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IRUH3301

Neutron Test Report

October 2010

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INTRODUCTION

This test report covers the neutron fluence tests performed on the IRUH3301 Low Dropout linear regulator in a hermetic package. Since all part numbers within the IRUH3301 product line contain the same active components, performance under radiation will be the same. The neutron fluence test was performed to determine the effects displacement damage had on the device performance. On October 13, 2010, International Rectifier characterized this device for neutron hardness at the University of Massachusetts, Nuclear Research Facility using their Fast Neutron Irradiator.

SUMMARY OF RESULTS

All of the test samples passed the post radiation test requirements for fluence levels of 1E11 and 1E12 n/cm^2. The results do show degradation in the device's Dropout Voltage and Over-current Latch-up characteristics after exposure to neutron irradiation levels above 1E12 n/cm^2 but the devices are still functional at this level up to 1E13 n/cm^2.

TEST METHOD

The test method used in the development of the Test Plan was MIL-PRF-883, method 1017 Neutron Irradiation. This method established the basic requirements for the performance and execution of the tests.

TEST PLAN

The samples were exposed to neutron irradiation in an un-biased state with the device leads open enclosed in an ESD conductive bag. Post radiation testing of the devices occurred after the decay of radioactivity of the devices reached an acceptable safe level determined by the facilities personnel. The rate of decay was dependent on the amount of exposure to neutrons and the package materials. The devices were contained in a 20 +/- 10C environment to minimize the effects due to annealing. The devices were tested on October 13, 2010 for post exposure affects.

Serial numbers: 2, 3, 4, 6, 7, 8, 9, 10, 12, 13
Control Sample: 14, 15

The Radiation Test Specification is included in Appendix B. The testing occurred in the following manner:

1.0 Purpose

The purpose of this test is to characterize and establish Neutron effects for International Rectifier's hybrid low dropout regulator devices. The data resulting from the tests may be incorporated in the IR data sheet for the product.

2.0 Test Responsibility

International Rectifier shall be responsible for conducting the tests, which shall be performed at the University of Massachusetts Research Reactor facility. International Rectifier shall be responsible for the final Test Report.

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3.0 Test Facility

3.1 Nuclear Reactor

The University of Massachusetts Research Reactor shall be used to provide the necessary Neutron beam and energy. University of Massachusetts Research Reactor (UMRR) shall provide adequate dosimetry for verification of the neutron beam parameters.

3.2 Test Equipment

The necessary test equipment including interface board, cables, power supplies, measurement system, etc. shall be provided by International Rectifier.

3.3 Sample Size

Sample size shall be determined based on device type, characterization parameters. The sample size for this test is 10 devices and 2 devices for control samples.

4.0 Test Device

4.0 The following device is planned for Neutron characterization:

a. IRUH3301A2BK

4.1 All devices shall be subjected to 240hrs of burn-in and verified for correct electrical performance prior to arrival at UMRR.

4.2 The device leads will be left open during this test and all parts shall be contained inside a conductive ESD bag during irradiation.

5.0 Test Method

MIL-STD-883, Method 1017 shall be used to establish procedure for all testing described herein with the exception of the sample size.

6.0 Neutron Source

The nuclear reactor at Lowell, Mass is capable of providing fast neutron flux level $\geq 10^{11}$ n/cm^2 – s with relatively low thermal fluence and gamma irradiation. The Fast Neutron Irradiator (FNI) offers near uniform spectrum over a large cross-sectional area (12 x 12 x 6). The dosimetry system used to verify the radiation exposure was P-32, ASTM E-265.

7.0 Record Keeping

The Reactor facility shall provide dosimetry data for the FNI. IR will be responsible for collecting and compiling the test data.

8.0 Test Procedure

International Rectifier shall control the following test procedure, based on Test Method 1017. IR's design engineering department shall be responsible for selecting the neutron fluence level the product is exposed to. The facility personnel shall be responsible for loading and moving the device container.
Exposure levels shall be 1E11 n/cm^2, 1E12 n/cm^2, and 1E13 n/cm^2.

Test Procedure - Table 1

Step	Description	Conditions
1	Pre test all devices prior to radiation exposure.	Per T090182G
2	Place all devices in ESD safe bag all device pins are open	
3	Place devices into the shielded container	Unbiased
4	Lower the container into the irradiation chamber	Facilities personnel
5	Expose the devices to pre-determined level	See exposure levels
6	Remove devices at completion of exposure time	Facilities personnel
7	Allow devices to decay to safe level	Facilities personnel
8	Test devices after post irradiation	Per T090182G
9	End test. Read and Record data	

9.0 Test Report

The Test Report shall include the following information.

a. Device type, serial numbers
b. Test dates
c. Facility, source type
d. Fluence
e. Certificate of Exposure
f. Bias conditions
g. Comments and observations
h. Pre and Post Electrical data
i. Summary descriptive including graphs

TEST FACILITY

The University of Massachusetts, Lowell, Nuclear Research Reactor is a 1 Mega-Watt, $Uranium^{235}$ enhanced core reactor. The Fast Neutron Irradiation (FNI) chamber (see Figure 1) is designed to give a fast flux level from 10^{10} to 10^{16} n/cm^2-s with relatively low thermal fluence and gamma dose rates. It is also designed to provide a 1MeV equivalent flux over the effective range.

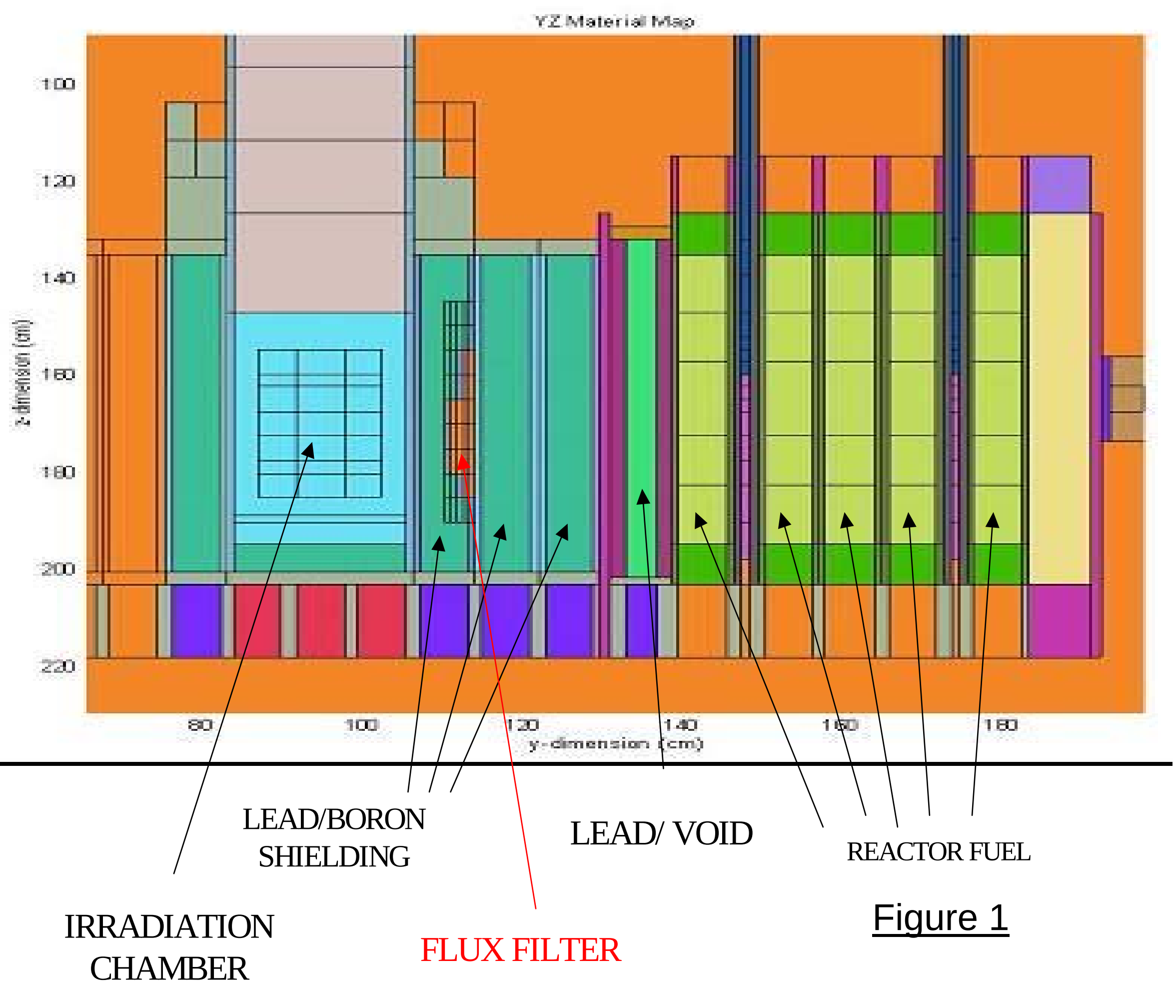

Figure 1

Test Results

The key pre and post radiation test results are shown graphically in Figures 2 thru 7. As outlined in the Test Plan, ten devices were exposed to neutron irradiation at fluence levels of 1E11, 1E12, and 1E13 n/cm^2. The devices were tested after completion of radiation exposure and radioactive decay recovery. The data is displayed in the following graphs with the Average, Minimum, Maximum and Average Control Sample for all the device samples shown. The Control sample results are shown with its own curve on each graph. The radiation exposure had minimal affect on the samples up to a fluence level of 1E12 n/cm^2.

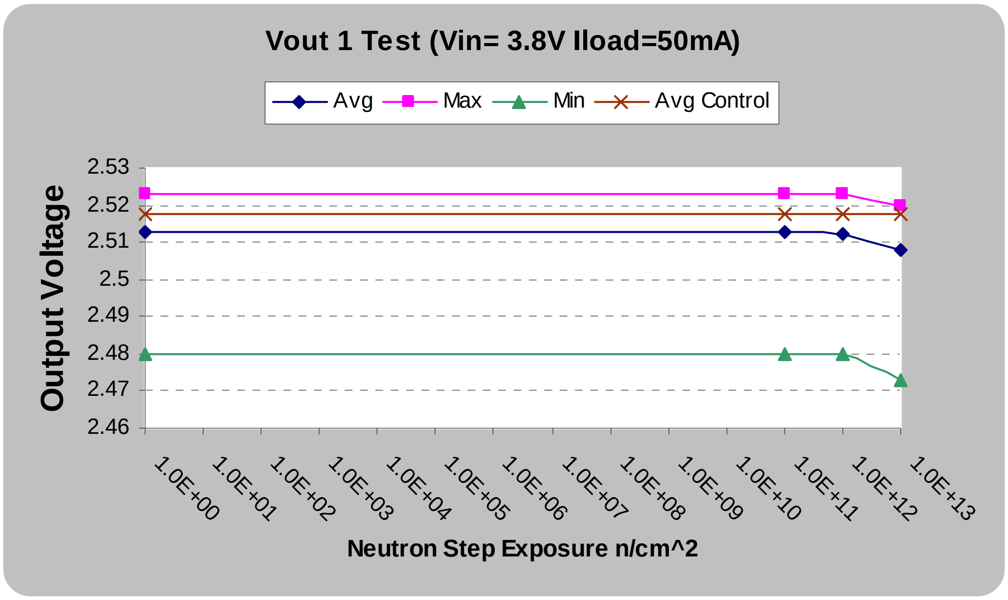

Figure 2

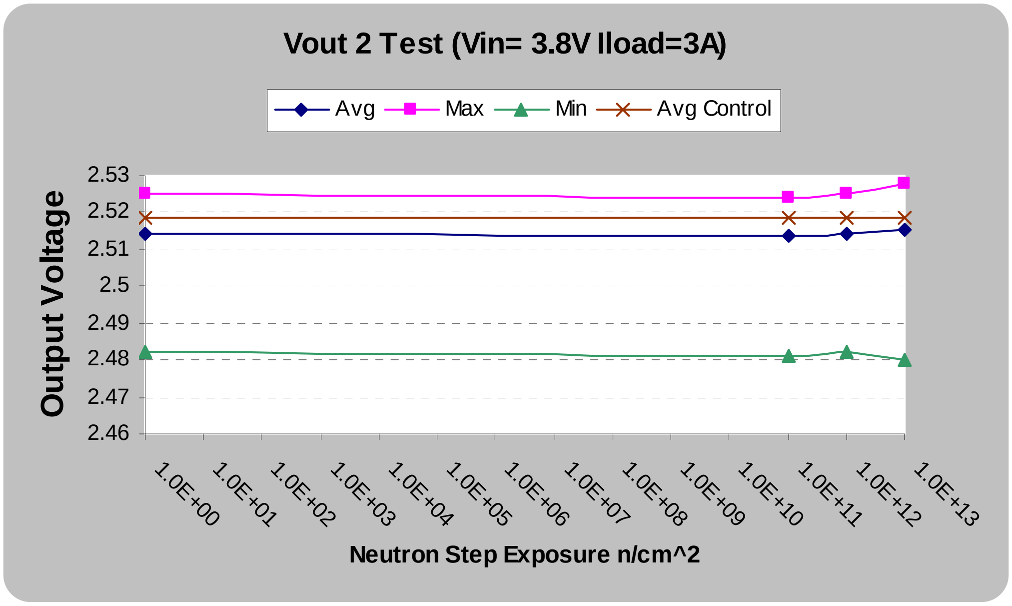

Figure 3

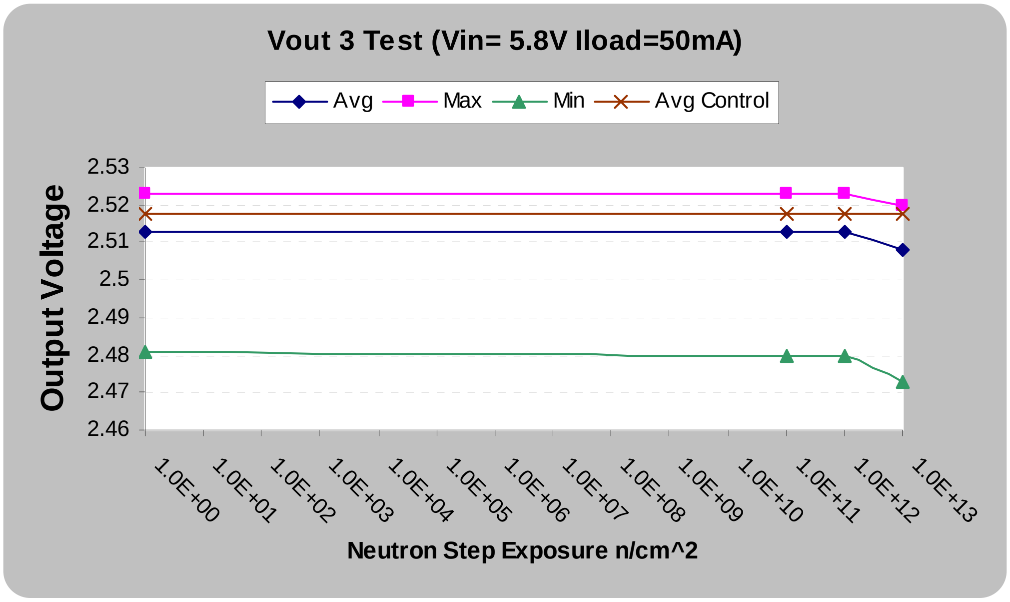

Figure 4

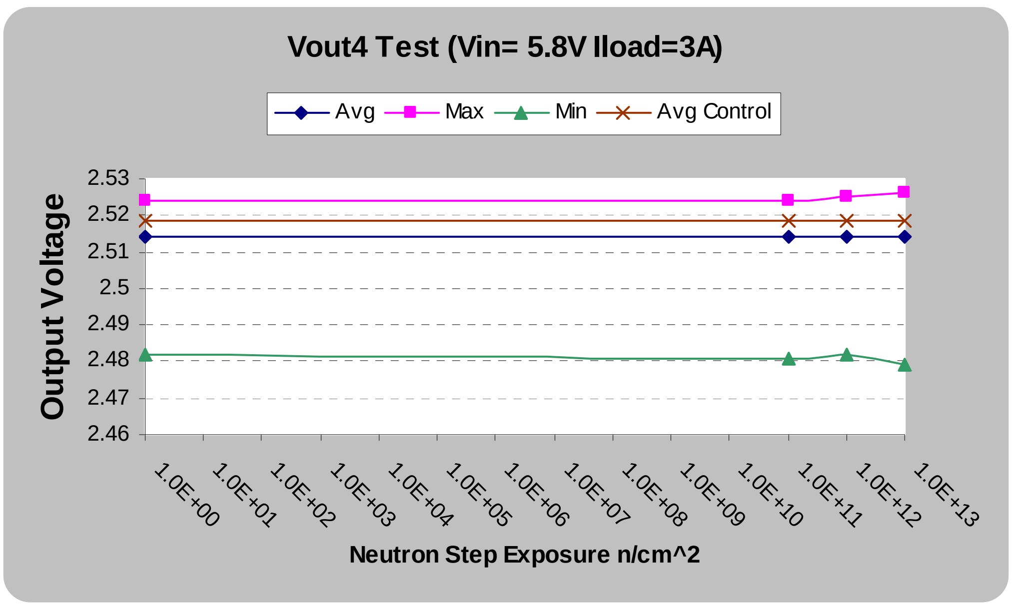

Figure 5

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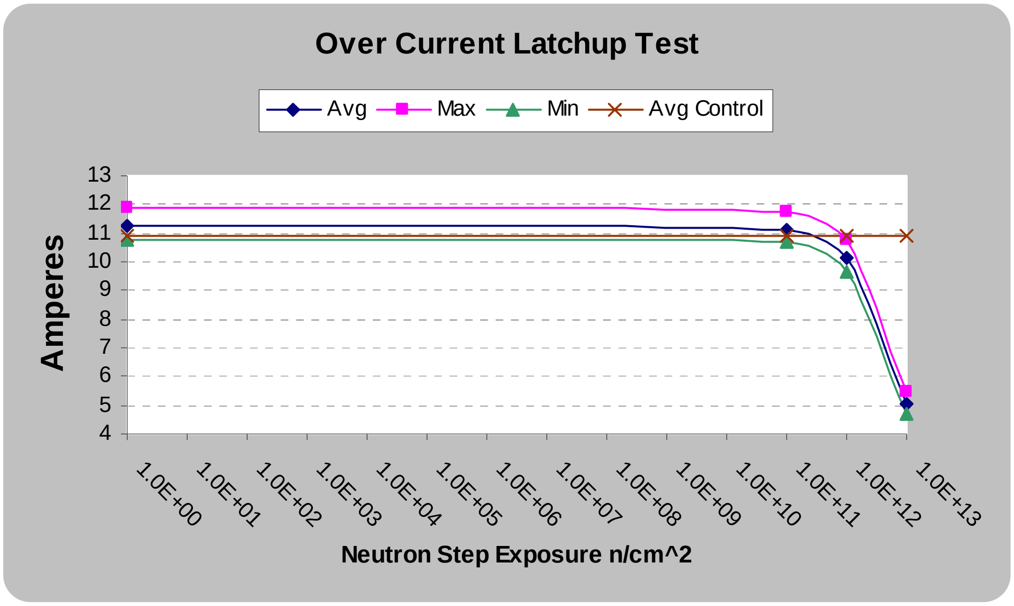

Figure 6

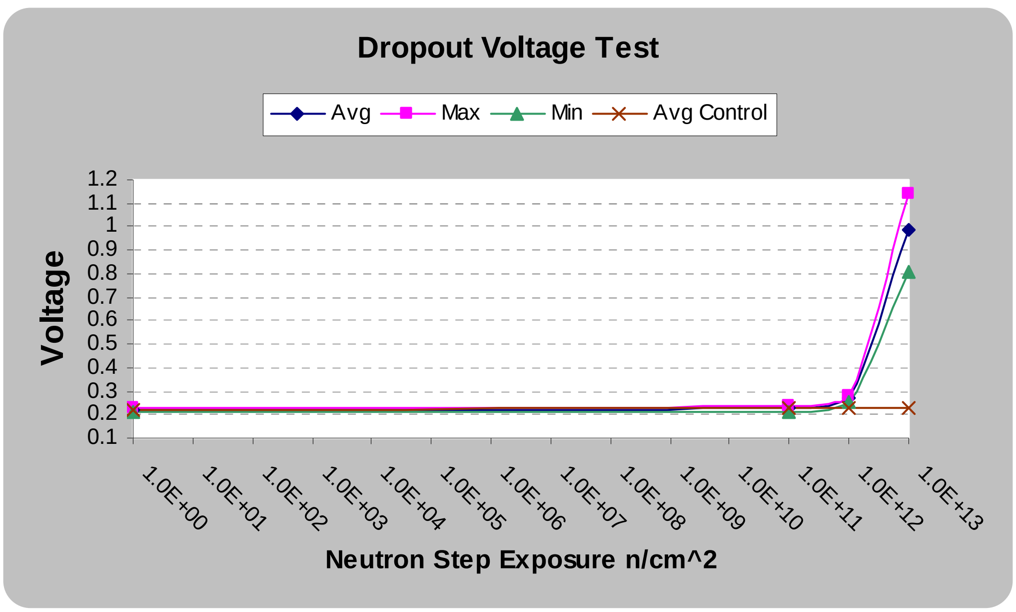

Figure 7

CONCLUSION

The IRHU3301 has demonstrated hardness to neutron radiation exposure to a fluence level of 1E12 n/cm^2. All devices exposed to a fluence level of 1E12 n/cm^2 passed the test limits specified in the Radiation Test Specification in Appendix B. The IRUH3301 part showed degradation on Dropout Voltage and Over Current Latchup tests when exposed to a fluence level of 1E13 n/cm^2, but all other test including the output voltage are well within the test limits.

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Appendix A

Electrical Data

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Electrical Test Data (Pre-radiation)

Rad Level (n/cm2)	Vout (Vin=3.8V,Io =50mA)	Vout (Vin=3.8V,Io =3A)	Vout (Vin=5.8V,Io =50mA)	Vout (Vin=5.8V,Io =3A)	Over Current Latchup	Dropout Voltage	Shutdown Threshold On	Shutdown Threshold Off	Vout @ Shutdown
1	3	4	5	6	7	9	10	11	12
	2.462	2.462	2.462	2.462	3.5	0	0.8	0.8	-100
	2.537	2.537	2.537	2.537	15	0.4	1.2	1.2	100
	V	V	V	V	A	V	V	V	mV
Serial #									
2	2.523	2.524	2.523	2.524	11.39	0.218	1.04	0.96	2.2
3	2.516	2.517	2.516	2.517	11.19	0.215	1.06	0.98	2.2
4	2.523	2.524	2.523	2.524	11.87	0.208	1.04	0.97	2.1
6	2.521	2.522	2.521	2.522	11.6	0.217	1.06	0.98	2.1
7	2.517	2.518	2.517	2.518	11.08	0.218	1.04	0.97	2.1
8	2.522	2.523	2.522	2.524	10.78	0.221	1.04	0.96	2.1
9	2.48	2.482	2.481	2.482	11.2	0.218	1.05	0.98	2.1
10	2.521	2.522	2.521	2.522	11.6	0.224	1.05	0.98	2.1
12	2.523	2.525	2.523	2.524	10.97	0.221	1.05	0.97	2.2
13	2.483	2.484	2.483	2.484	10.79	0.228	1.06	0.99	2.1
14	2.517	2.518	2.517	2.518	10.78	0.227	1.04	0.96	2.2
15	2.518	2.519	2.518	2.519	11.09	0.217	1.05	0.98	2.1

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Electrical Test Data (Post 1e11 n/cm^2 exposure)

Rad Level (n/cm2)	Vout (Vin=3.8V,Io =50mA)	Vout (Vin=3.8V,Io =3A)	Vout (Vin=5.8V,Io =50mA)	Vout (Vin=5.8V,Io =3A)	Over Current Latchup	Dropout Voltage	Shutdown Threshold On	Shutdown Threshold Off	Vout @ Shutdown
1.00E+11	3	4	5	6	7	9	10	11	12
	2.462	2.462	2.462	2.462	3.5	0	0.8	0.8	-100
	2.537	2.537	2.537	2.537	15	0.4	1.2	1.2	100
	V	V	V	V	A	V	V	V	mV
Serial #									
2	2.523	2.524	2.523	2.524	11.28	0.225	1.04	0.96	2.2
3	2.516	2.517	2.516	2.518	11.08	0.221	1.06	0.98	2.1
4	2.523	2.524	2.523	2.524	11.77	0.212	1.04	0.97	2
6	2.521	2.522	2.521	2.522	11.49	0.22	1.06	0.98	2
7	2.516	2.518	2.517	2.518	10.89	0.223	1.04	0.97	2.1
8	2.522	2.523	2.522	2.524	10.68	0.227	1.04	0.96	2.1
9	2.48	2.481	2.48	2.481	11.1	0.223	1.05	0.98	2.1
10	2.521	2.522	2.521	2.522	11.49	0.23	1.05	0.98	2.1
12	2.523	2.524	2.523	2.524	10.79	0.228	1.05	0.97	2
13	2.483	2.484	2.483	2.484	10.69	0.234	1.06	0.99	2.1
14	2.517	2.518	2.517	2.518	10.78	0.232	1.04	0.96	2.2
15	2.518	2.519	2.518	2.519	11.09	0.221	1.05	0.98	2.1

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Electrical Test Data (Post 1e12 n/cm^2 exposure)

Rad Level (n/cm2)	Vout (Vin=3.8V,Io =50mA)	Vout (Vin=3.8V,Io =3A)	Vout (Vin=5.8V,Io =50mA)	Vout (Vin=5.8V,Io =3A)	Over Current Latchup	Dropout Voltage	Shutdown Threshold On	Shutdown Threshold Off	Vout @ Shutdown
1.00E+12	3	4	5	6	7	9	10	11	12
	2.462	2.462	2.462	2.462	3.5	0	0.8	0.8	-100
	2.537	2.537	2.537	2.537	15	0.4	1.2	1.2	100
	V	V	V	V	A	V	V	V	mV
Serial #									
2	2.521	2.523	2.522	2.523	10.29	0.263	1.04	0.96	2.3
3	2.517	2.518	2.517	2.518	10.1	0.263	1.06	0.98	2.2
4	2.522	2.524	2.522	2.524	10.79	0.25	1.04	0.97	2
6	2.521	2.522	2.521	2.522	10.57	0.26	1.06	0.98	2
7	2.516	2.518	2.517	2.518	9.98	0.268	1.04	0.97	2.1
8	2.521	2.523	2.521	2.523	9.67	0.275	1.04	0.96	2.1
9	2.48	2.482	2.48	2.482	10.1	0.266	1.05	0.98	2.1
10	2.521	2.523	2.522	2.523	10.49	0.27	1.05	0.98	2.1
12	2.523	2.525	2.523	2.525	9.8	0.274	1.05	0.97	2.1
13	2.482	2.484	2.482	2.484	9.69	0.283	1.06	0.99	2.1
14	2.517	2.518	2.517	2.518	10.78	0.232	1.04	0.96	2.1
15	2.518	2.519	2.518	2.519	11.09	0.222	1.05	0.98	2.1

Electrical Test Data (Post 1e13 n/cm^2 exposure)

Rad Level (n/cm2)	Vout (Vin=3.8V,Io =50mA)	Vout (Vin=3.8V,Io =3A)	Vout (Vin=5.8V,Io =50mA)	Vout (Vin=5.8V,Io =3A)	Over Current Latchup	Dropout Voltage	Shutdown Threshold On	Shutdown Threshold Off	Vout @ Shutdown
1.00E+13	3	4	5	6	7	9	10	11	12
	2.462	2.462	2.462	2.462	3.5	0	0.8	0.8	-100
	2.537	2.537	2.537	2.537	15	0.4	1.2	1.2	100
	V	V	V	V	A	V	V	V	mV
Serial #									
2	2.515	2.523	2.515	2.521	5.27	0.896	0.85	0.96	2
3	2.514	2.521	2.514	2.52	5.07	0.968	0.84	0.98	1.9
4	2.517	2.525	2.517	2.523	5.5	0.808	1.04	0.97	2.1
6	2.515	2.523	2.516	2.521	5.37	0.869	1.06	0.98	2.1
7	2.514	2.522	2.514	2.52	4.89	1.044	1.04	0.97	2
8	2.518	2.526	2.519	2.525	4.68	1.139	0.84	0.96	1.9
9	2.473	2.48	2.473	2.479	4.99	1.022	1.05	0.98	2.1
10	2.516	2.523	2.516	2.522	5.27	0.91	1.05	0.98	2
12	2.52	2.528	2.52	2.526	4.69	1.11	0.84	0.97	1.9
13	2.477	2.485	2.477	2.484	4.79	1.109	0.84	0.99	1.9
14	2.517	2.518	2.517	2.518	10.78	0.232	1.04	0.96	2
15	2.518	2.519	2.518	2.519	11.09	0.221	1.05	0.98	2.1

Appendix B

Radiation Test Specification

Table 1: Pre Radiation Tests, 25C only								
Prog. Ref.	Test	Symbol	Test Conditions	Rad Level:	Notes	MIN	MAX	Units
A	Output Voltage	Vout	Vout (Vin=3.8V,Io=50mA)	Pre Rad		2.462	2.537	V
A	Output Voltage	Vout	Vout (Vin=3.8V,Io=3A)	Pre Rad		2.462	2.537	V
A	Output Voltage	Vout	Vout (Vin=5.8V,Io=50mA)	Pre Rad		2.462	2.537	V
A	Output Voltage	Vout	Vout (Vin=5.8V,Io=3A)	Pre Rad		2.462	2.537	V
A	Dropout Voltage	Vdrop	Io=3A	Pre Rad		0.00	0.40	V
A	Over Current Latchup	Ilatch	Vin=5.0V	Pre Rad		3.50	15.00	A
A	Shutdown Threshold off	Vshdn	Vin=5.0V, VSHUTDOWN RAMP from 0.5V to 2.0V, output monitored for a 1% drop below The nominal of Vout.	Pre Rad		0.80	1.20	V
A	Shutdown Threshold On	Vshdn	Vin=5.0V, VSHUTDOWN RAMP from 2.0V to 0.5V, output monitored for 500mV of Vout.	Pre Rad		0.80	1.20	V
A	Vout@ Shutdown	Voshdn	Vin=5.0V, Io=0A, SHD=5.0V	Pre Rad		-0.10	0.10	V

Table 2: Post Radiation Tests, 25C only, all radiation levels								
Prog.								
Ref.	Test	Symbol	Test Conditions	Rad Level:	Notes	MIN	MAX	Units
B	Output Voltage	Vout	Vout (Vin=3.8V,Io=50mA)	Post Rad		2.437	2.549	V
B	Output Voltage	Vout	Vout (Vin=3.8V,Io=3A)	Post Rad		2.437	2.549	V
B	Output Voltage	Vout	Vout (Vin=5.8V,Io=50mA)	Post Rad		2.437	2.549	V
B	Output Voltage	Vout	Vout (Vin=5.8V,Io=3A)	Post Rad		2.437	2.549	V
B	Dropout Voltage	Vdrop	Io=3A	Post Rad		0.00	0.40	V
B	Over Current Latchup	Ilatch	Vin=5.0V	Post Rad		3.50	15.00	A
B	Shutdown Threshold off	Vshdn	Vin=5.0V, VSHUTDOWN RAMP from 0.5V to 2.0V, output monitored for a 1% drop below The nominal of Vout.	Post Rad		0.80	1.20	V
B	Shutdown Threshold On	Vshdn	Vin=5.0V, VSHUTDOWN RAMP from 2.0V to 0.5V, output monitored for 500mV of Vout.	Post Rad		0.80	1.20	V
B	Vout@ Shutdown	Voshdn	Vin=5.0V, Io=0A, SHD=5.0V	Post Rad		-0.10	0.10	V

Neutron Radiation Requirements	
Fast Neutron Irradiator Facility @ UMass, Lowell	
Bias Conditions	All pins open. Parts inside an ESD conductive bag.
Fluence Step Profile	1.0E+11, 1.0E+12, 1.0E+13
Equivalent Fluence	1MeV (neutrons/cm^2)
Test Temperature	20C +/-10C

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Appendix C

Neutron Test Set Up

Neutron Irradiation Set Up

1. Devices are placed into the aluminum / boron container.
2. The container is then lowered into the irradiation chamber.
3. At the completion of the run time, remove container from the radiation chamber.
4. Allow devices to decay (radioactive) to an acceptable safe level before testing.
5. Repeat process as required.