neutron/cm^2)	
Units	(A)	0	1.E+12
1	Un-biased Irradiation	1.1250	1.1238
2	Un-biased Irradiation	1.1387	1.1356
3	Un-biased Irradiation	1.1265	1.1246
4	Un-biased Irradiation	1.1299	1.1285
5	Un-biased Irradiation	1.2056	1.2000
11	Control Unit	1.1142	1.1113
12	Control Unit	1.1270	1.1222
	Un-biased Irradiation Statistics		
	Average Un-biased	1.1451	1.1425
	Std Dev Un-biased	0.0342	0.0325
	Ps90%/90% (+KTL) Un-biased	1.2389	1.2316
	Ps90%/90% (-KTL) Un-biased	1.0513	1.0534
	Specification MIN	0.90	0.90
	Status (Measurements)	PASS	PASS
	Specification MAX		
	Status (Measurements)		
	Status (-KTL) Un-biased	PASS	PASS
	Status (+KTL) Un-biased		

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 / Bias
1	NC	Float
2	SET	Float
3	$V_{CONTROL}$	Float
4	IN	Float
5	OUT = CASE	Float

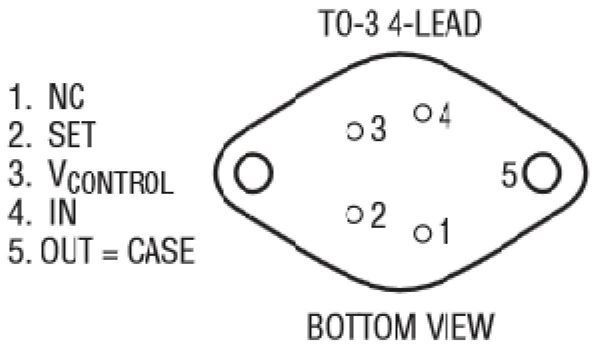

Figure B1: Pin-Out

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 Regan
Reactor Engineer

Appendix D

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

PARAMETER	CONDITIONS	$T_A = 25°C$ MIN	$T_A = 25°C$ MAX	SUB-GROUP	$-55°C < T_A < 125°C$ MIN	$-55°C < T_A < 125°C$ MAX	SUB-GROUP	UNITS
SET Pin Current (Note 6)	$V_{IN} = 1V$, $V_{CONTROL} = 2V$, $I_{LOAD} = 1mA$	9.9	10.1	1	9.8	10.2	2, 3	μA
Output Offset Voltage ($V_{OUT} - V_{SET}$)	$V_{IN} = 1V$, $V_{CONTROL} = 2V$, $I_{LOAD} = 1mA$	–5	5	1	–6	6	2, 3	mV
Load Regulation, I_{SET}	I_{LOAD} = 1mA to 0.9A	–15	15	1	–30	30	2, 3	nA
Load Regulation, V_{OS}	I_{LOAD} = 1mA to 0.9A	–1.0	1.0	1	–1.5	1.5	2, 3	mV
Line Regulation, I_{SET} (Note 11)	V_{IN} = 1V to 26V, $V_{CONTROL}$ = 2V to 26V, I_{LOAD} = 1mA	–0.45	0.45	1	–0.6	0.6	2, 3	nA/V
Line Regulation, V_{OS} (Note 11)	V_{IN} = 1V to 26V, $V_{CONTROL}$ = 2V to 26V, I_{LOAD} = 1mA	–0.05	0.05	1	–0.06	0.06	2, 3	mV/V
Minimum Load Current (Notes 3, 11)	$V_{IN} = 10V$, $V_{CONTROL} = 10V$ $V_{IN} = 26V$, $V_{CONTROL} = 26V$		0.4 0.9	1 1		0.6 1	2, 3 2, 3	mA mA
$V_{CONTROL}$ Dropout Voltage (Note 4)	$V_{IN} = 1V$, $I_{LOAD} = 0.1A$ $V_{IN} = 1V$, $I_{LOAD} = 0.5A$ $V_{IN} = 1V$, $I_{LOAD} = 0.9A$		1.4 1.5 1.5	1 1 1		1.5 1.7	2, 3 2, 3 2, 3	V V V
V_{IN} Dropout Voltage (Note 4)	$V_{CONTROL} = 2V$, $I_{LOAD} = 0.1A$ $V_{CONTROL} = 2V$, $I_{LOAD} = 0.5A$ $V_{CONTROL} = 2V$, $I_{LOAD} = 0.8A$		0.17 0.27 0.45	1 1 1		0.2 0.6	2, 3 2, 3 2, 3	V V V
$V_{CONTROL}$ Pin Current (Note 5)	$V_{IN} = 1V$, $V_{CONTROL} = 2V$, $I_{LOAD} = 0.1A$ $V_{IN} = 1V$, $V_{CONTROL} = 2V$, $I_{LOAD} = 0.9A$		5.3 22	1 1		6.3 30	2, 3 2, 3	mA mA
Current Limit	$V_{IN} = 5V$, $V_{CONTROL} = 5V$, $V_{SET} = 0V$, $V_{OUT} = -0.1V$	0.9		1	0.9		2, 3	A
Error Amplifier RMS Output Noise (Note 7)	$I_{LOAD} = 0.9A$, $10Hz \le f \le 100kHz$, $C_{OUT} = 10μF$, $C_{SET} = 0.1μF$	TYP = 40		1				$μV_{RMS}$
Reference Current RMS Output Noise (Note 7)	$10Hz \le f \le 100kHz$	TYP = 1		1				nA_{RMS}

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

PARAMETER	CONDITIONS	10KRads(Si) MIN	10KRads(Si) MAX	20KRads(Si) MIN	20KRads(Si) MAX	50KRads(Si) MIN	50KRads(Si) MAX	100KRads(Si) MIN	100KRads(Si) MAX	200KRads(Si) MIN	200KRads(Si) MAX	UNITS
SET Pin Current (Note 6)	V_{IN} = 1V, $V_{CONTROL}$ = 2V, I_{LOAD} = 1mA	9.8	10.2	9.8	10.2	9.8	10.3	9.8	10.4	9.8	10.5	µA
Output Offset Voltage (V_{OUT} – V_{SET})	V_{IN} = 1V, $V_{CONTROL}$ = 2V, I_{LOAD} = 1mA	–8	8	–8	8	–8	8	–9	9	–10	10	mV
Load Regulation, I_{SET}	I_{LOAD} = 1mA to 0.9A	–15	15	–15	15	–25	25	–25	25	–25	25	nA
Load Regulation, V_{OS}	I_{LOAD} = 1mA to 0.9A	–1.25	1.25	–1.3	1.3	–1.35	1.35	–1.4	1.4	–1.5	1.5	mV
Line Regulation, I_{SET}	V_{IN} = 1V to 26V, $V_{CONTROL}$ = 2V to 26V, I_{LOAD} = 1mA	–0.8	0.8	–0.8	0.8	–0.9	0.9	–0.9	0.9	–1	1	nA/V
Line Regulation, V_{OS}	V_{IN} = 1V to 26V, $V_{CONTROL}$ = 2V to 26V, I_{LOAD} = 1mA	–0.06	0.06	–0.08	0.08	–0.1	0.1	–0.15	0.15	–0.2	0.2	mV/V
Minimum Load Current (Note 3)	V_{IN} = 10V, $V_{CONTROL}$ = 10V V_{IN} = 26V, $V_{CONTROL}$ = 26V		0.4 0.9		0.4 0.9		0.4 0.9		0.4 0.9		0.4 0.9	mA mA
$V_{CONTROL}$ Dropout Voltage (Note 4)	V_{IN} = 1V, I_{LOAD} = 0.1A V_{IN} = 1V, I_{LOAD} = 0.9A		1.5 1.5		1.5 1.5		1.55 1.55		1.6 1.6		1.65 1.65	V V
V_{IN} Dropout Voltage (Note 4)	$V_{CONTROL}$ = 2V, I_{LOAD} = 0.1A $V_{CONTROL}$ = 2V, I_{LOAD} = 0.8A		0.2 0.5		0.21 0.51		0.23 0.53		0.25 0.55		0.3 0.6	V V
CONTROL Pin Current (Note 5)	V_{IN} = 1V, $V_{CONTROL}$ = 2V, I_{LOAD} = 0.1A V_{IN} = 1V, $V_{CONTROL}$ = 2V, I_{LOAD} = 0.9A		5.3 22		5.3 22		5.3 22		5.3 22		5.3 22	mA mA
Current Limit	V_{IN} = 5V, $V_{CONTROL}$ = 5V, V_{SET} = 0V, V_{OUT} = –0.1V	0.9		0.9		0.9		0.9		0.9		A
Error Amplifier RMS Output Noise (Note 7)	I_{LOAD} = 0.9A, 10Hz ≤ f ≤100kHz, C_{OUT} = 10µF, C_{SET} = 0.1µF	TYP = 40		TYP = 40		TYP = 40		TYP = 40		TYP = 40		μV_{RMS}
Reference Current RMS Output Noise (Note 7)	10Hz ≤ f ≤100kHz	TYP = 1		TYP = 1		TYP = 1		TYP = 1		TYP = 1		nA_{RMS}

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: Unless otherwise specified, all voltages are with respect to V_{OUT}. The RH3080MK DICE is tested and specified under pulse load conditions such that $T_J \approx T_A$.

Note 3: Minimum load current is equivalent to the quiescent current of the part. Since all quiescent and drive current is delivered to the output of the part, the minimum load current is the minimum current required to maintain regulation.

Note 4: Dropout results from either of minimum control voltage, $V_{CONTROL}$, or minimum input voltage, V_{IN}, both specified with respect to V_{OUT}. These specifications represent the minimum input-to-output differential voltage required to maintain regulation.

Note 5: The $V_{CONTROL}$ pin current is the drive current required for the output transistor. This current tracks output current with roughly a 1:60 ratio. The minimum value is equal to the quiescent current of the device.

Note 6: SET pin is clamped to the output with diodes. These devices only carry current under transient overloads.

Note 7: Adding a small capacitor across the reference current resistor lowers output noise. Adding this capacitor bypasses the resistor shot noise and reference current noise; output noise is then equal to error amplifier noise (see LT3080 data sheet and Application Note AN83).

Note 8: Dice are probe tested at 25°C to the limits shown in Table 1. Except for high current tests, dice are tested under low current conditions which assure full load current specifications when assembled.

Note 9: Dice that are not qualified by Linear Technology with a can sample are guaranteed to meet specifications of Table 1 only. Dice qualified by Linear Technology with a can sample meet specifications in all tables.

Note 10: This IC includes overtemperature protection that is intended to protect the device during momentary overload conditions. Junction temperature exceeds the maximum operating junction temperature when overtemperature protection is active. Continuous operation above the specified maximum operating junction temperature may impair device reliability.

Note 11: Current limit may decrease to zero at input-to-output differential voltages (V_{IN} – V_{OUT}) greater than 26V. Operation at voltages for both IN and $V_{CONTROL}$ is allowed up to a maximum of 36V as long as the difference between input and output voltage is below the specified differential (V_{IN} – V_{OUT}) voltage. Line and load regulation specifications are not applicable when the device is in current limit.

Note 12: Please refer to LT3080 standard product data sheet for Typical Performance Characteristics, Pin Functions, Applications Information and Typical Applications.