International
IOR Rectifier

RDHA710SE10A2F

Neutron Test Report

December 2005

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INTRODUCTION

This test report covers the neutron fluence tests performed on the RDHA710SE10A2F Dual Solid-State-Relay in a hermetic package. The neutron fluence test was performed to determine the effects displacement damage had on the device performance. On December 21, 2005, 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 up to 2E12 n/cm^2. The results show degradation in the device's propagation delay after exposure to neutron irradiation of 2E12 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 all of the device leads open in a 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 December 21, 2005 for post exposure effects.

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 Dual Solid State Relay. 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.

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. As a minimum, the sample size shall meet the requirements of Mil-STD-883, method 1017. The sample size for this test is 5 devices (10 circuits) and one device for a control sample.

4.0 Test Device

4.0 The following device is planned for Neutron characterization:
a. RDHA710SE10A2S

4.1 All devices shall be subjected to 160hrs of burn-in and verified for correct electrical performance prior to arrival at UMRR.

4.2 The device leads will be 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.

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^{11} x 12^{11} x 6^{11}). 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 1E10 n/cm^2, 2E11 n/cm^2, and 2E12 n/cm^2.

Test Procedure - Table 1

Step	Description	Conditions
1	Pre test all devices prior to radiation exposure.	Per T090132G
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 T090132G
9	End test. Read and Record data	

9.0 Test Report

The Test Report shall include the following information.

a. Device type(s), serial numbers, wafer lot identification (per active component)
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.

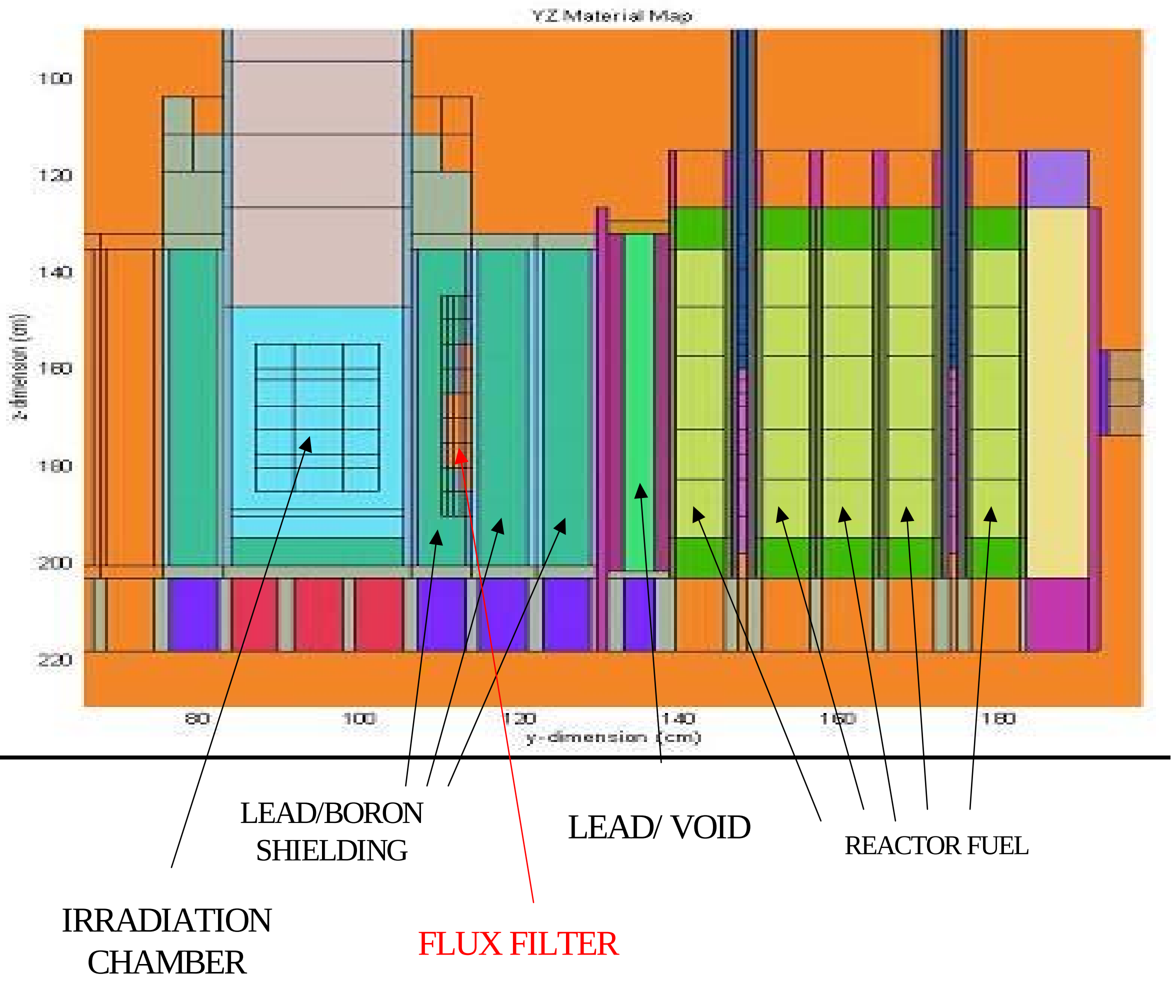


Figure 1

Test Results

The key pre and post radiation test results are shown graphically in Figures 2 thru 3. As outlined in the Test Plan, five devices were exposed to neutron irradiation at fluence levels of 1E10, 2E11, and 2E12 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, and Maximum for all the device samples shown. The radiation exposure had minimal effect on the samples up to a fluence level of 2E12 n/cm^2. There were no catastrophic failures for any device. All parameters were within the post radiation limits for the device.

Figure 2

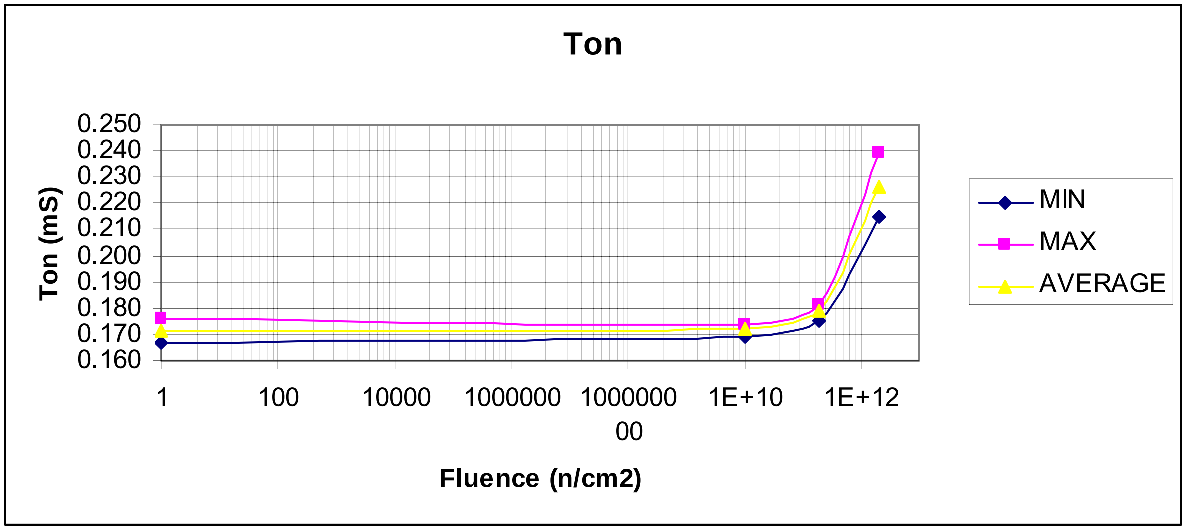
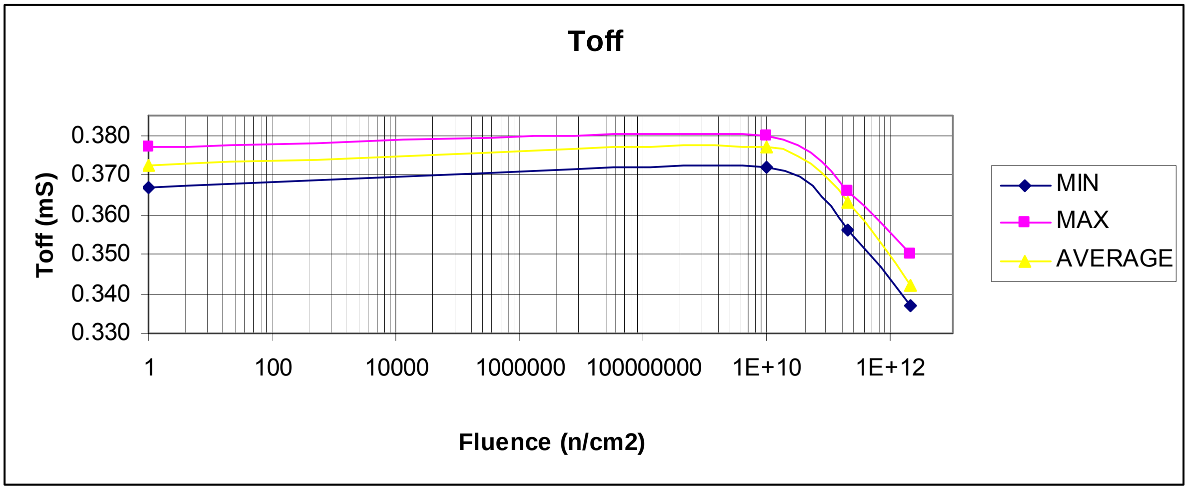


Figure 3



CONCLUSION

The RDHA710SE10A2F has demonstrated hardness to neutron radiation exposure to a fluence level of 2E12 n/cm^2 with no effect on its overall performance and the results show it to meet all the post radiation test requirements. There are parametric shifts on the devices propagation delay at fluence levels above 2E11 n/cm^2, which need to be considered in designs where tight tolerances over the life of the product need to be maintained.

Appendix A

Electrical Data

Electrical Test Data (Pre-radiation)

TEST	IQin	IDin	IIHSS 1	IIHSS 2	IO [leak] 1	IO [leak] 2	Rdson 1	Rdson 2	Ton 1	Trise 1	Ton 2	Trise 2	Toff 1	Tfall 1	Toff 2	Tfall 2
MAX LIMIT	1000	50	1000	1000	25000	25000	100	100	.45	.40	.45	.40	.75	1.8	.75	1.8
MIN LIMIT	-1000	----	-1000	-1000	----	----	----	----	----	----	----	----	----	----	----	----
SERIAL #	(nA)	(mA)	(nA)	(nA)	(nA)	(nA)	(mOhm)	(mOhm)	(mS)	(mS)	(mS)	(mS)	(mS)	(mS)	(mS)	(mS)
18	509	28.40	0.06	0.25	21.90	21.60	70.30	68.40	0.20	0.26	0.17	0.26	0.37	1.03	0.40	1.07
2	507	28.80	0.02	0.18	22.20	21.90	69.80	72.90	0.17	0.26	0.17	0.25	0.38	1.07	0.39	1.04
9	577	28.30	0.03	0.26	22.00	21.60	69.50	70.30	0.17	0.26	0.17	0.26	0.37	1.03	0.38	1.02
27	546	28.50	0.06	0.30	22.10	21.70	78.00	71.50	0.17	0.25	0.17	0.25	0.37	1.01	0.38	1.09
28	562	28.80	0.03	0.27	22.20	21.20	73.30	69.50	0.17	0.27	0.17	0.25	0.38	1.04	0.38	1.02
33	505	28.40	0.07	0.22	22.20	21.40	76.50	74.60	0.18	0.25	0.17	0.26	0.37	1.05	0.38	1.06

Electrical Test Data (Post 1e10 n/cm^2 exposure)

TEST	IQin	IDin	IIHSS 1	IIHSS 2	IO [leak] 1	IO [leak] 2	Rdson 1	Rdson 2	Ton 1	Trise 1	Ton 2	Trise 2	Toff 1	Tfall 1	Toff 2	Tfall 2
MAX LIMIT	1000	50	1000	1000	25000	25000	100	100	.45	.40	.45	.40	.75	1.8	.75	1.8
MIN LIMIT	-1000	----	-1000	-1000	----	----	----	----	----	----	----	----	----	----	----	----
SERIAL #	(nA)	(mA)	(nA)	(nA)	(nA)	(nA)	(mOhm)	(mOhm)	(mS)	(mS)	(mS)	(mS)	(mS)	(mS)	(mS)	(mS)
18	109	28.50	0.12	0.26	30.90	30.00	85.90	82.10	0.20	0.26	0.18	0.26	0.37	0.99	0.53	1.51
2	109	28.90	0.12	0.28	31.60	31.30	85.50	89.50	0.17	0.27	0.19	0.29	0.38	1.00	0.54	1.52
9	102	28.40	0.13	0.26	31.70	30.80	85.00	85.40	0.17	0.27	0.18	0.28	0.37	1.04	0.54	1.47
27	151	28.60	0.14	0.29	31.30	31.30	89.70	86.60	0.17	0.25	0.18	0.27	0.38	1.05	0.51	1.52
28	118	28.90	0.12	0.43	31.20	30.60	93.60	84.20	0.17	0.26	0.18	0.29	0.38	1.02	0.52	1.46
33	140	28.50	0.16	0.36	31.50	30.40	88.90	89.50	0.17	0.25	0.18	0.26	0.38	1.00	0.54	1.52

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

TEST	IQin	IDin	IIHSS 1	IIHSS 2	IO [leak] 1	IO [leak] 2	Rdson 1	Rdson 2	Ton 1	Trise 1	Ton 2	Trise 2	Toff 1	Tfall 1	Toff 2	Tfall 2
MAX LIMIT	1000	50	1000	1000	25000	25000	100	100	.45	.40	.45	.40	.75	1.8	.75	1.8
MIN LIMIT	-1000	----	-1000	-1000	----	----	----	----	----	----	----	----	----	----	----	----
SERIAL #	(nA)	(mA)	(nA)	(nA)	(nA)	(nA)	(mOhm)	(mOhm)	(mS)	(mS)	(mS)	(mS)	(mS)	(mS)	(mS)	(mS)
18	111	28.40	± Invalid	± Invalid	26.50	26.00	81.40	79.00	0.20	0.26	0.18	0.26	0.37	0.97	0.55	1.47
2	95	28.70	± Invalid	± Invalid	34.40	35.10	78.90	84.90	0.18	0.26	0.19	0.27	0.36	1.03	0.51	1.49
9	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
27	110	28.50	± Invalid	± Invalid	35.30	34.50	88.60	81.60	0.18	0.25	0.18	0.28	0.36	1.03	0.49	1.48
28	89	28.70	± Invalid	± Invalid	35.40	35.10	82.70	79.10	0.18	0.26	0.18	0.28	0.36	1.02	0.50	1.51
33	129	28.40	± Invalid	± Invalid	37.00	36.70	86.50	86.00	0.18	0.27	0.19	0.27	0.36	1.03	0.51	1.44

±Test system did not acquire valid leakage data. This was resolved for other levels of exposure.

* Device was not tested. Operator error.

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

TEST	IQin	IDin	IIHSS 1	IIHSS 2	IO [leak] 1	IO [leak] 2	Rdson 1	Rdson 2	Ton 1	Trise 1	Ton 2	Trise 2	Toff 1	Tfall 1	Toff 2	Tfall 2
MAX LIMIT	1000	50	1000	1000	25000	25000	100	100	.45	.40	.45	.40	.75	1.8	.75	1.8
MIN LIMIT	-1000	----	-1000	-1000	----	----	----	----	----	----	----	----	----	----	----	----
SERIAL #	(nA)	(mA)	(nA)	(nA)	(nA)	(nA)	(mOhm)	(mOhm)	(mS)	(mS)	(mS)	(mS)	(mS)	(mS)	(mS)	(mS)
18	24	28.40	0.12	0.26	23.40	23.00	93.0	77.90	0.20	0.26	0.18	0.30	0.37	0.97	0.55	1.51
2	9	28.80	5	8	93.90	101.00	89.2	82.40	0.23	0.27	0.24	0.28	0.34	1.03	0.48	1.49
9	22	28.40	3	6	95.40	94.20	100.0	88.20	0.22	0.27	0.22	0.27	0.35	1.03	0.50	1.52
27	28	28.60	6	7	95.00	93.80	92.0	81.30	0.23	0.26	0.23	0.27	0.34	1.00	0.48	1.49
28	39	28.90	7	5	98.80	98.00	96.0	78.70	0.22	0.27	0.22	0.27	0.34	1.01	0.34	1.02
33	41	28.40	3	4	96.60	96.30	93.0	85.20	0.24	0.26	0.22	0.27	0.34	1.00	0.48	1.53

Appendix B

Radiation Test Specification

PRODUCT DISCRIPTION: 10A DUAL SOLID STATE RELAY (FAST)

Automatic Test **Tester: PXI TEST CONSOLE 04-134-TC**

Table 1: Pre Radiation Tests, 25C tests only

Prog. Ref.	Test	Symbol	Test Conditions	Rad Level:	Notes	MIN	MAX	Units
A	In Supply Curr	Iqin	VDD = 5.0V, IN1 = IN2 = 0V	Pre rad		**-1**	**1**	uA
A	In Supply Curr	IDin	VDD = 5.0V, IN1 = IN2 = 3.3V	Pre rad		----	50	mA
A	In Buffer Curr	IHSS1	VDD = 5.0V, IN1 = 3.3V, IN2 = 0V	Pre rad		-1	1	uA
A	In Buffer Curr	IHSS2	VDD = 5.0V, IN1 = 0V, IN2 = 3.3V	Pre rad		-1	1	uA
A	Output Leakage	IOleak1	VDD = 5.0V, IN1 = 0.1V, IN2 = 0V, VO1 = 100V	Pre rad		----	25	uA
A	Output Leakage	IOleak2	VDD = 5.0V, IN1 = 0V, IN2 = 0.1V, VO2 = 100V	Pre rad		----	25	uA
A	Output ON Resistance	RDSon1	VDD = 5.0V, IN1 = 3.3V, IN2 = 0V, IO1 = 10A	Pre rad		----	100	mΩ
A	Output ON Resistance	RDSon2	VDD = 5.0V, IN1 = 0V, IN2 = 3.3V, IO2 = 10A	Pre rad		----	100	mΩ
A	Turn On Delay	ton1	VDD = 5.0V, IN1 = 3.3V, IN2 = 0V, VS = 30V, RLC = 7Ω / 100uF, PW = 50mS	Pre rad		----	0.45	mS
A	Rise Time	tr1		Pre rad		----	0.40	mS
A	Turn Off Delay	toff1	VDD = 5.0V, IN1 = 0V, IN2 = 0V, VS = 30V, RLC = 7Ω / 100uF, PW = 50mS	Pre rad		----	0.75	mS
A	Fall Time	tf1		Pre rad		----	1.80	mS
A	Turn On Delay	ton2	VDD = 5.0V, IN1 = 0V, IN2 = 3.3V, VS = 30V, RLC = 7Ω / 100uF, PW = 50mS	Pre rad		----	0.45	mS
A	Rise Time	tr2		Pre rad		----	0.40	mS
A	Turn Off Delay	toff2	VDD = 5.0V, IN1 = 0V, IN2 = 0V, VS = 30V, RLC = 7Ω / 100uF, PW = 50mS	Pre rad		----	0.75	mS
A	Fall Time	tf2		Pre rad		----	1.80	mS

Automatic Test **Tester: PXI TEST CONSOLE 04-134-TC**

Table 2: Post Radiation Tests, 25C tests only

Prog. Ref.	Test	Symbol	Test Conditions	Rad Level:	Notes	MIN	MAX	Units
B	In Supply Curr	Iqin	VDD = 5.0V, IN1 = IN2 = 0V	Post rad		**-1**	**1**	uA
B	In Supply Curr	IDin	VDD = 5.0V, IN1 = IN2 = 3.3V	Post rad		----	50	mA
B	In Buffer Curr	IHSS1	VDD = 5.0V, IN1 = 3.3V, IN2 = 0V	Post rad		-1	1	uA
B	In Buffer Curr	IHSS2	VDD = 5.0V, IN1 = 0V, IN2 = 3.3V	Post rad		-1	1	uA
B	Output Leakage	IOleak1	VDD = 5.0V, IN1 = 0.1V, IN2 = 0V, VO1 = 100V	Post rad		----	25	uA
B	Output Leakage	IOleak2	VDD = 5.0V, IN1 = 0V, IN2 = 0.1V, VO2 = 100V	Post rad		----	25	uA
B	Output ON Resistance	RDSon1	VDD = 5.0V, IN1 = 3.3V, IN2 = 0V, IO1 = 10A	Post rad		----	100	mΩ
B	Output ON Resistance	RDSon2	VDD = 5.0V, IN1 = 0V, IN2 = 3.3V, IO2 = 10A	Post rad		----	100	mΩ
B	Turn On Delay	ton1	VDD = 5.0V, IN1 = 3.3V, IN2 = 0V, VS = 30V, RLC = 7Ω / 100uF, PW = 50mS	Post rad		----	0.45	mS
B	Rise Time	tr1		Post rad		----	0.40	mS
B	Turn Off Delay	toff1	VDD = 5.0V, IN1 = 0V, IN2 = 0V, VS = 30V, RLC = 7Ω / 100uF, PW = 50mS	Post rad		----	0.75	mS
B	Fall Time	tf1		Post rad		----	1.80	mS
B	Turn On Delay	ton2	VDD = 5.0V, IN1 = 0V, IN2 = 3.3V, VS = 30V, RLC = 7Ω / 100uF, PW = 50mS	Post rad		----	0.45	mS
B	Rise Time	tr2		Post rad		----	0.40	mS
B	Turn Off Delay	toff2	VDD = 5.0V, IN1 = 0V, IN2 = 0V, VS = 30V, RLC = 7Ω / 100uF, PW = 50mS	Post rad		----	0.75	mS
B	Fall Time	tf2		Post rad		----	1.80	mS

Table 4: Neutron Radiation Requirements [4, 5]	
Fast Neutron Irradiator Facility @ UMass, Lowell	
Bias Conditions	All pins open. Parts inside an ESD conductive bag.
Fluence Step Profile	1.0E+10, 2E+11, 1.8E+12
Equivalent Fluence	1MeV (neutrons/cm^2)
Test Temperature	20C +/-10C
Test Procedure	T030061G

[4] Performed during initial qualification of the device and retested only when specified by Quality Assurance due to a change per MIL-PRF-38534. The sample size for the hybrid qualification is 5 devices (10 CIRCUITS); 1 device will not be irradiated and used as a control sample.

[5] All handling guidelines for neutron irradiated product outlined in T030061G must be followed for this multiple exposure test. Fluence steps are considered cumulative.

Table 5: Test Hardware

	Test Fixture	Test System
Pre Radiation Tests	04-135-TF, 04-107-002-P	PXI 04-134-TC
Post Radiation Tests	04-135-TF, 04-107-002-P	PXI 04-134-TC

Table 6: Test Programs

	Test Type	Test System	Program Name	Program Location
A	Pre Rad	PXI	05-028-TS	C:\PXI_TestSoftware_TestData\TestPrograms\05-28-TS_OMR9707\05-028-TS.llb\05-028-TS.vi
B	Post Rad	PXI	05-028-TS	C:\PXI_TestSoftware_TestData\TestPrograms\05-28-TS_OMR9707\05-028-TS.llb\05-028-TS.vi

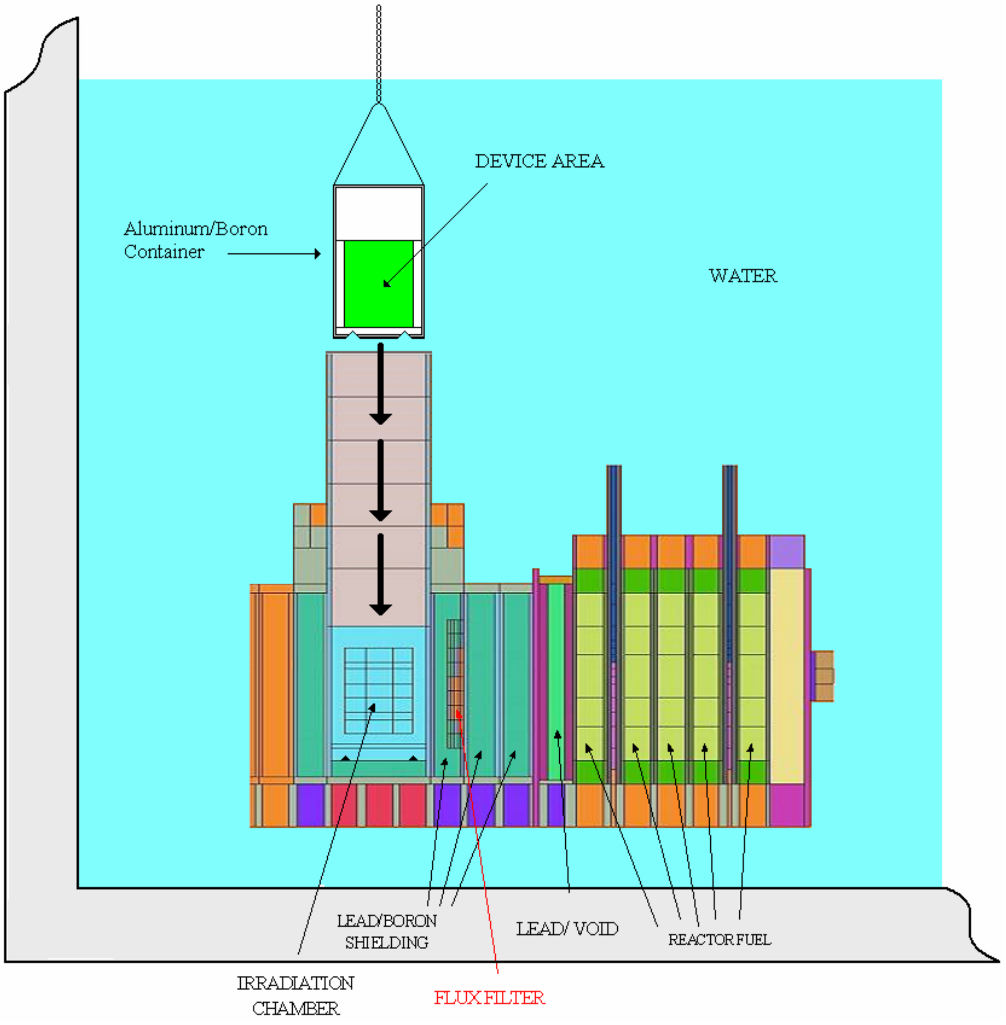
Notes	
1.	
2.	
3.	

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.



Appendix D

Neutron Exposure Certificate

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RADIATION LABORATORY

Thursday, January 05, 2006

Chris DiCienzo
International Rectifier Corporation
205 Crawford Street
Leominster, MA 01453

Subject: **Certificate of Neutron Exposure**

Product:	Electronic Devices 051221-2
Irradiation Date:	December 21, 2005
Irradiation Facility:	Reactor Facility- FNI
Irradiation Length:	360 sec @ 5kW
Desired (1MeV Si Eq.)Exposure:	2.0E11 neutrons/cm^2
Dosimetry system:	P-32, ASTM E-265

Neutron Dosimetry Results:

	Front Tablet	Back Tablet
Efficiency	0.1751	0.1748
P-32 Decay Constant	5.63E-07	5.63E-07
Rel. Damage Factor	0.544	0.544
Spectral Avg. X-sect	7.35E-27	7.35E-27
Net Disintegrations	3406.52	2708.72
Activity[1]	1.23E+01	9.80E+00
Saturated Activity[2]	6.08E+04	4.83E+04
Target Atoms[3]	6.72E+21	6.74E+21
Reaction Rate[4]	9.04E-18	7.17E-18
Fluence(>10kev)[5]	4.43E+11	3.51E+11

(1) ASTM E261 (Eq. 1)
(2) ASTM E261 (Eq. 3)
(3) ASTM E261 (Eq. 6)
(4) ASTM E261 (Eq. 5)
(5) ASTM E261 (Eq. 38)

Front Tablet Fluence (1MeV Si Eq.) = 2.41E+11 n/cm^2
Back Tablet Fluence (1MeV Si Eq.) = 1.91E+11 n/cm^2

Average Neutron Fluence (1MeV Si Eq.) = 2.16E+11 n/cm^2

Reviewed by ____________________
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RADIATION LABORATORY

Thursday, January 05, 2006

Chris DiCienzo
International Rectifier Corporation
205 Crawford Street
Leominster, MA 01453

Subject: **Certificate of Neutron Exposure**

Product:	Electronic Devices 051221-3
Irradiation Date:	December 21, 2005
Irradiation Facility:	Reactor Facility- FNI
Irradiation Length:	324 sec @ 50kW
Desired (1MeV Si Eq.)Exposure:	1.8E12 neutrons/cm^2
Dosimetry system:	P-32, ASTM E-265

Neutron Dosimetry Results:

	Front Tablet	Back Tablet
Efficiency	0.1795	0.1779
P-32 Decay Constant	5.63E-07	5.63E-07
Rel. Damage Factor	0.544	0.544
Spectral Avg. X-sect	7.35E-27	7.35E-27
Net Disintegrations	29788.42	22631.32
Activity [1]	1.03E+02	7.83E+01
Saturated Activity [2]	5.65E+05	4.29E+05
Target Atoms [3]	6.50E+21	6.58E+21
Reaction Rate [4]	8.70E-17	6.53E-17
Fluence(>10kev) [5]	3.83E+12	2.88E+12

(1) ASTM E261 (Eq. 1)
(2) ASTM E261 (Eq. 3)
(3) ASTM E261 (Eq. 6)
(4) ASTM E261 (Eq. 5)
(5) ASTM E261 (Eq. 38)

Front Tablet Fluence (1MeV Si Eq.) = 2.09E+12 n/cm^2
Back Tablet Fluence (1MeV Si Eq.) = 1.57E+12 n/cm^2

Average Neutron Fluence (1MeV Si Eq.) = 1.83E+12 n/cm^2

Reviewed by______________________
Thomas Regan
Reactor Engineer