ISL75051SEH

Neutron Test Report

TR027
Rev.1.00
Oct 21, 2019

Introduction

This report summarizes results of 1MeV equivalent neutron testing of the ISL75051SEH low dropout voltage linear regulator (LDO). The test was conducted in order to determine the sensitivity of the part to Displacement Damage (DD) caused by neutron or proton environments. Neutron fluences ranged from 2 x 10^{12} n/cm^2 to 1 x 10^{14} n/cm^2. This project was carried out in collaboration with VPT, Inc. (Blacksburg, VA), whose support is gratefully acknowledged. This report is also applicable to the other variants (ISL75051SRH, ISL75051ASEH, ISL73051ASEH).

Related Literature

For a full list of related documents, visit our website:

- ISL75051SEH, ISL75051SRH, ISL75051ASEH, ISL73051ASEH device pages
- MIL-STD-883 test method 1017

Part Description

The ISL75051SEH is a radiation hardened low voltage, high current single output low dropout linear voltage regulator (LDO) specified for a 3.0A output current. The device operates over an input voltage range of 2.2V to 5.5V and is capable of providing output voltages of 0.8V to 4V, with the output voltage adjusted by an external resistor divider network. The ENABLE feature allows the part to be placed into a low quiescent current shutdown mode.

The ISL75051SEH Overcurrent Protection (OCP) pin allows the short-circuit output current limit threshold to be programmed with an external resistor. The BiCMOS design consumes significantly lower quiescent current as a function of load in comparison to bipolar LDOs, which results in higher efficiency and the ability to consider packages with smaller footprints. The quiescent current of the part was traded off against a highly competitive load transient response, resulting in a superior total AC regulation band for an LDO in this category.

The ISL75051SEH is implemented in the 0.6µm P6 BiCMOS power management process. This process is in volume production under MIL-PRF-38535 certification and is used for a wide range of commercial power management devices. Table 1 shows a pin assignment for the part.

TABLE 1. PIN ASSIGNMENT

TERMINAL NUMBER	TERMINAL SYMBOL	TERMINAL NUMBER	TERMINAL SYMBOL
1	GND	10	EN
2	V_{OUT}	11	OCP
3	V_{OUT}	12	V_{IN}
4	V_{OUT}	13	V_{IN}
5	V_{OUT}	14	V_{IN}
6	V_{OUT}	15	V_{IN}
7	V_{OUT}	16	V_{IN}
8	ADJ	17	V_{IN}
9	BYP	18	PG

The ISL75051SEH is specified for a total dose (TID) tolerance of 100krad(Si) at a high (50-300rad(Si)/s) dose rate and at 50krad(Si) at a low (< 0.01rad(Si)/s) dose rate, as specified in MIL-STD-883 test method 1019. The part is acceptance tested on a wafer-by-wafer basis at low dose rate to 50krad(Si) and at high dose rate to 100krad(Si).

The ISL75051SEH is also SEE tolerant to a Linear Energy Transfer (LET) value of 86.4MeV•cm^2/mg. Single-Event Transients (SET) have evolved into a major issue in power management parts driving voltage-sensitive loads, and the part provides superior performance in this environment.

Specifications for radiation hardened QML devices are controlled by the Defense Logistics Agency (DLA) in Columbus, OH. The SMD is the controlling document and must be cited when ordering.

Test Description

Irradiation Facilities

Neutron irradiation was performed by the VPT team at the University of Massachusetts Lowell Fast Neutron Irradiation (FNI) facility, which provides a controlled 1MeV equivalent neutron flux. Parts were tested in an unbiased configuration with all leads shorted together in accordance with TM 1017 of MIL-STD-883. As neutron irradiation activates many of the heavier elements found in a packaged integrated circuit, the parts exposed at the higher neutron levels required (as expected) some ‘cooldown’ time before being shipped back to Renesas (Palm Bay, FL) for electrical testing.

Test Fixturing

No formal irradiation test fixturing was involved, as these DD tests are ‘bag tests’ in the sense that the parts are irradiated in an electrically inactive state with all leads shorted together.

Characterization Equipment and Procedures

Electrical testing was performed before and after irradiation using the Intersil production Automated Test Equipment (ATE). All electrical testing was performed at room temperature.

Experimental Matrix

Testing proceeded in general accordance with the guidelines of MIL-STD-883 Test Method 1017. The experimental matrix consisted of 5 samples irradiated at 2 x 10^{12} n/cm^2, 5 irradiated at 1 x 10^{13} n/cm^2, 5 irradiated at 3 x 10^{13} n/cm^2 and 5 irradiated at 1 x 10^{14} n/cm^2. Two control units were used.

ISL75051SEHF/PROTO samples were drawn from fabrication lot WTP8WD (serial numbers 1 through 8) and from lot WXW7CAE (serial numbers 9 through 20). Samples were packaged in the standard hermetic 18 Ld ceramic flatpack production package, code K18.E. Samples were screened to the SMD limits over-temperature before the start of neutron testing.

Results

Neutron testing of the ISL75051SEH is complete and the results are reported in the balance of this report. It should be carefully realized when interpreting the data that each neutron irradiation was performed on a different five-unit sample; this is not total dose testing, where the damage is cumulative over a number of downpoints.

Attributes Data

Table 2 shows the attributes data.

TABLE 2. ISL75051SEH ATTRIBUTES DATA

PART	SERIAL	SAMPLE SIZE	FLUENCE, n/cm^2	PASS (Note 1)	FAIL	NOTES
ISL75051SEH	1 through 5	5	2 x 10^{12}	5	0	All passed
ISL75051SEH	6 through 10	5	1 x 10^{13}	5	0	All passed
ISL75051SEH	11 through 15	5	3 x 10^{13}	5	0	All passed
ISL75051SEH	16 through 20	5	1 x 10^{14}	4	1	S/N 20 failed parametrically, adjusted pin voltage at 1.8V out, 5.0V_{IN}

NOTE:

1. “Pass” indicates a sample that passes all SMD limits.

Variables Data

The plots in Figures 1 through 23 show data plots for key parameters before and after irradiation to each level. The reported parameters and their datasheet limits are shown in Table 3 on page 15. The plots show the median of each parameter as a function of neutron irradiation. We chose to plot the median because of the small sample sizes (five per cell) involved. We also show the applicable electrical limits taken from the SMD; it should be carefully noted that these limits are provided for guidance only as the ISL75051SEH is not specified or guaranteed for the neutron environment. Intersil does not design, qualify or guarantee its parts for the DD environment, but has performed some limited neutron testing for customer guidance.

Variables Data Plots

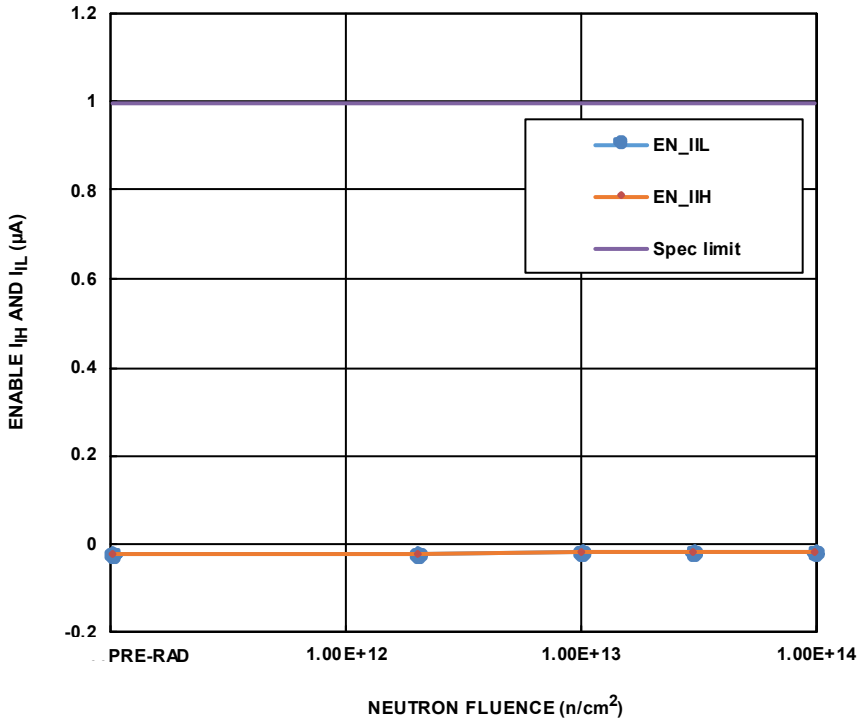

FIGURE 1. ISL75051SEH enable low and enable high current as a function of 1MeV equivalent neutron irradiation at 2 x 10^{12} n/cm^2, 1 x 10^{13} n/cm^2, 3 x 10^{13} n/cm^2 and 1 x 10^{14} n/cm^2. Sample size for each cell was 5. The datasheet limit is 1.0µA maximum.

Variables Data Plots (Continued)

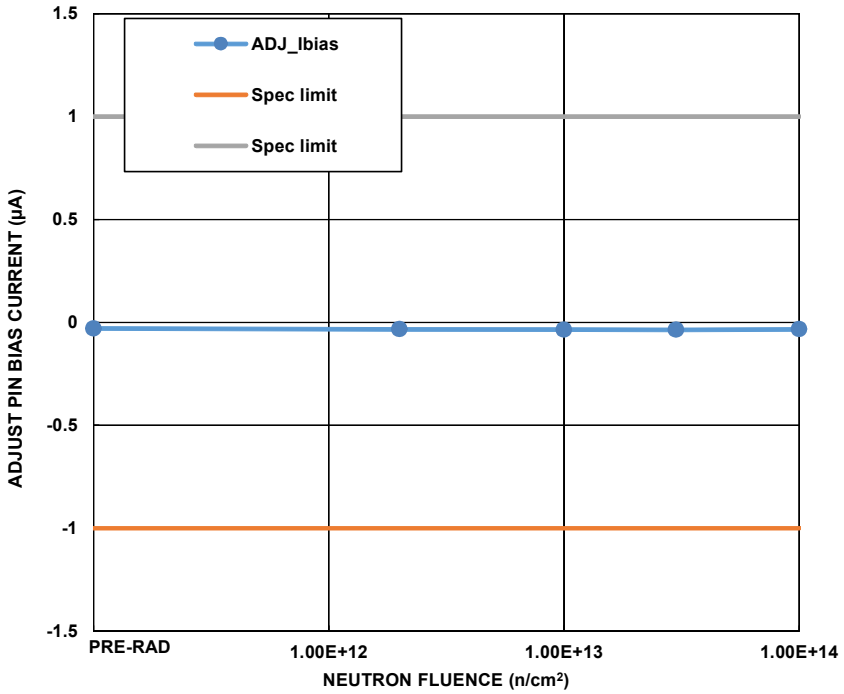

FIGURE 2. ISL75051SEH adjust pin bias current as a function of 1MeV equivalent neutron irradiation at 2 x 10^{12} n/cm^2, 1 x 10^{13} n/cm^2, 3 x 10^{13} n/cm^2 and 1 x 10^{14} n/cm^2. Sample size for each cell was 5. The datasheet limits are -1.0µA to 1.0µA.

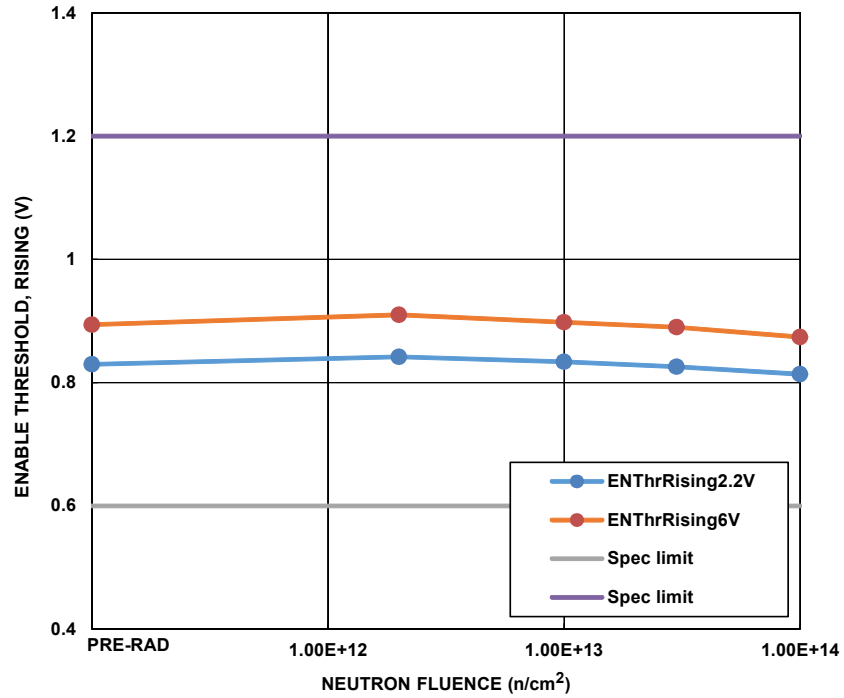

FIGURE 3. ISL75051SEH rising enable threshold at 2.2V and 6.0V input voltage as a function of 1MeV equivalent neutron irradiation at 2 x 10^{12} n/cm^2, 1 x 10^{13} n/cm^2, 3 x 10^{13} n/cm^2 and 1 x 10^{14} n/cm^2. Sample size for each cell was 5. The datasheet limits are 0.6V to 1.2V.

Variables Data Plots (Continued)

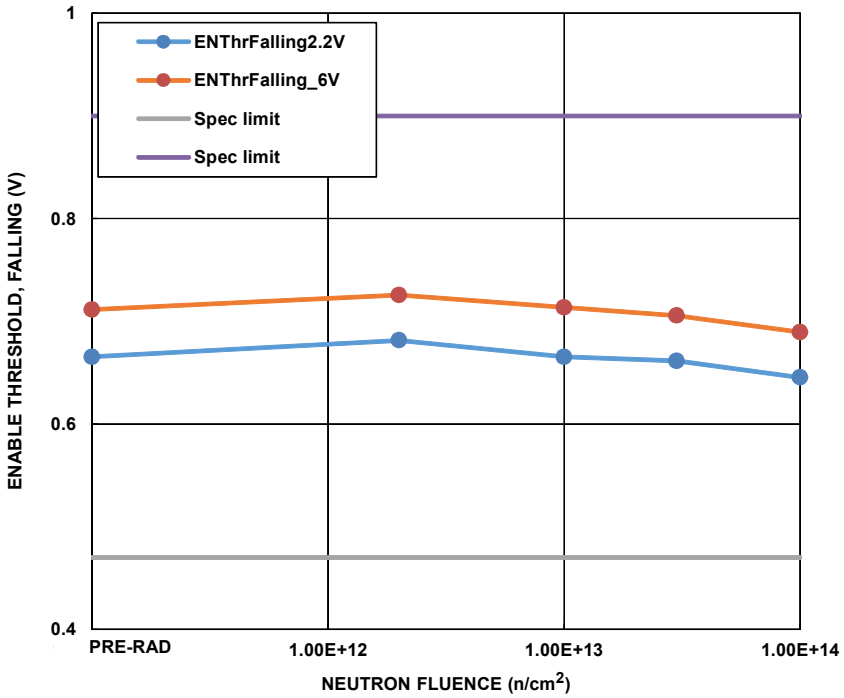

FIGURE 4. ISL75051SEH falling enable threshold at 2.2V and 6.0V input voltage as a function of 1MeV equivalent neutron irradiation at 2 x 10^{12} n/cm^2, 1 x 10^{13} n/cm^2, 3 x 10^{13} n/cm^2 and 1 x 10^{14} n/cm^2. Sample size for each cell was 5. The datasheet limits are 0.47V to 0.9V.

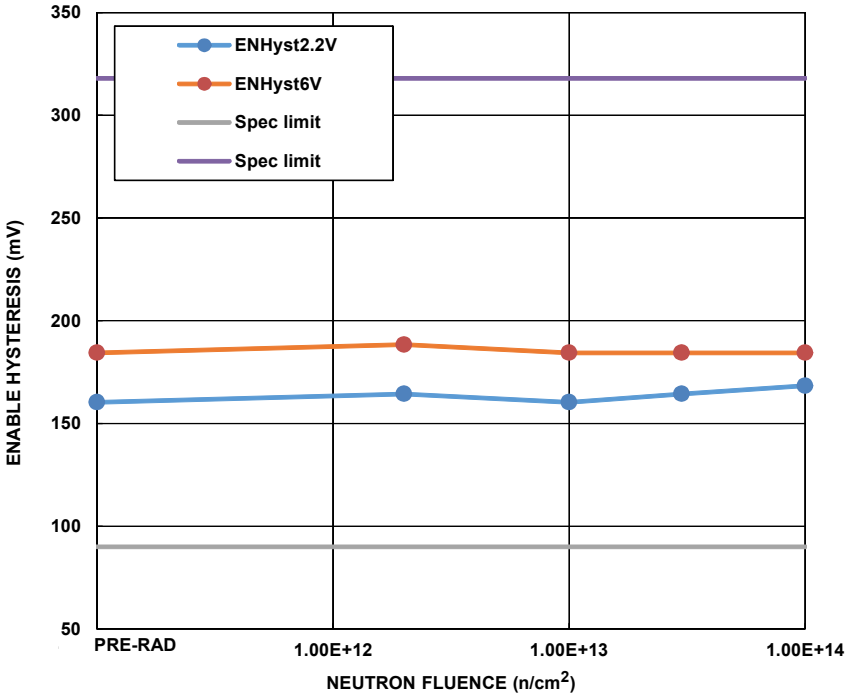

FIGURE 5. ISL75051SEH enable hysteresis at 2.2V and 6.0V input voltage as a function of 1MeV equivalent neutron irradiation at 2 x 10^{12} n/cm^2, 1 x 10^{13} n/cm^2, 3 x 10^{13} n/cm^2 and 1 x 10^{14} n/cm^2. Sample size for each cell was 5. The datasheet limits are 90.0mV to 318.0mV.

Variables Data Plots (Continued)

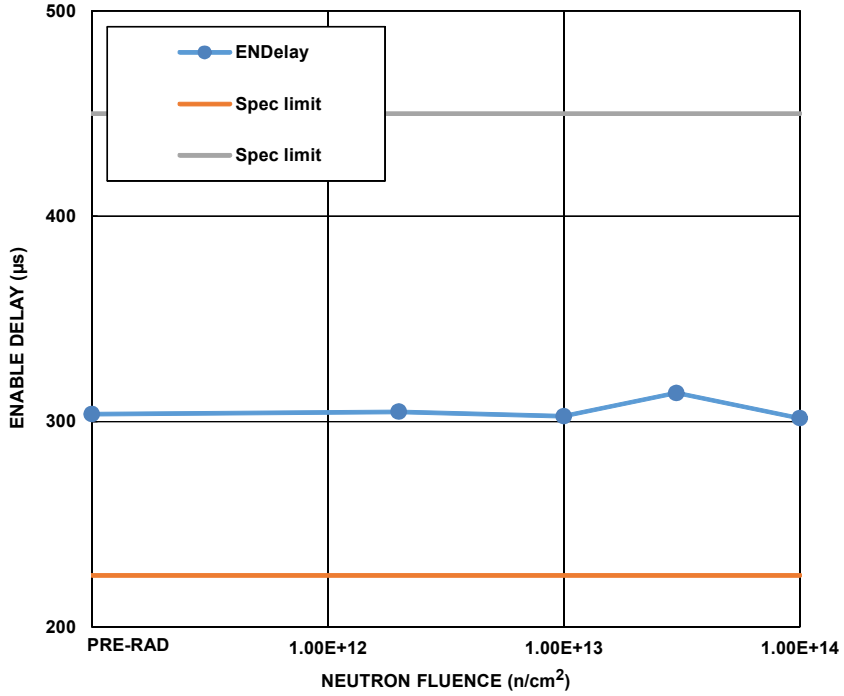

FIGURE 6. ISL75051SEH enable delay as a function of 1MeV equivalent neutron irradiation at 2 x 10^{12} n/cm^2, 1 x 10^{13} n/cm^2, 3 x 10^{13} n/cm^2 and 1 x 10^{14} n/cm^2. Sample size for each cell was 5. The datasheet limits are 225.0µs to 450.0µs.

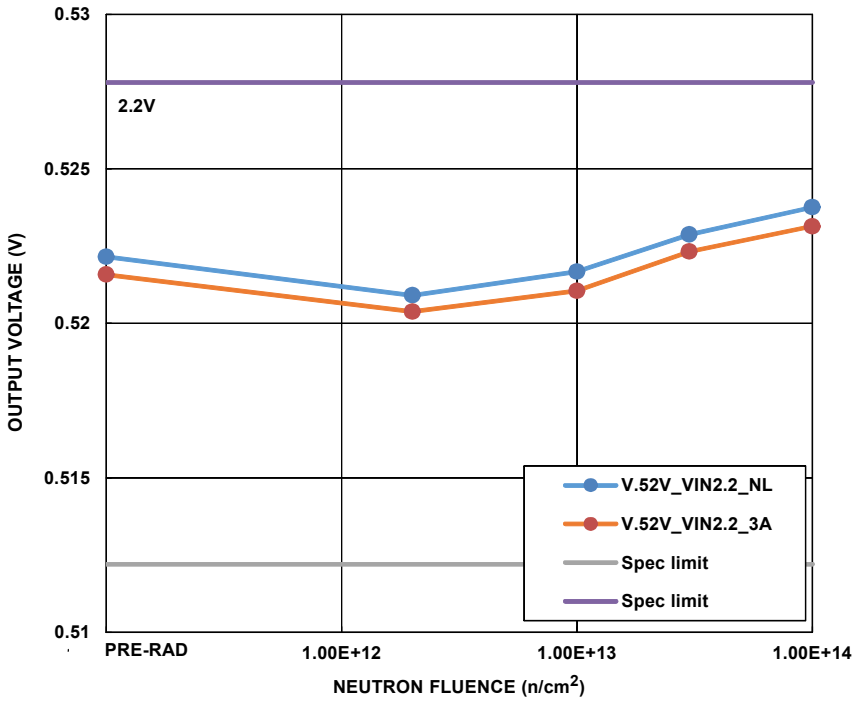

FIGURE 7. ISL75051SEH output voltage at 2.2V input voltage, 0.52V output voltage, no load and 3.0A output current, as a function of 1MeV equivalent neutron irradiation at 2 x 10^{12} n/cm^2, 1 x 10^{13} n/cm^2, 3 x 10^{13} n/cm^2 and 1 x 10^{14} n/cm^2. Sample size for each cell was 5. The datasheet limits are 0.5122V to 0.5278V.

Variables Data Plots (Continued)

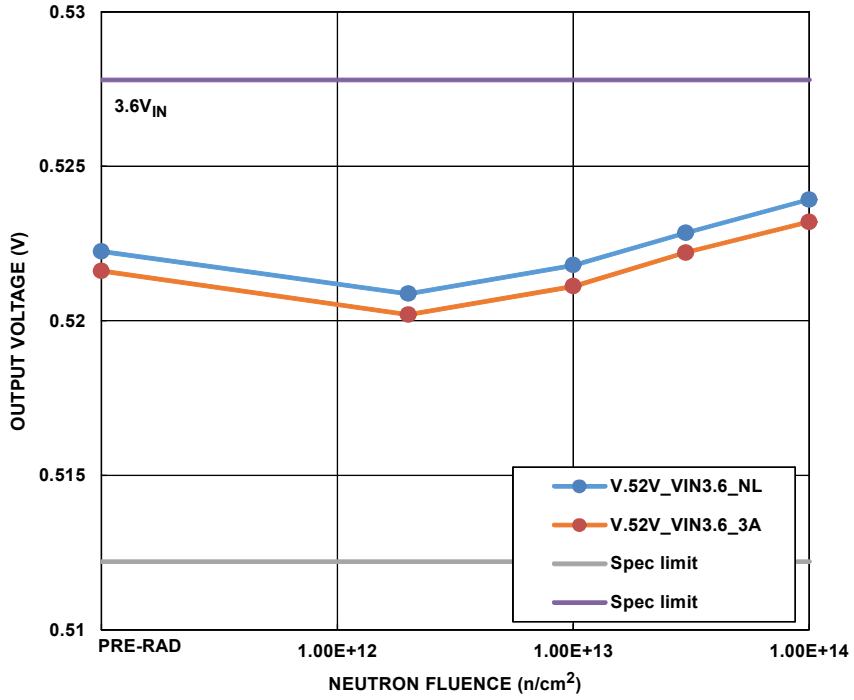

FIGURE 8. ISL75051SEH output voltage at 3.6V input voltage, 0.52V output voltage, no load and 3.0A output current, as a function of 1MeV equivalent neutron irradiation at 2 x 10^{12} n/cm^2, 1 x 10^{13} n/cm^2, 3 x 10^{13} n/cm^2 and 1 x 10^{14} n/cm^2. Sample size for each cell was 5. The datasheet limits are 0.5122V to 0.5278V.

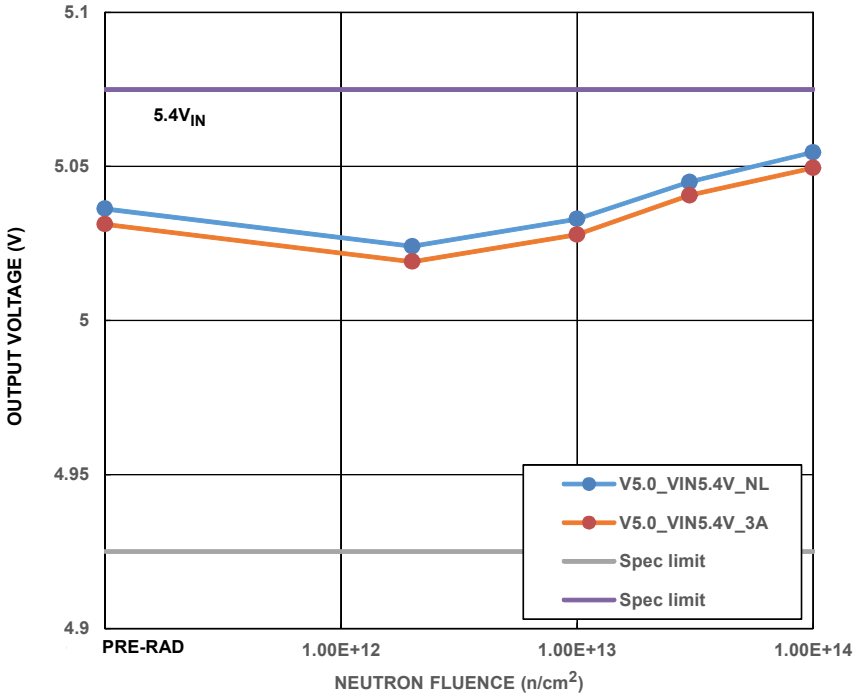

FIGURE 9. ISL75051SEH output voltage at 5.4V input voltage, 5.0V output voltage, no load and 3.0A output current, as a function of 1MeV equivalent neutron irradiation at 2 x 10^{12} n/cm^2, 1 x 10^{13} n/cm^2, 3 x 10^{13} n/cm^2 and 1 x 10^{14} n/cm^2. Sample size for each cell was 5. The datasheet limits are 4.925V to 5.075V.

Variables Data Plots (Continued)

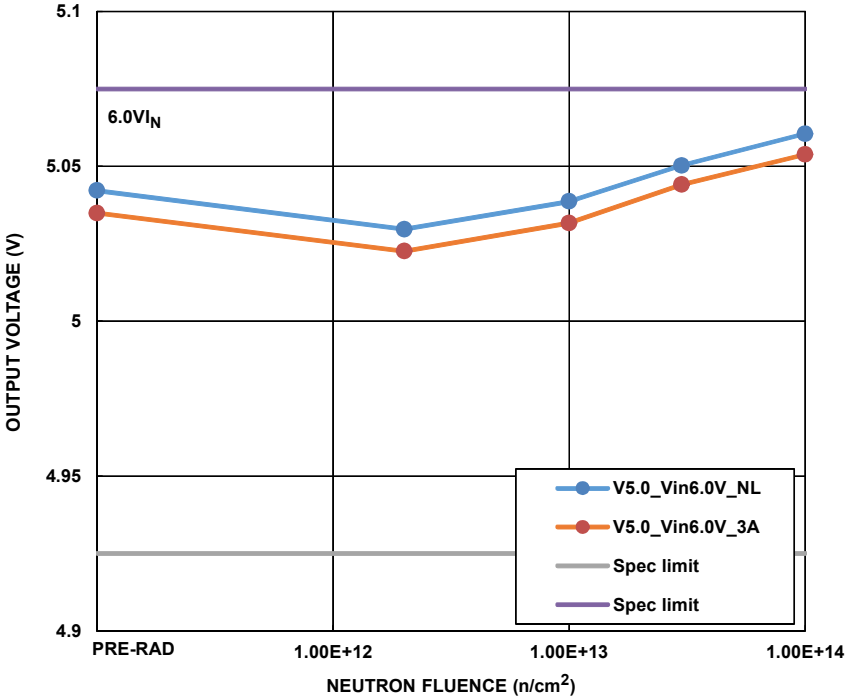

FIGURE 10. ISL75051SEH output voltage at 6.0V input voltage, 5.0V output voltage, no-load and 3.0A output current, as a function of 1MeV equivalent neutron irradiation at 2 x 10^{12} n/cm^2, 1 x 10^{13} n/cm^2, 3 x 10^{13} n/cm^2 and 1 x 10^{14} n/cm^2. Sample size for each cell was 5. The datasheet limits are 4.925V to 5.075V.

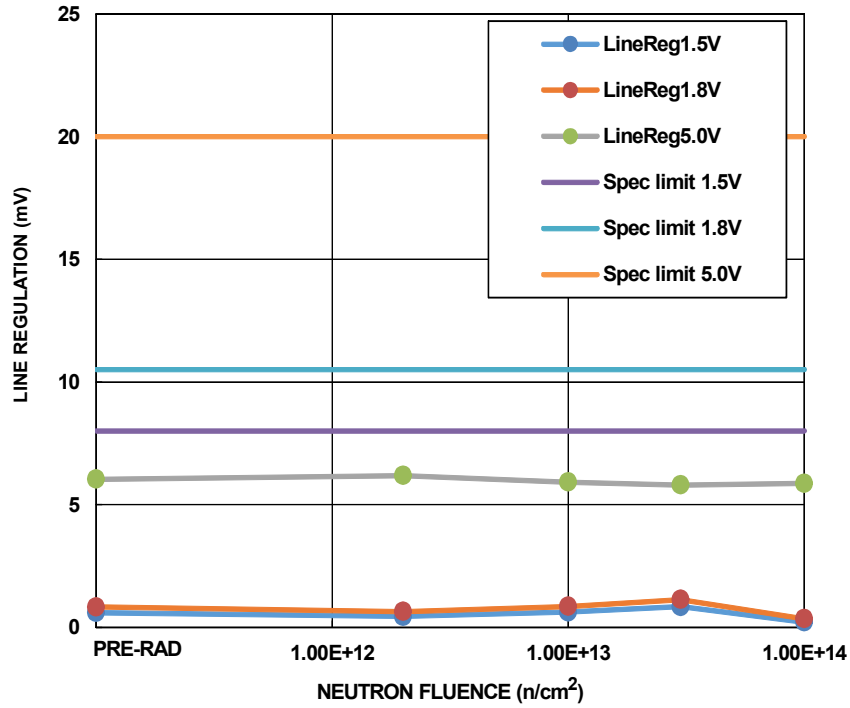

FIGURE 11. ISL75051SEH line regulation at 1.5V, 1.8V and 5.0V output voltage as a function of 1MeV equivalent neutron irradiation at 2 x 10^{12} n/cm^2, 1 x 10^{13} n/cm^2, 3 x 10^{13} n/cm^2 and 1 x 10^{14} n/cm^2. Sample size for each cell was 5. The datasheet limits are 8.0mV maximum (1.5V), 10.5mV maximum (1.8V) and 20.0mV maximum (5.0V).

Variables Data Plots (Continued)

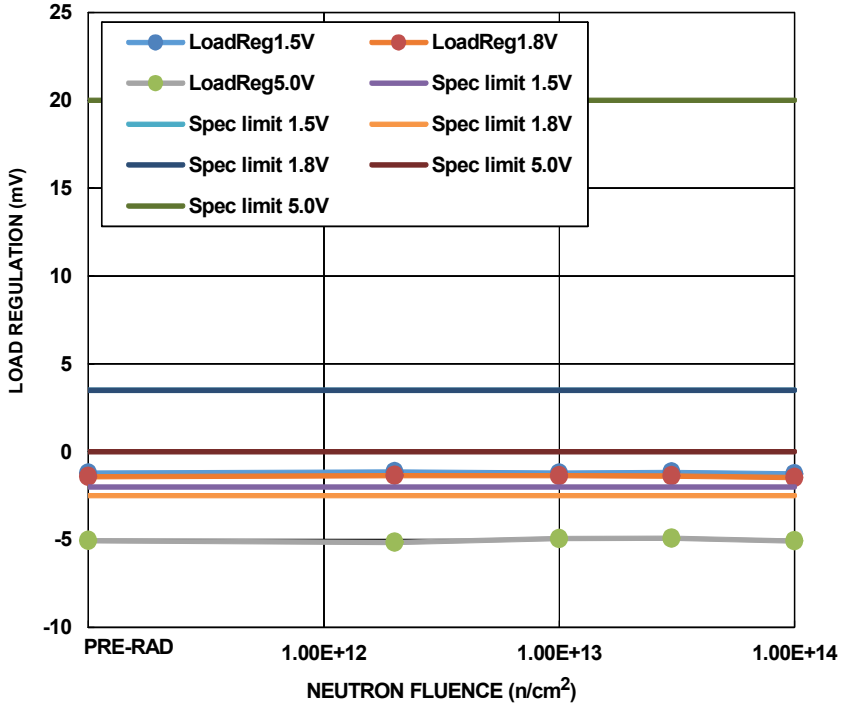

FIGURE 12. ISL75051SEH load regulation at 1.5V, 1.8V and 5.0V output voltage as a function of 1MeV equivalent neutron irradiation at 2×10^{12} n/cm^2, 1×10^{13} n/cm^2, 3×10^{13} n/cm^2 and 1×10^{14} n/cm^2. Sample size for each cell was 5. The datasheet limits are -4.0mV to -0.1mV (1.5V), -4.0mV to -0.05mV (1.8V) and -15.0mV to -0.05mV (5.0V).

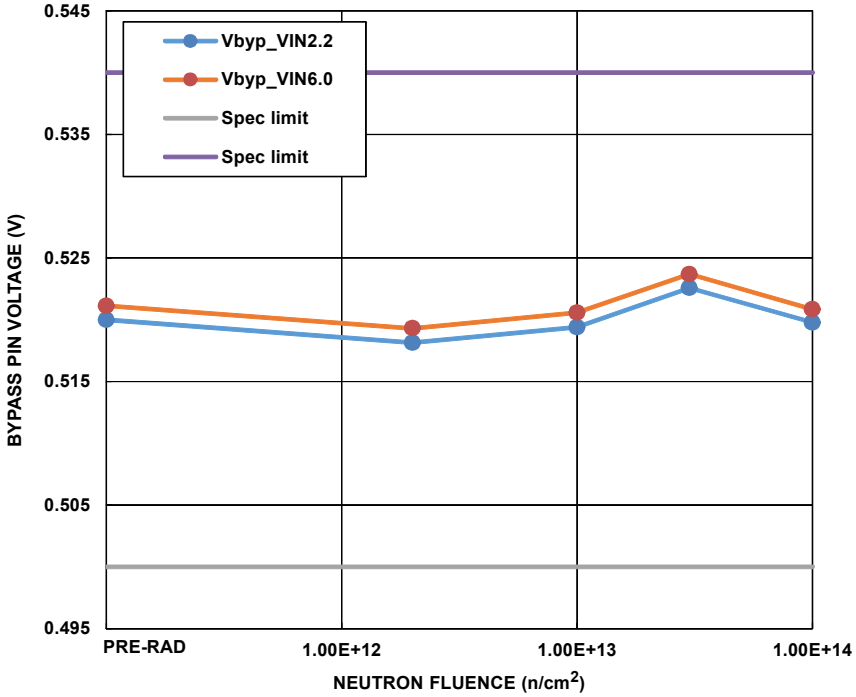

FIGURE 13. ISL75051SEH bypass pin voltage at 2.2V and 6.0V input voltage as a function of 1MeV equivalent neutron irradiation at 2×10^{12} n/cm^2, 1×10^{13} n/cm^2, 3×10^{13} n/cm^2 and 1×10^{14} n/cm^2. Sample size for each cell was 5. The datasheet limits are 0.5V to 0.54V.

Variables Data Plots (Continued)

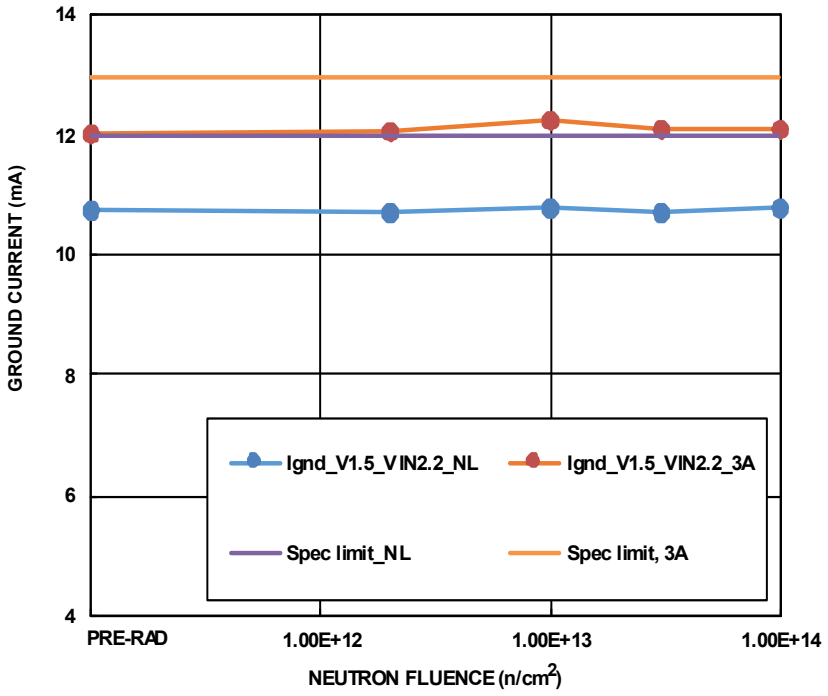

FIGURE 14. ISL75051SEH ground current at 1.5V output voltage and 2.2V input voltage, no load and 3.0A load cases, as a function of 1MeV equivalent neutron irradiation at 2 x 10^{12} n/cm^2, 1 x 10^{13} n/cm^2, 3 x 10^{13} n/cm2 and 1 x 10^{14} n/cm^2. Sample size for each cell was 5. The datasheet limits are 12.0mA maximum (no load) and 13.0mA maximum (3.0A load).

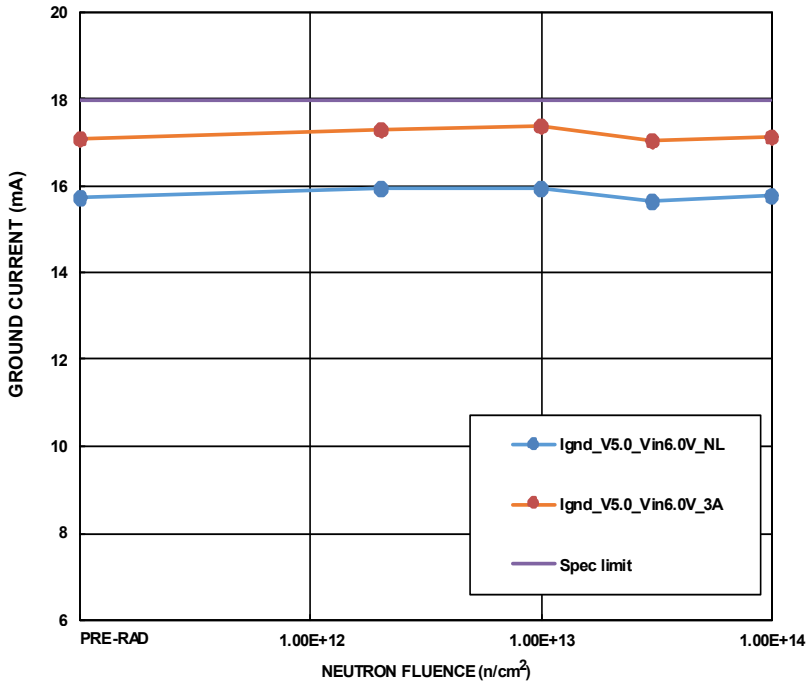

FIGURE 15. ISL75051SEH ground current at 5.0V output voltage and 6.0V input voltage, no load and 3.0A load cases, as a function of 1MeV equivalent neutron irradiation at 2 x 10^{12} n/cm^2, 1 x 10^{13} n/cm^2, 3 x 10^{13} n/cm^2 and 1 x 10^{14} n/cm^2. Sample size for each cell was 5. The datasheet limits are 18.0mA (no load and 3.0A load).

Variables Data Plots (Continued)

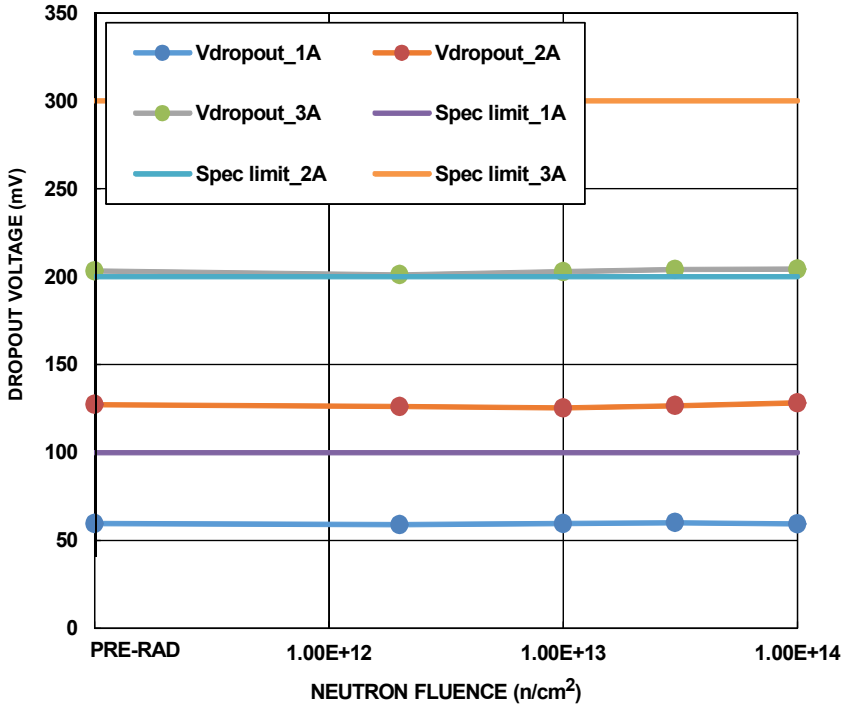

FIGURE 16. ISL75051SEH dropout voltage, 1.0A, 2.0A and 3.0A output current, as a function of 1MeV equivalent neutron irradiation at 2 x 10^{12} n/cm^2, 1 x 10^{13} n/cm^2, 3 x 10^{13} n/cm^2 and 1 x 10^{14} n/cm^2. Sample size for each cell was 5. The datasheet limits are 100.0mV maximum (1.0A), 200.0mV maximum (2.0A) and 300.0mV maximum (3.0A).

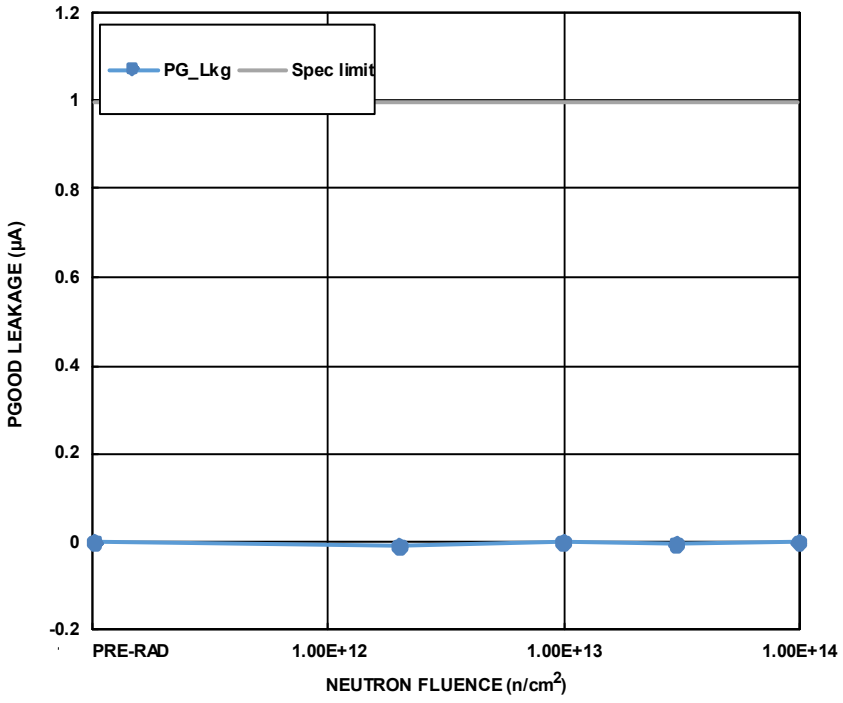

FIGURE 17. ISL75051SEH PGOOD leakage as a function of 1MeV equivalent neutron irradiation at 2 x 10^{12} n/cm^2, 1 x 10^{13} n/cm^2, 3 x 10^{13} n/cm^2 and 1 x 10^{14} n/cm^2. Sample size for each cell was 5. The datasheet limits is 1.0µA maximum.

Variables Data Plots (Continued)

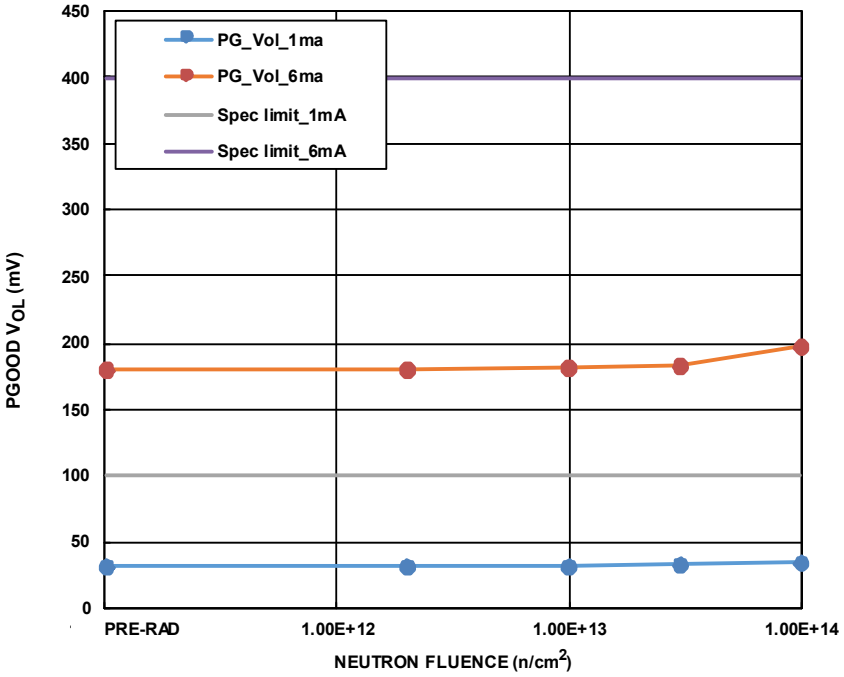

FIGURE 18. ISL75051SEH PGOOD output low voltage at 1.0mA and 6.0mA as a function of 1MeV equivalent neutron irradiation at 2 x 10^{12} n/cm^2, 1 x 10^{13} n/cm^2, 3 x 10^{13} n/cm^2 and 1 x 10^{14} n/cm^2. Sample size for each cell was 5. The datasheet limits are 100.0mV maximum (1.0mA) and 400.0mV maximum (6.0mA).

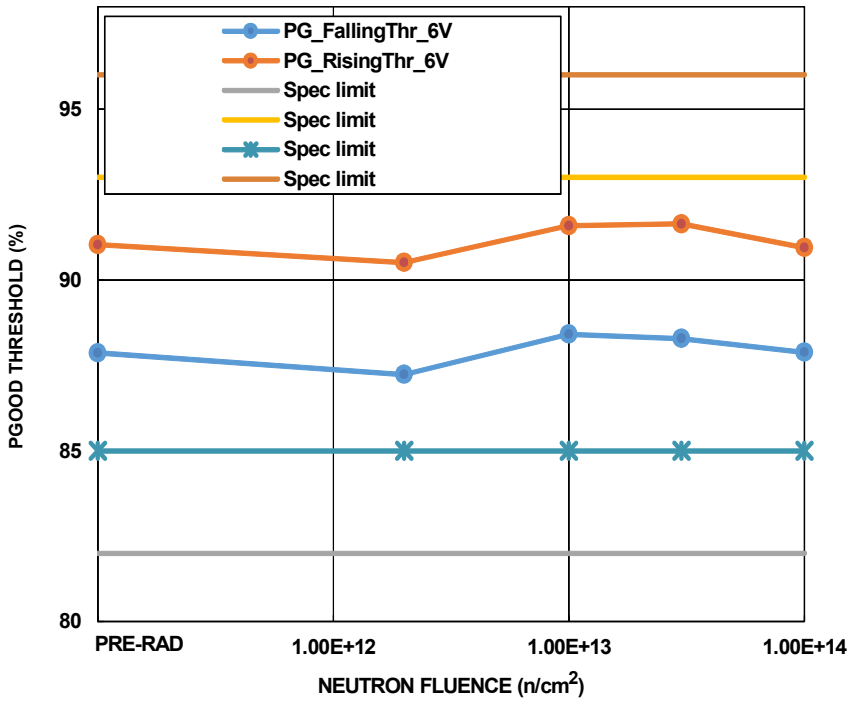

FIGURE 19. ISL75051SEH PGOOD rising and falling threshold, 6.0V input voltage, as a function of 1MeV equivalent neutron irradiation at 2 x 10^{12} n/cm^2, 1 x 10^{13} n/cm^2, 3 x 10^{13} n/cm^2 and 1 x 10^{14} n/cm^2. Sample size for each cell was 5. The datasheet limits are 82% to 93% (falling) and 85% to 96% (rising).

Variables Data Plots (Continued)

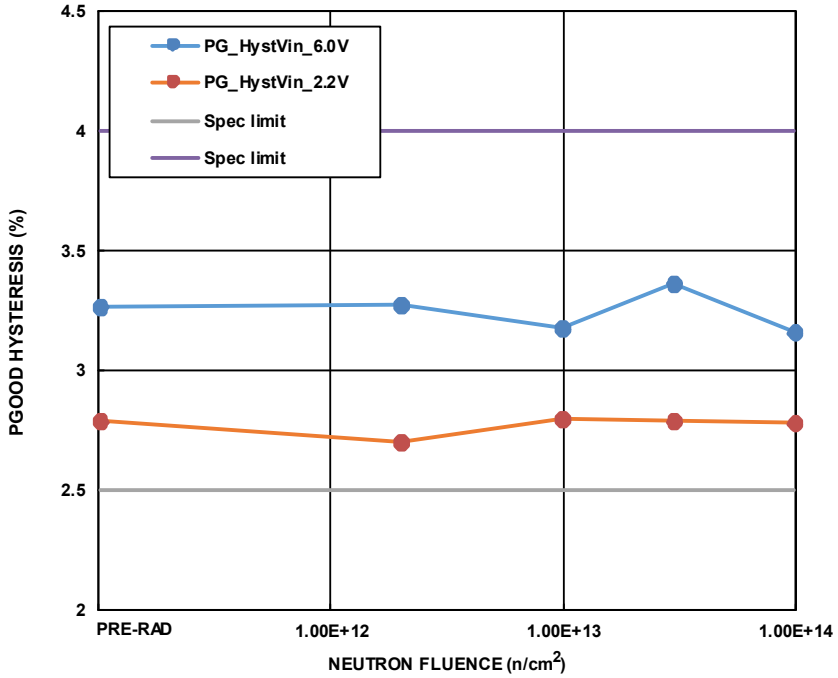

FIGURE 20. ISL75051SEH PGOOD hysteresis at 2.2V and 6.0V input voltage, as a function of 1MeV equivalent neutron irradiation at 2 x 10^{12} n/cm^2, 1 x 10^{13} n/cm^2, 3 x 10^{13} n/cm^2 and 1 x 10^{14} n/cm^2. Sample size for each cell was 5. The datasheet limits are 2.5% to 4.0%.

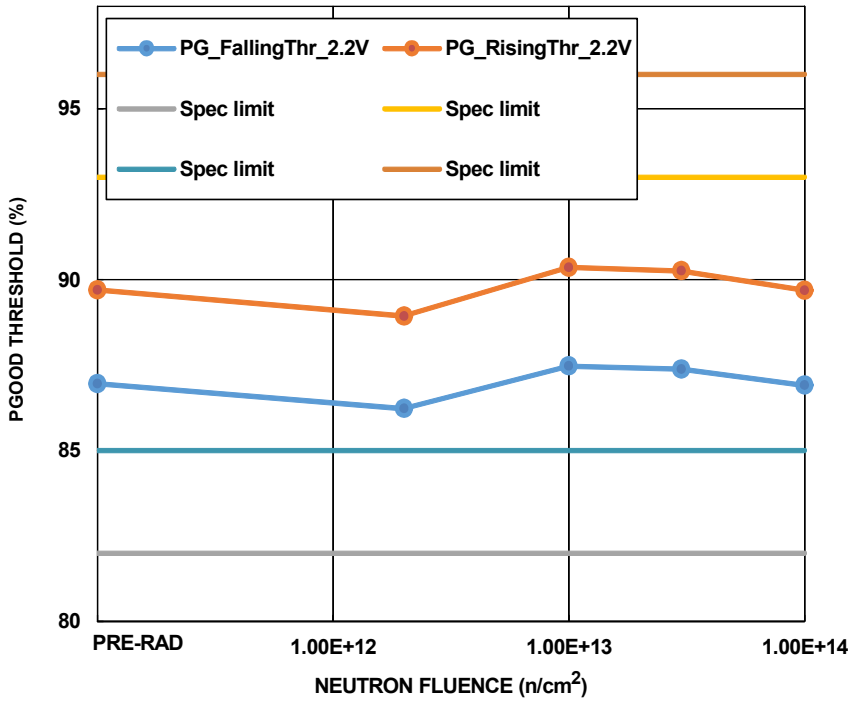

FIGURE 21. PGOOD rising and falling threshold, 2.2V input voltage, as a function of 1MeV equivalent neutron irradiation at 2 x 10^{12} n/cm^2, 1 x 10^{13} n/cm^2, 3 x 10^{13} n/cm^2 and 1 x 10^{14} n/cm^2. Sample size for each cell was 5. The data sheet limits are 82% to 93% (falling) and 85% to 96% (rising).

Variables Data Plots (Continued)

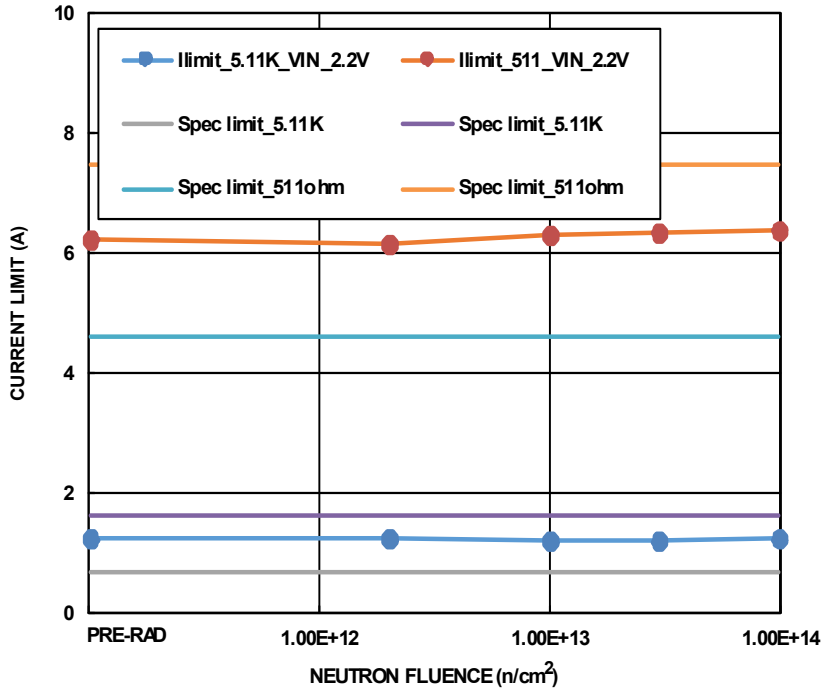

FIGURE 22. ISL75051SEH output current limit, 2.2V input voltage, 5.11kΩ and 511Ω set resistor cases as a function of 1MeV equivalent neutron irradiation at 2 x 10^{12} n/cm^2, 1 x 10^{13} n/cm^2, 3 x 10^{13} n/cm^2 and 1 x 10^{14} n/cm^2. Sample size for each cell was 5. The datasheet limits are 0.65A to 1.6A (5.11kΩ set resistor) and 4.6A to 7.5A (511Ω set resistor).

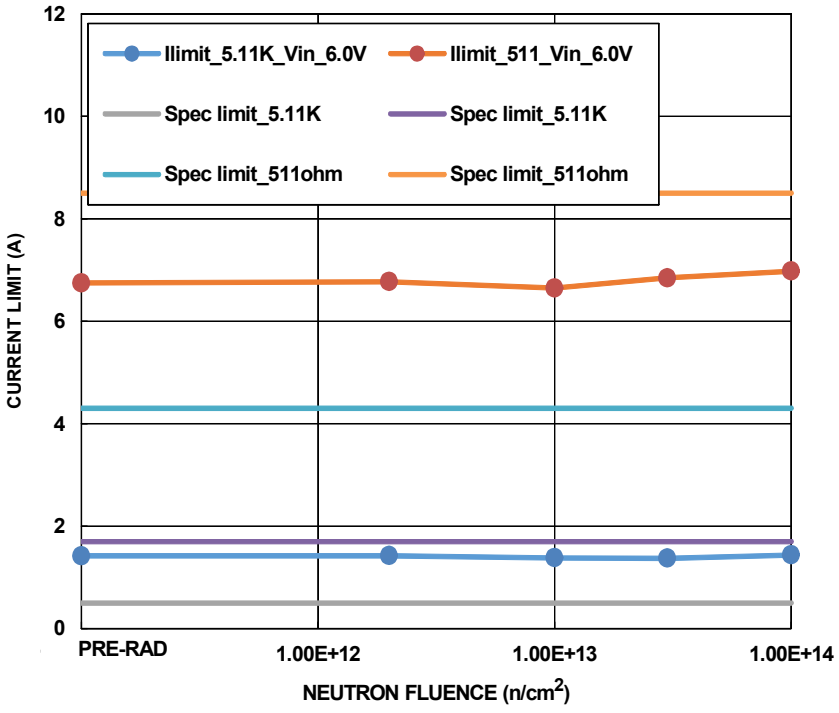

FIGURE 23. ISL75051SEH output current limit, 6.0V input voltage, 5.11kΩ and 511Ω set resistor cases, as a function of 1MeV equivalent neutron irradiation at 2 x 10^{12} n/cm^2, 1 x 10^{13} n/cm^2, 3 x 10^{13} n/cm^2 and 1 x 10^{14} n/cm^2. Sample size for each cell was 5. The datasheet limits are 0.5A to 1.7A (5.11kΩ set resistor) and 4.3A to 8.5A (511Ω set resistor).

Conclusion

This report summarizes the results of 1MeV equivalent neutron testing of the ISL75051SEH low dropout voltage linear regulator. The test was conducted in order to determine the sensitivity of the part to displacement damage (DD) caused by neutron or proton environments in space. Neutron fluences ranged from 2×10^{12} n/cm^2 to 1×10^{14} n/cm^2. This project was carried out in collaboration with VPT, Inc. (Blacksburg, VA), and their support is gratefully acknowledged.

The part performed very well. The samples met all specifications (Bin 1) after 2×10^{11} n/cm^2, 1×10^{13} n/cm^2 and 3×10^{13} n/cm^2. ATE testing showed one parametric reject after 1×10^{14} n/cm^2. The part marginally failed the adjust pin voltage at the high end of the spec. The part may be usable to a neutron level of 3×10^{13} n/cm^2.

Appendices

Reported Parameters

The limits are from the SMD and are provided for guidance only in Table 3 as the ISL75051SEH part is not designed or guaranteed for the neutron environment. A number of parameters are plotted in the same figure (i.e., Figure 1, on page 3, which plots the neutron response of both the enable low and enable High currents) in order to save space.

TABLE 3. REPORTED PARAMETERS

FIGURE NUMBER	PARAMETER	LIMIT, LOW	LIMIT, HIGH	UNITS	NOTES
1	Enable Low current	-	1.0	µA	
1	Enable High current	-	1.0	µA	
2	Adjust pin bias current	-1.0	1.0	µA	
3	Enable threshold, rising	0.6	1.2	µA	
4	Enable threshold, falling	0.47	0.9	µA	
5	Enable hysteresis	90.0	318.0	mV	
6	Enable delay	225.0	450.0	µs	
7	Output voltage, 0.52V	0.5122	0.5278	V	No load, $2.2V_{IN}$
7	Output voltage, 0.52V	0.5122	0.5278	V	3.0A load, $2.2V_{IN}$
8	Output voltage, 0.52V	0.5122	0.5278	V	No load, $3.6V_{IN}$
8	Output voltage, 0.52V	0.5122	0.5278	V	3.0A load, $3.6V_{IN}$
9	Output voltage, 5.0V	4.925	5.075	V	No load, $5.4V_{IN}$
9	Output voltage, 5.0V	4.925	5.075	V	3.0A load, $5.4V_{IN}$
10	Output voltage, 5.0V	4.925	5.075	V	No load, $6.0V_{IN}$
10	Output voltage, 5.0V	4.925	5.075	V	3.0A load, $6.0V_{IN}$
11	Line regulation	-	8.0	mV	$1.5V_{OUT}$
11	Line regulation	-	10.5	mV	$1.8V_{OUT}$
11	Line regulation	-	20.0	mV	$5.0V_{OUT}$
12	Load regulation	-4.0	-0.1	mV	$1.5V_{OUT}$
12	Load regulation	-4.0	-0.05	mV	$1.8V_{OUT}$
12	Load regulation	-15.0	-0.05	mV	$5.0V_{OUT}$
13	Bypass pin voltage	0.5	0.54	V	
14	Ground current, 1.5V	-	12.0	mA	No load, $2.2V_{IN}$
14	Ground current, 1.5V	-	13.0	mA	3.0A load, $2.2V_{IN}$
15	Ground current, 5.0V	-	18.0	mA	No load, $6.0V_{IN}$
15	Ground current, 5.0V	-	18.0	mA	3.0A load, $6.0V_{IN}$
16	Dropout voltage, 1.0A	-	100.0	mV	

TABLE 3. REPORTED PARAMETERS (Continued)

FIGURE NUMBER	PARAMETER	LIMIT, LOW	LIMIT, HIGH	UNITS	NOTES
16	Dropout voltage, 2.0A	-	200.0	mV	
16	Dropout voltage, 3.0A	-	300.0	mV	
17	PGOOD leakage	-	1.0	µA	
18	PGOOD VOL	-	100	mV	1mA
18	PGOOD VOL	-	400	mV	6mA
19	PGOOD Rising threshold	85	96	%	6.0V_{IN}
19	PGOOD Falling threshold	82	93	%	6.0V_{IN}
20	PGOOD hysteresis	2.5	4.0	%	6.0V and 2.2V_{IN}
21	PGOOD Rising threshold	85	96	V	2.2V_{IN}
21	PGOOD Falling threshold	82	93	%	2.2V_{IN}
22	Output current limit, 5.11kΩ	0.65	1.6	%	2.2V_{IN}
22	Output current limit, 511Ω	4.6	7.5	A	2.2V_{IN}
23	Output current limit, 5.11kΩ	0.5	1.7	A	6.0V_{IN}
23	Output current limit, 511Ω	4.3	8.5	A	6.0V_{IN}

Revision History

DATE	REVISION	CHANGE
Oct 21, 2019	1.00	Added ISL75051SRH, ISL75051ASEH, ISL73051ASEH to page 1. Updated Related Literature section. Added Revision History. Updated disclaimer.

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(Rev.1.0 Mar 2020)

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