ISL75054M

Neutron Test Results of the ISL75054M Radiation Tolerant Ultra Low Noise 1A LDO

Introduction

This report summarizes results of 1MeV equivalent neutron testing of the ISL75054M low dropout linear regulator. This test was conducted to determine the sensitivity of the part to displacement damage (DD) caused by neutron or proton environments. Neutron fluences ranged from $5{\times}10^{11}n/cm^2$ to $1{\times}10^{13}n/cm^2$.

Product Description

The ISL75054M is a radiation tolerant low dropout linear regulator with ultra-low noise and high PSRR intended for ADC, RF, and other noise sensitive applications. The device has an operating supply voltage range of 2.7V to 30V and an output voltage range of 0.5V to V_{IN} - V_{DO}. Built-in protection includes V_{IN} - V_{OUT} foldback current limiting, externally programmable current limit, and over-temperature protection. The ISL75054M features excellent noise performance and PSRR for radiation tolerant LDOs, with ultra-low RMS noise of 3.9µVRMS from 10Hz to 100kHz and ultra-high PSRR of 104dB at 120Hz. Detailed Electrical Specifications for these devices are contained in the datasheet.

The ISL75054M is fabricated on a Silicon-On Insulator (SOI) process, which makes it latch-up free. It is offered in a 16 lead heatsink thin shrink small outline package (HTSSOP) and operates across the full military temperature range of -55°C to +125°C. A block diagram is shown in Figure 1.

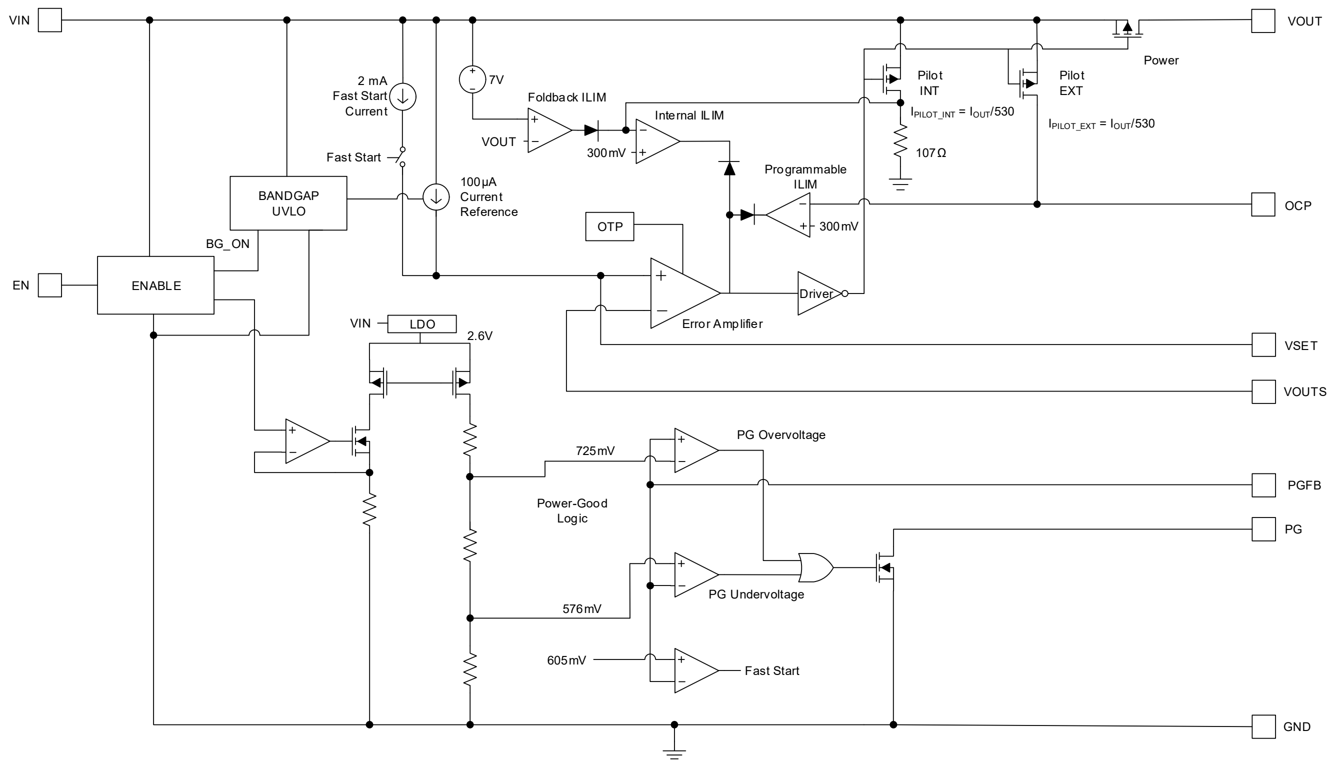

Figure 1. Block Diagram

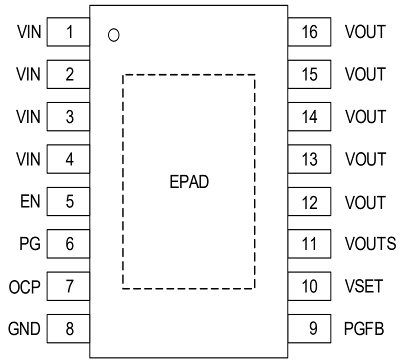

Figure 2. Pin Assignments

Related Literature

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

- ISL75054M device page
- MIL-STD-883 Test Method 1017

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1. Test Description

1.1 Irradiation Facilities

Neutron fluence irradiations were performed on the test samples on May 27, 2025, at the University of Massachusetts, Lowell (UMASS Lowell) fast neutron irradiator per Mil-STD-883G, Method 1017.2, with each part unpowered during irradiation. The target irradiation levels were 5×10^{11}n/cm^2, 2×10^{12}n/cm^2, and 1×10^{13}n/cm^2. The parts were shipped back to Renesas (Palm Bay, FL) for post-irradiation electrical testing.

1.2 Test Fixturing

No formal irradiation test fixturing is involved, as these DD tests are "bag tests" in the sense that the parts are irradiated with all leads unbiased.

1.3 Radiation Dosimetry

Table 1 shows dosimetry from UMASS Lowell indicating the total accumulated gamma dose and actual neutron fluence exposure levels for each set of samples.

Table 1. Neutron Fluence Dosimetry Data

Irradiation	Requested Fluence (n/cm^2)	Reactor Power (kW)	Time (s)	Flux (n/cm^2-s)[1][2]	Gamma Dose (rad(Si))[3]	Measured Fluence (n/cm^2)[4]
CRF#98191-C	5.00E+11	40	262	3.06E+09	119	6.12E+11
CRF#98191-D	2.00E+12	80	531	6.12E+09	484	2.38E+12
CRF#98191-E	1.00E+13	800	266	6.12E+10	2424	1.19E+13

1. Dosimetry method: ASTM E-265
2. The neutron fluence rate is determined from *Initial Testing of the New Ex-Core Fast Neutron Irradiator at UMass Lowell (6/18/02)*. Validated on 6/07/2011 under the Trident II D5LE neutron facility study by Navy Crane. Re-affirmed 8/1/17 using SACRR transistor transfer calibration based on ASTM E1855 – 15.
3. Based on reactor power at 1000kW, the gamma dose is 41 ±5.3%krad(Si)/hr as mapped by TLD-based dosimetry.
4. Validated by S-32 flux monitors

1.4 Characterization Equipment and Procedures

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

1.5 Experimental Matrix

Testing proceeded in general accordance with the guidelines of MIL-STD-883 TM 1017. The experimental matrix consisted of five samples to be irradiated at 5×10^{11}n/cm^2, five to be irradiated at 2×10^{12}n/cm^2, and five to be irradiated at 1×10^{13}n/cm^2. The actual levels achieved, which are shown in Table 1, were 6.12×10^{11}n/cm^2, 2.38×10^{12}n/cm^2, and 1.19×10^{13}n/cm^2. Three control units were used.

The 18 ISL75054M samples were drawn from Lot F6X120. Samples were packaged in the 16 lead HTTSOP.

2. Results

Neutron testing of the ISL75054M is complete and the results are reported in the balance of this report. It should be understood when interpreting the data that each neutron irradiation was performed on a different set of samples; this is not total dose testing, where the damage is cumulative.

2.1 Attributes Data

Table 2 shows the ISL75054M Attributes Data.

Table 2. Attributes Data

1MeV Fluence, (n/cm^2)		Sample Size	Pass[1]	Fail	Notes
Planned	Actual				
5×10^{11}	6.12E+11	5	5	0	All passed
2×10^{12}	2.38E+12	5	0	5	All failed
1×10^{13}	1.19E+13	5	0	5	All failed

1. A Pass indicates a sample that passes all post-irradiation datasheet limits.

2.2 Key Parameter Variables Data

The plots in Figure 3 through Figure 27 show data plots for key parameters before and after irradiation to each neutron fluence level. The plots show the mean of each parameter as a function of neutron irradiation. Each marker represents a different set of six samples. The line connecting them is for trend visualization only. The plots also include error bars at each down-point, representing the minimum and maximum measured values of the samples, although in some plots the error bars might not be visible due to their values compared to the scale of the graph. The applicable electrical limits taken from the datasheet are also shown.

All samples passed the post-irradiation datasheet limits after the 5×10^{11}n/cm^2 exposure (6.12×10^{11}n/cm^2 actual) but all failed at least one datasheet parameter after the 2×10^{12}n/cm^2 exposure, although they stayed fully functional. All five units failed after the 1×10^{13}n/cm^2 exposure with some units being non-functional.

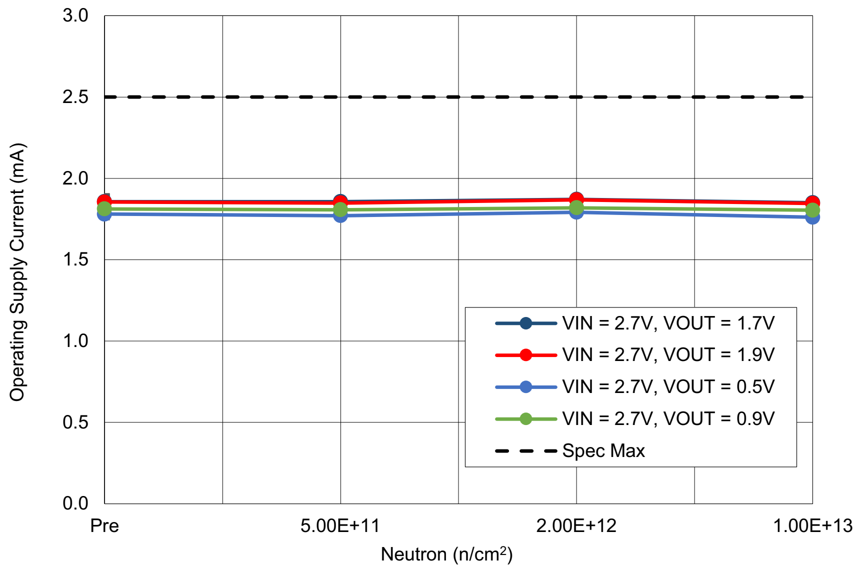

Figure 3. ISL75054M average operating supply current at V_{IN} = 2.7V; V_{OUT} = 0.5V, 0.9V, 1.7V, and 1.9V, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limit is 2.5mA maximum.

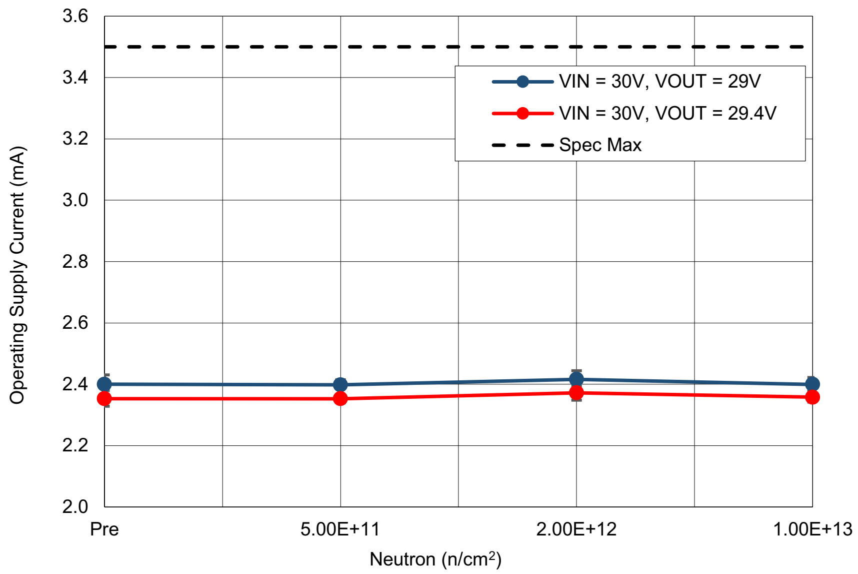

Figure 4. ISL75054M average operating supply current at V_{IN} = 30V, with V_{OUT} = 29V and 29.4V, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limit is 3.5mA maximum.

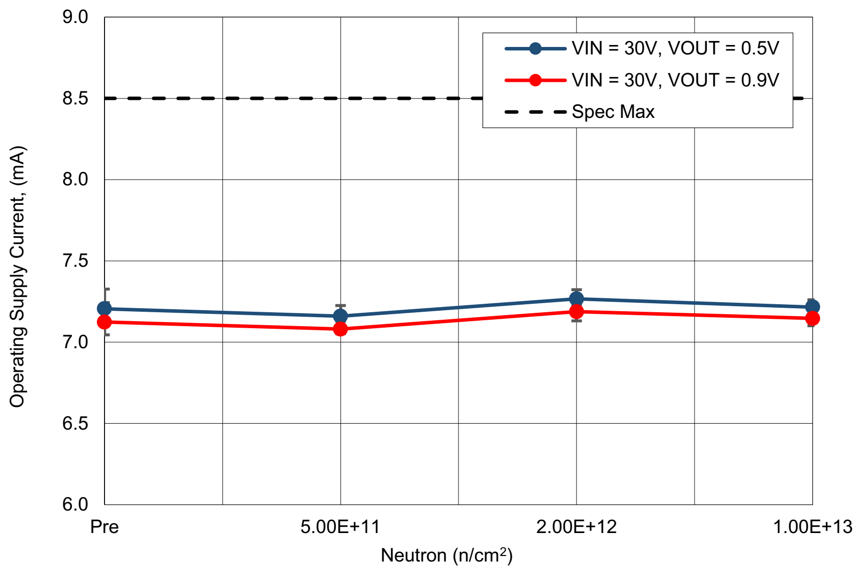

Figure 5. ISL75054M average operating supply current at V_{IN} = 30V, V_{OUT} = 0.5V, and V_{IN} = 30V, V_{OUT} = 0.9V, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limit is 8.5mA maximum.

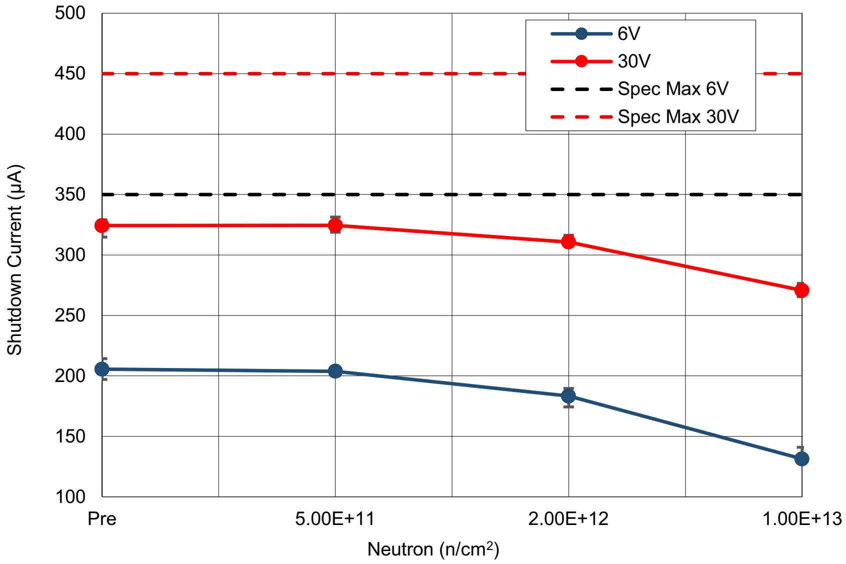

Figure 6. ISL75054M average shutdown supply current at V_{CC} = 6V and 30V, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limits are 350µA maximum at 6V and 450µA maximum at 30V.

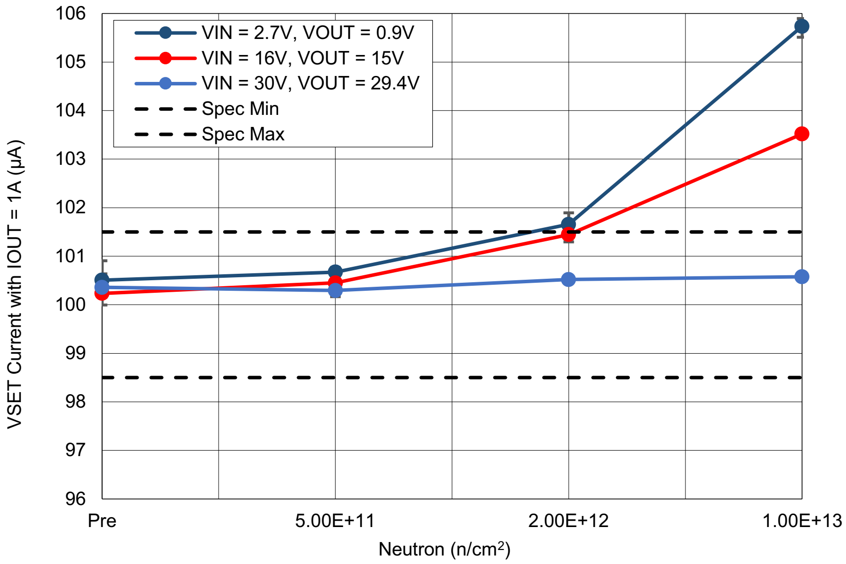

Figure 7. ISL75054M average V_{SET} current with I_{OUT} = 1A; V_{IN} = 2.7V, V_{OUT} = 0.9V, V_{IN} = 16V, V_{OUT} = 15V and V_{IN} = 30V, V_{OUT} = 29.4V, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limits are 98.5µA minimum and 101.5µA maximum.

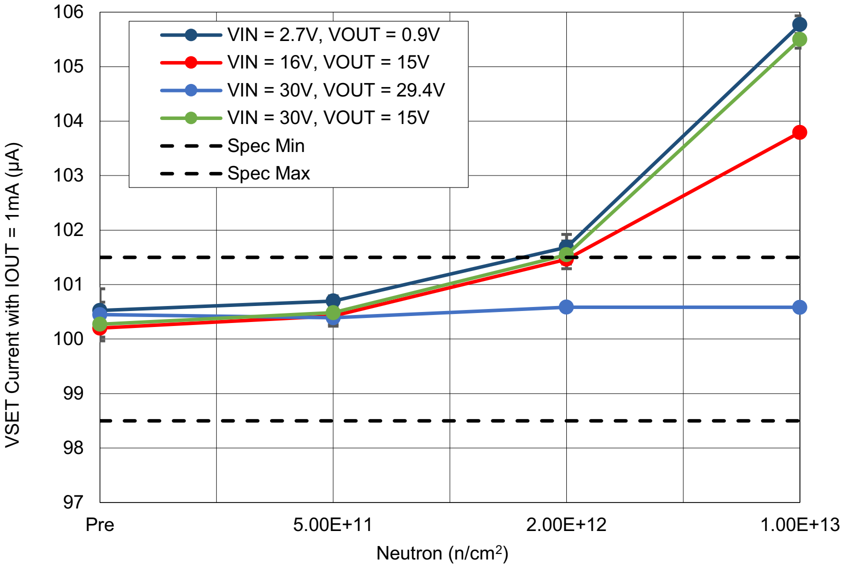

Figure 8. ISL75054M average V_{SET} current with I_{OUT} = 1mA; V_{IN} = 2.7V, V_{OUT} = 0.9V, V_{IN} = 16V, V_{OUT} = 15V, V_{IN} = 30V, V_{OUT} = 29.4V and V_{IN} = 30V, V_{OUT} = 15V, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limits are 98.5µA minimum and 101.5µA maximum.

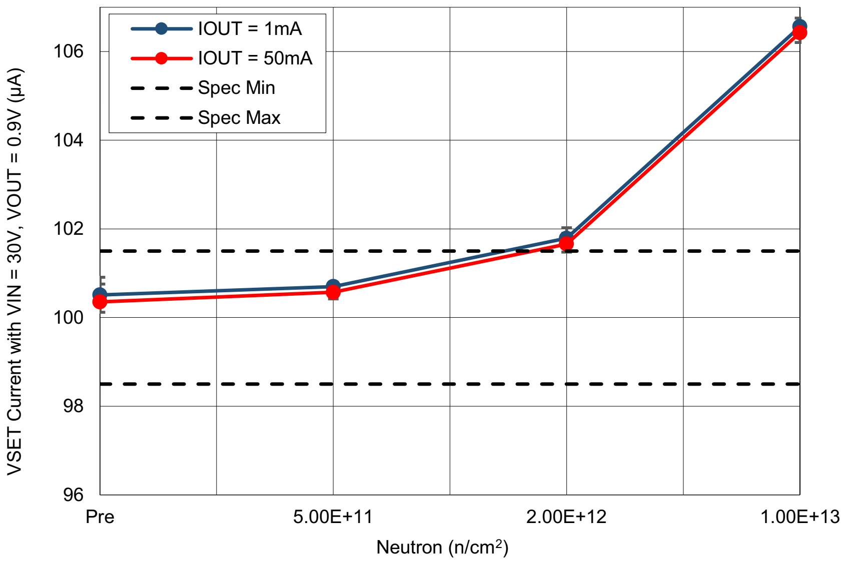

Figure 9. ISL75054M average V_{SET} current with V_{OUT} = 0.5V; V_{IN} = 2.7V, I_{OUT} = 1mA and 1A, V_{IN} = 30V, I_{OUT} = 1mA and 50mA, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limits are 98.5µA minimum and 101.5µA maximum.

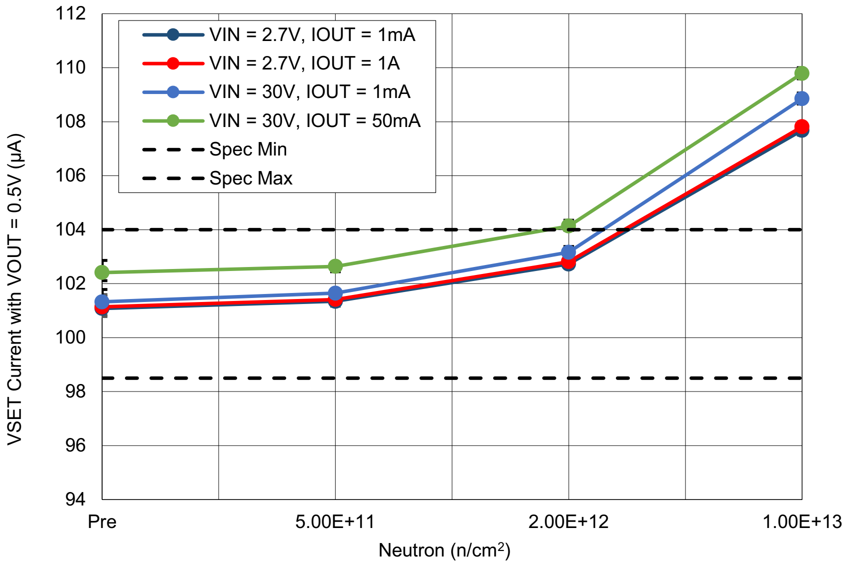

Figure 10. ISL75054M average V_{SET} current with V_{IN} = 30V and V_{OUT} = 0.9V; I_{OUT} = 1mA and 50mA, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limits are 98.5µA minimum and 104µA maximum.

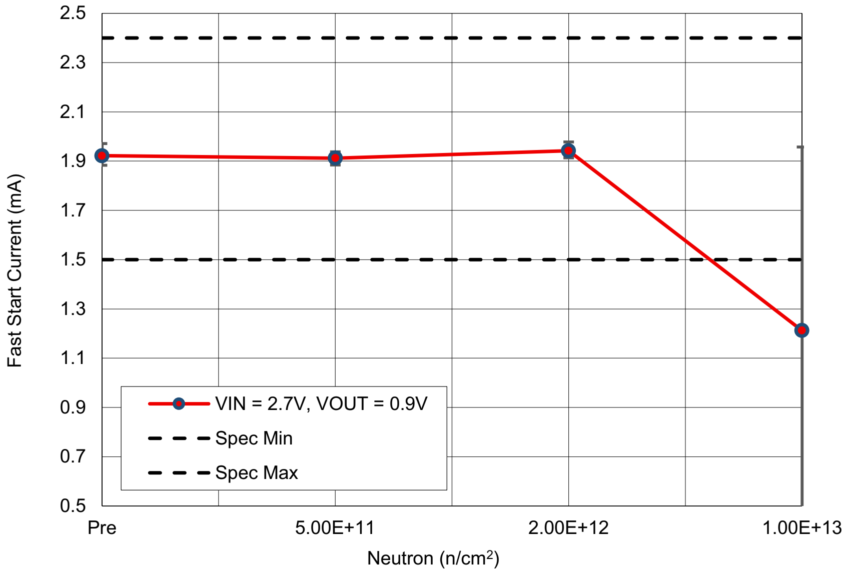

Figure 11. ISL75054M average V_{SET} fast start current with V_{IN} = 2.7V, V_{OUT} = 0.9V, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limits are 1.5mA minimum and 2.4mA maximum.

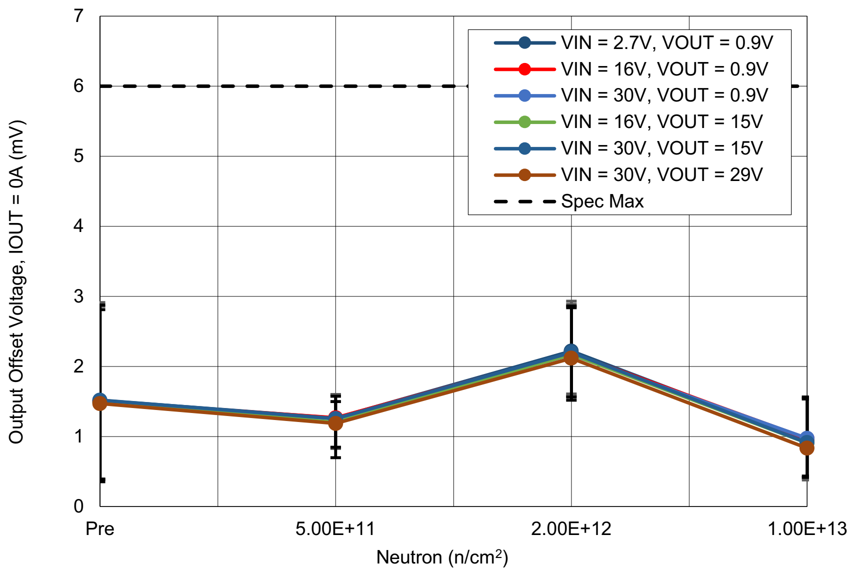

Figure 12. ISL75054M average output offset voltage with I_{OUT} = 0A; V_{IN} = 2.7V, V_{OUT} = 0.9V, V_{IN} = 16V, V_{OUT} = 0.9V, V_{IN} = 30V, V_{OUT} = 0.9V, V_{IN} = 16V, V_{OUT} = 15V and V_{IN} = 30V, V_{OUT} = 15V, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limit is 6mV maximum.

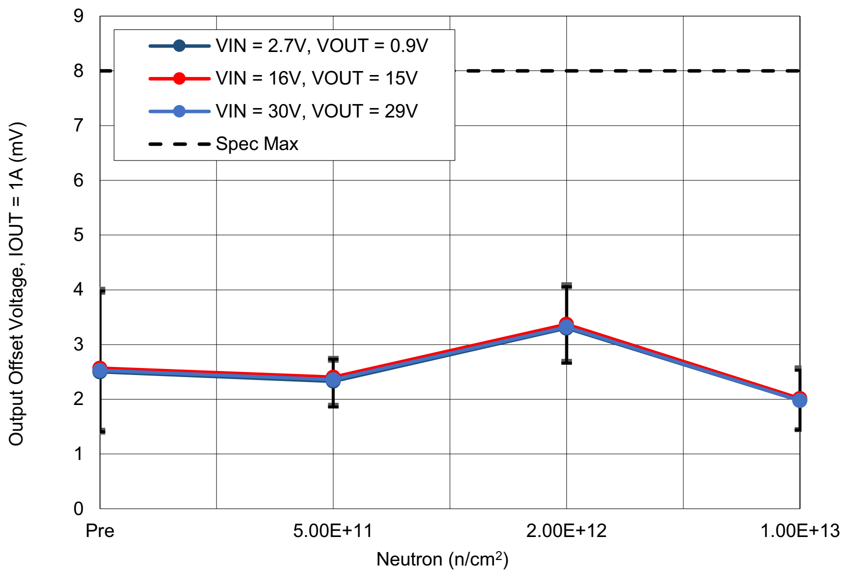

Figure 13. ISL75054M average output offset voltage with I_{OUT} = 1A; V_{IN} = 2.7V, V_{OUT} = 0.9V, V_{IN} = 16V, V_{OUT} = 15V and V_{IN} = 30V, V_{OUT} = 29V, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limit is 8mV maximum.

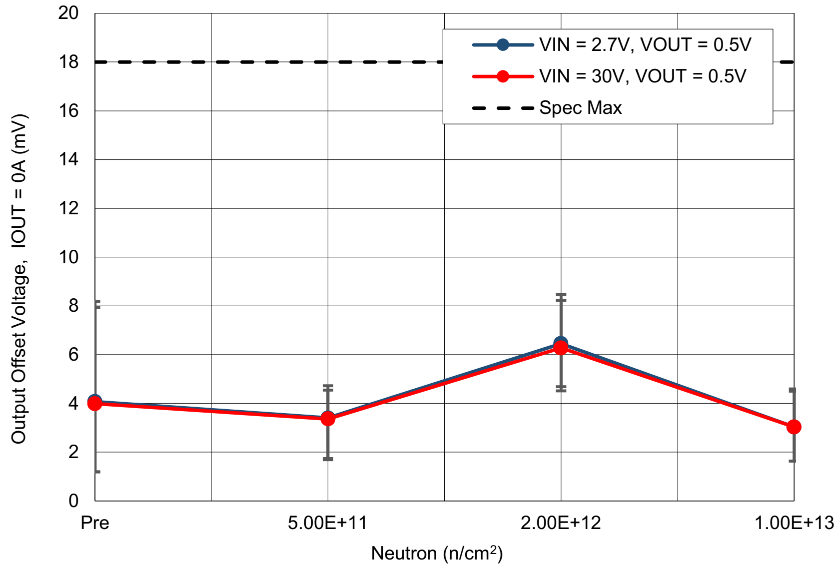

Figure 14. ISL75054M average output offset voltage with V_{OUT} = 0.5V and I_{OUT} = 0A; V_{IN} = 2.7V and 30V, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limit is 18mV maximum.

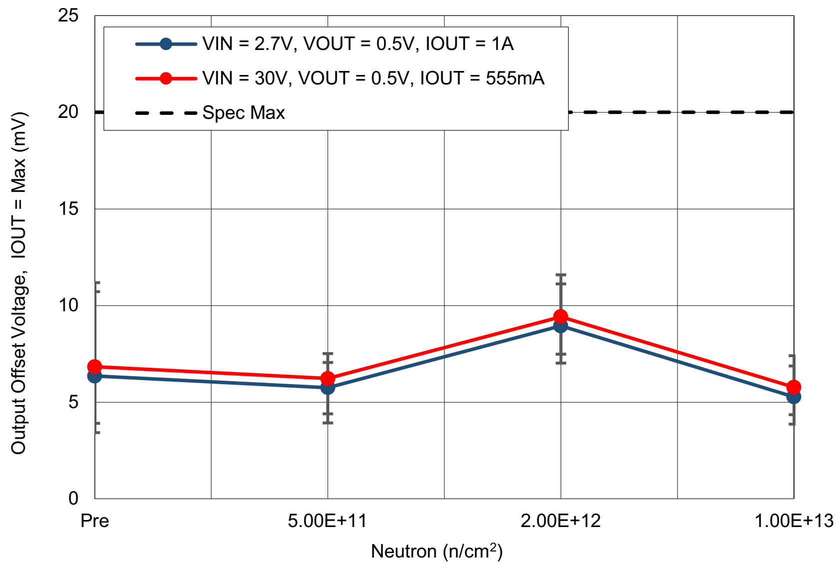

Figure 15. ISL75054M average output offset voltage with V_{OUT} = 0.5V and I_{OUT} = Max; V_{IN} = 2.7V, I_{OUT} = 1A and V_{IN} = 30V, I_{OUT} = 555mA, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limit is 20mV maximum.

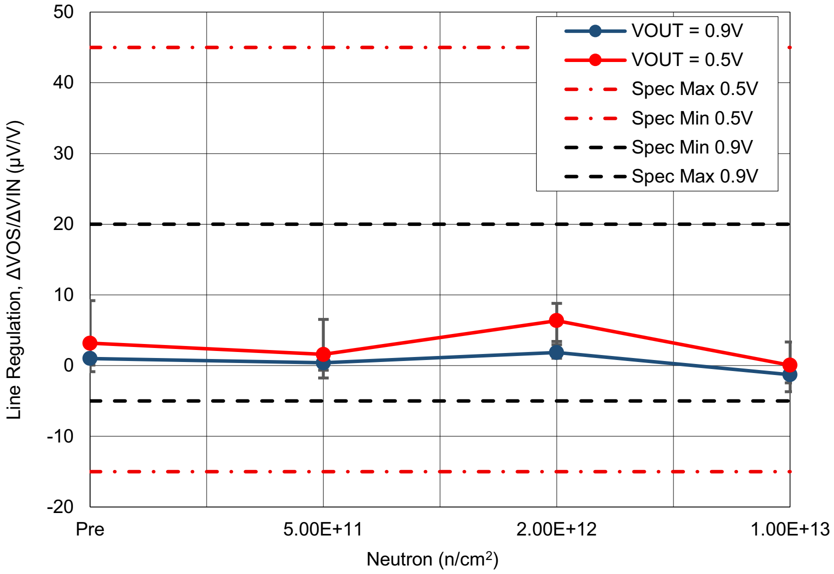

Figure 16. ISL75054M average line regulation ($\Delta V_{OS}/\Delta V_{IN}$), at V_{OUT} = 0.9V and 0.5V, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limits are -15µV/V minimum and 45µV/V maximum for V_{OUT} = 0.5V and -0.5µV/V minimum and 20µV/V maximum for V_{OUT} = 0.9V.

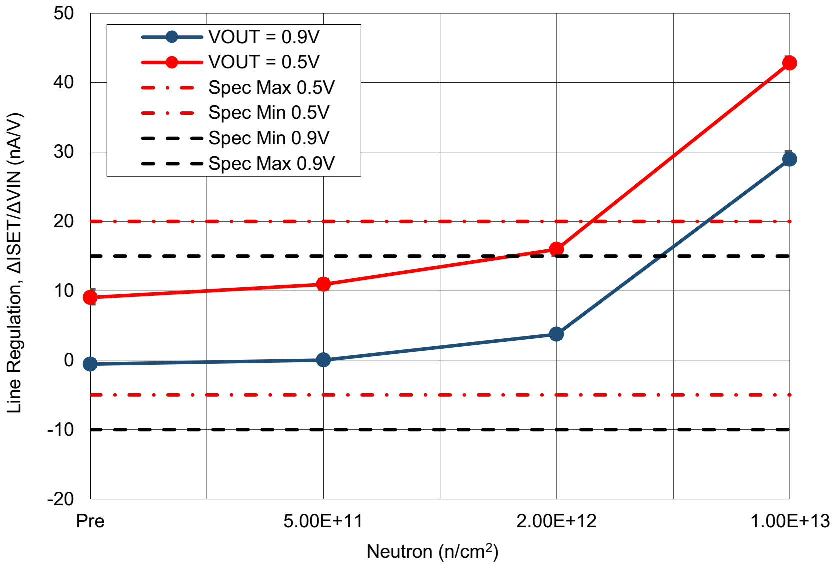

Figure 17. ISL75054M average line regulation ($\Delta I_{SET}/\Delta V_{IN}$), at V_{OUT} = 0.9V and 0.5V, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limits are -5nA/V minimum and 20nA/V maximum for V_{OUT} = 0.5V and -10nA/V minimum and 15n/V maximum for V_{OUT} = 0.9V.

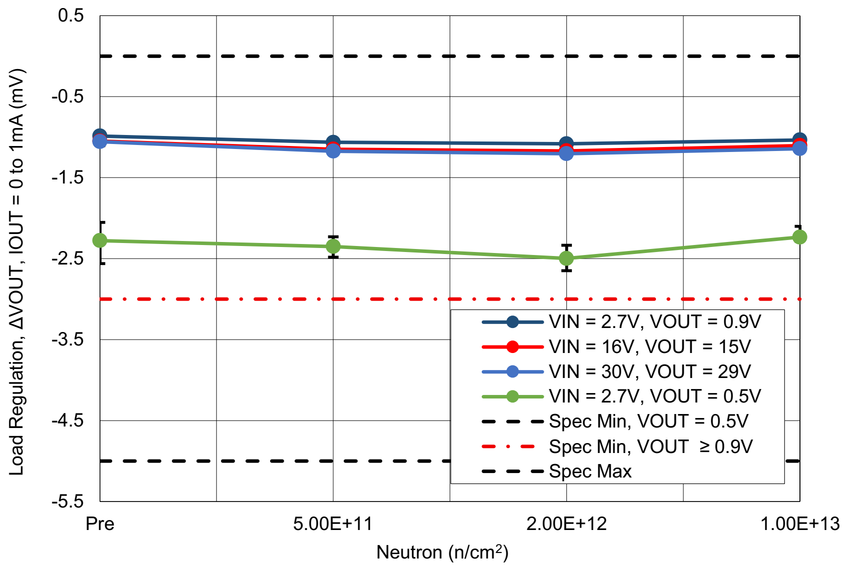

Figure 18. ISL75054M average load regulation (ΔV_{OUT}), at I_{OUT} = 0 to 1mA; V_{IN} = 2.7V, V_{OUT} = 0.9V, V_{IN} = 16V, V_{OUT} = 15V, V_{IN} = 30V, V_{OUT} = 29V and V_{IN} = 2.7V, V_{OUT} = 0.5V, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limits are -5mV minimum and 0mV maximum for V_{OUT} = 0.5V, and -3mV minimum and 0mV maximum for V_{OUT} = 0.9V.

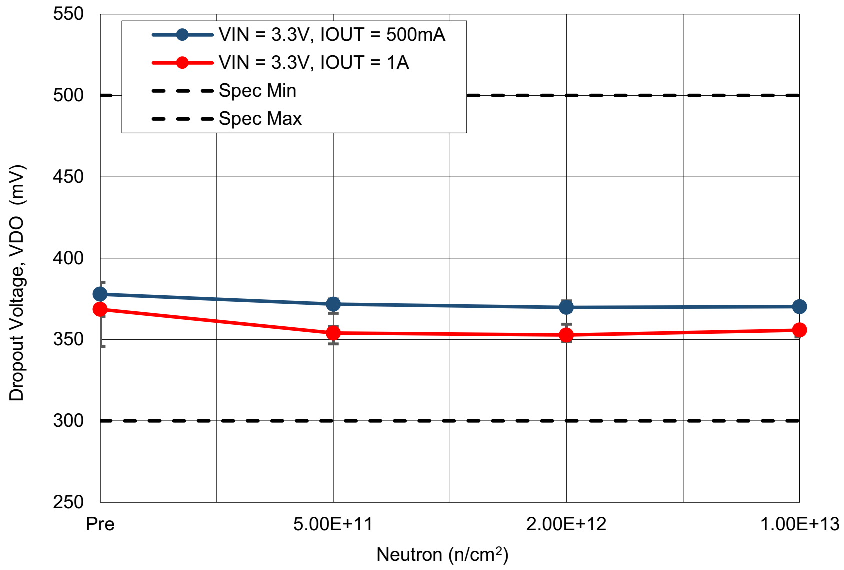

Figure 19. ISL75054M average dropout voltage at V_{IN} = 3.3V with I_{OUT} = 500mA and 1A, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limits are 300mV minimum and 500mV maximum.

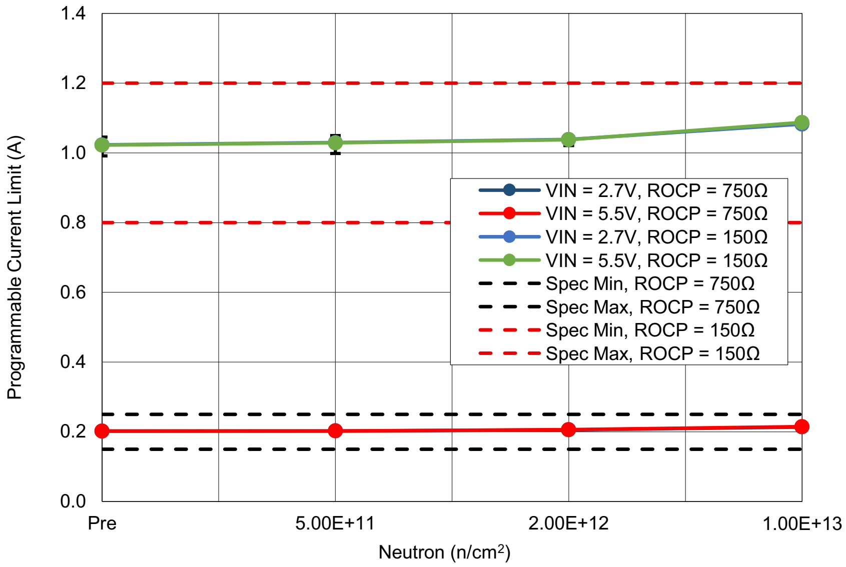

Figure 20. ISL75054M programmable current limit at V_{IN} = 2.7V and 5.5V with R_{OCP} = 150Ω and 750Ω, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limits are 0.15A minimum and 0.25A maximum for R_{OCP} = 750Ω and 0.8A minimum and 1.2A maximum for R_{OCP} = 150Ω.

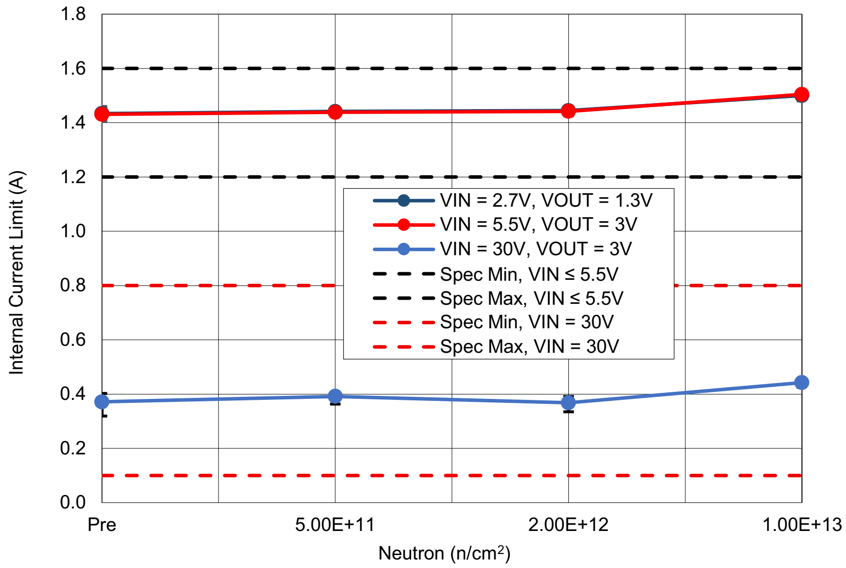

Figure 21. ISL75054M average internal current limit with V_{IN} = 2.7V, V_{OUT} = 1.3V, V_{IN} = 5.5V, V_{OUT} = 3V and V_{IN} = 30V, V_{OUT} = 3V, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limits are 1.2A minimum and 1.6A maximum for V_{IN} ≤ 5.5V and 0.1A minimum and 0.8A maximum for V_{IN} = 30V.

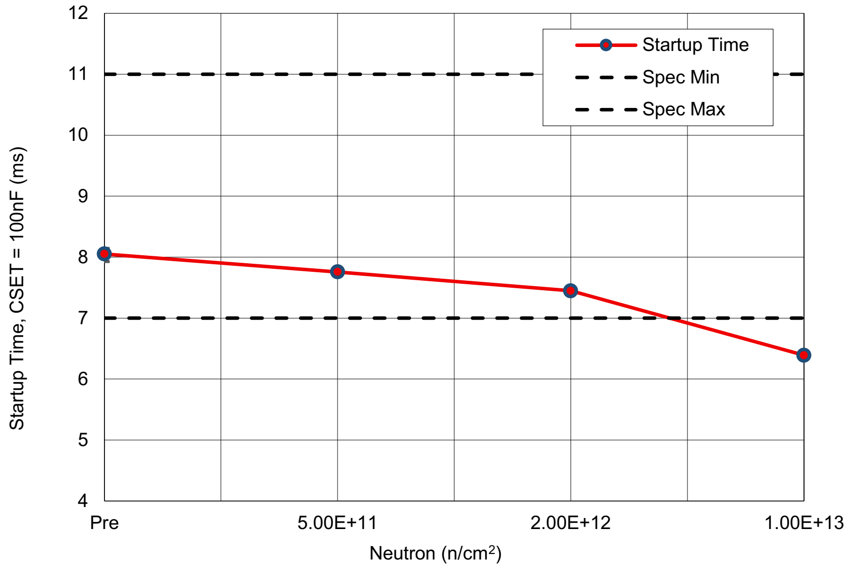

Figure 22. ISL75054M average Startup Time with C_{SET} = 100nF as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limits are 7ms minimum and 11ms maximum.

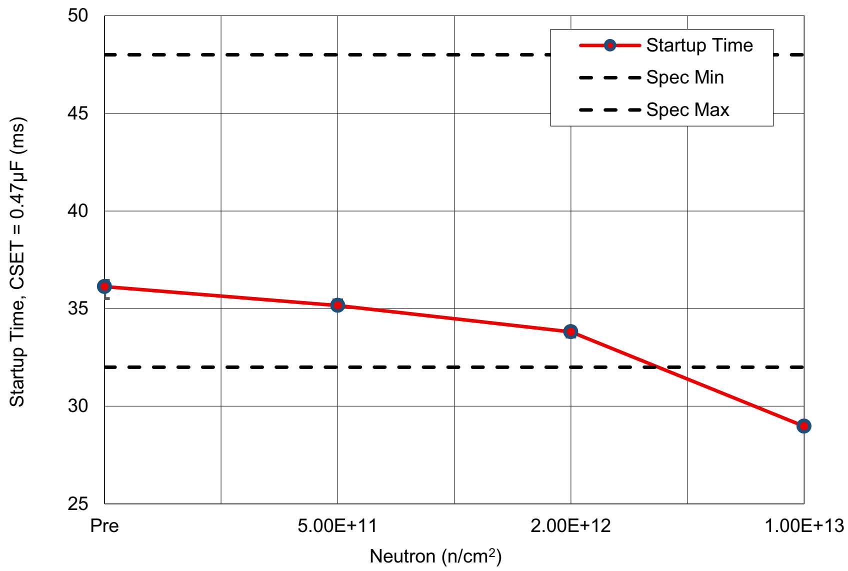

Figure 23. ISL75054M average Startup Time with C_{SET} = 0.47µF as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limits are 32ms minimum and 48ms maximum.

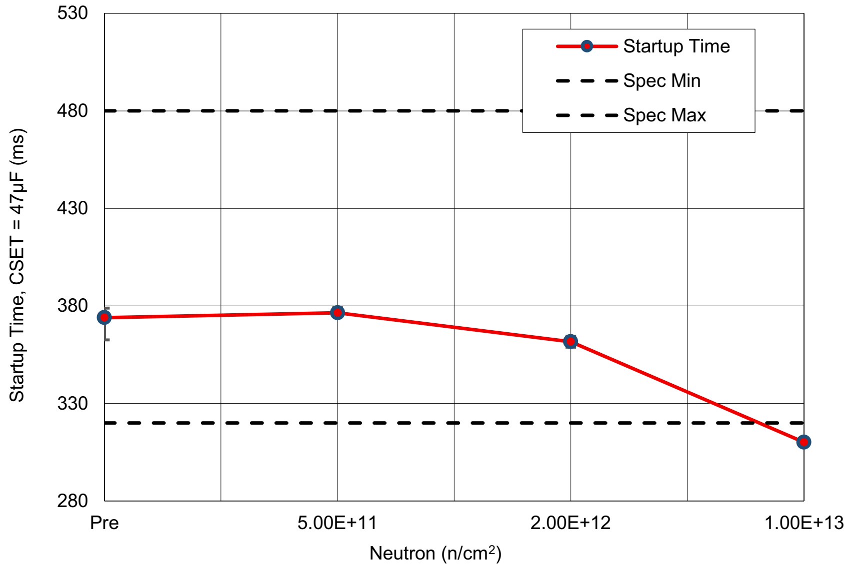

Figure 24. ISL75054M average Startup Time with C_{SET} = 47µF as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limits are 320ms minimum and 480ms maximum.

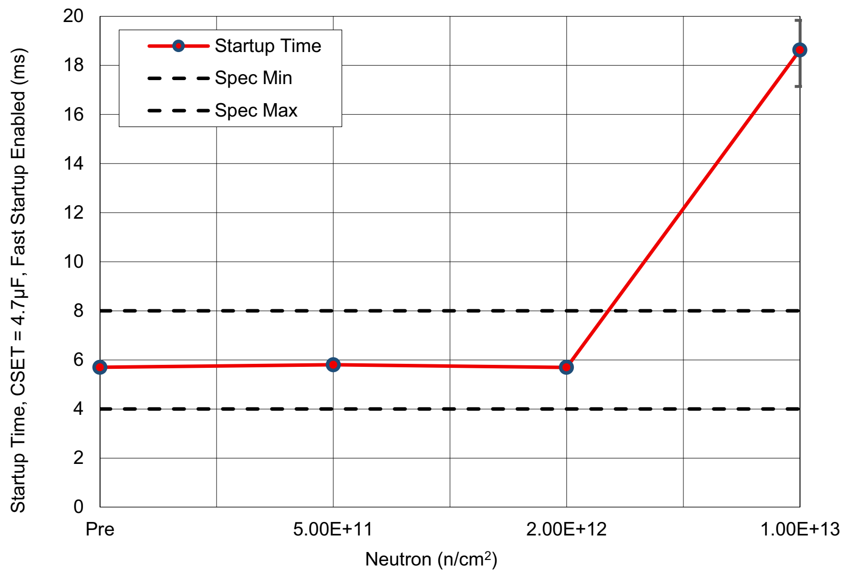

Figure 25. ISL75054M average Startup Time with C_{SET} = 4.7µF and Fast Startup Enabled as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limits are 4ms minimum and 8ms maximum.

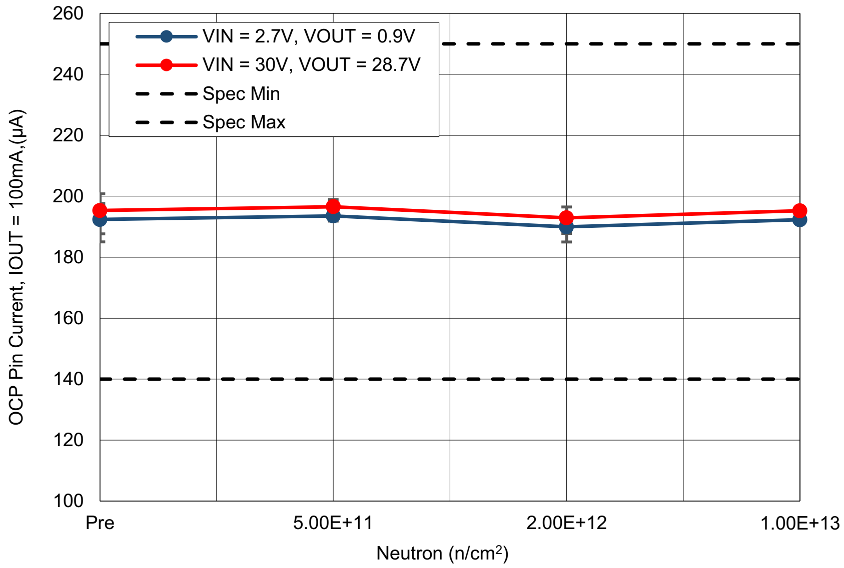

Figure 26. ISL75054M average OCP pin current with I_{OUT} = 100mA, V_{IN} = 2.7V, V_{OUT} = 0.9V and V_{IN} = 30V, V_{OUT} = 28.7V, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limits are 140µA minimum and 250µA maximum.

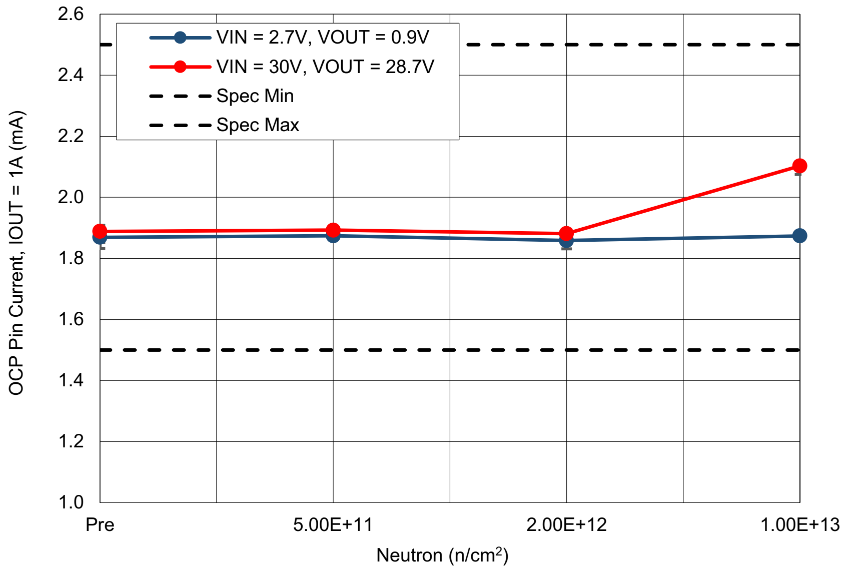

Figure 27. ISL75054M average OCP pin current with I_{OUT} = 1A, V_{IN} = 2.7V, V_{OUT} = 0.9V and V_{IN} = 30V, V_{OUT} = 28.7V, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limits are 1.5mA minimum and 2.5mA maximum.

3. Discussion and Conclusion

The results of 1MeV equivalent neutron testing of the ISL75054M radiation-tolerant low dropout linear regulator have been reported. Parts were tested after actual fluences of 6.12×10^{11}n/cm^2, 2.38×10^{12}n/cm^2 and 1.19×10^{13}n/cm^2. The results of key parameters before and after irradiation to each level are plotted in Figure 3 through Figure 27. The plots show the mean of each parameter as a function of neutron irradiation, with error bars that represent the minimum and maximum measured values. The figures also show the applicable electrical limits taken from the datasheet.

Although some parts remained functional to 1.19×10^{13}n/cm^2, they began showing parametric failures at 2.38×10^{12}n/cm^2. The parameters that failed were VSET current and line regulation. The process that the part is built on is a 0.15µm BCD SOI process that has lateral NPN and PNP Bipolars, that are used in some precision current blocks of the design. Displacement damage in BJTs degrades the gain and increases the leakage current. Gain degradation is due to the production of recombination centers everywhere in the device, with effects in the neutral base, emitter-base space-charge region, and neutral emitter being important in general. Leakage current increases due to the introduction of generation centers in device depletion regions. Lateral bipolars are more affected by displacement damage than vertical bipolars.

4. Revision History

Revision	Date	Description
1.00	Aug 12, 2025	Initial release.

A. Reported Parameters

Table 3 lists the key parameters that are considered indicative of part performance. These parameters are plotted in Figure 3 through Figure 27. All limits are taken from the *ISL75054M Datasheet*.

Table 3. Key Parameters (TA = 25°C)

Fig.	Parameter	Conditions	Min	Max	Units
3	Operating Supply Current	I_{OUT} = 0A; V_{OUT} = 0.5V; V_{IN} = 2.7V	-	2.5	mA
		I_{OUT} = 0A; V_{OUT} = 0.9V; V_{IN} = 2.7V			
		I_{OUT} = 0A; V_{OUT} = 1.7V; V_{IN} = 2.7V			
		I_{OUT} = 0A; V_{OUT} = 1.9V; V_{IN} = 2.7V			
4		I_{OUT} = 0A; V_{OUT} = 29V; V_{IN} = 30V	-	3.5	mA
		I_{OUT} = 0A; V_{OUT} = 29.4V; V_{IN} = 30V			
5		I_{OUT} = 0A; V_{OUT} = 0.5V; V_{IN} = 30V	-	8.5	mA
		I_{OUT} = 0A; V_{OUT} = 0.9V; V_{IN} = 30V			
6	Shutdown Current	EN = 0V; V_{IN} = 6V	-	350	µA
		EN = 0V; V_{IN} = 30V	-	450	µA
7	V_{SET} Current	V_{IN} = 2.7V to 30V; V_{OUT} = 0.9V to V_{IN} -V_{DO}; I_{OUT} = 1A, or 50mA for V_{IN}-V_{OUT} > 2.2V	98.5	101.5	µA
8					
9					
10		V_{IN} = 2.7V to 30V; V_{OUT} = 0.5V; I_{OUT} = 1A, or 50mA for V_{IN}-V_{OUT} > 2.2V	98.5	104	µA
11	V_{SET} Fast Start Current	V_{PGFB} = 560mV; V_{IN} = 2.7V; V_{SET} = 0.9V	1.5	2.4	mA
12	Output Offset Voltage	V_{IN} = 2.7V to 30V; V_{OUT} = 0.9V to V_{IN} - V_{DO}; I_{OUT} = 0mA	-	6	mV
13		V_{IN} = 2.7V to 30V; V_{OUT} = 0.9V to V_{IN} - V_{DO}; Maximum I_{OUT}	-	8	mV
14		V_{IN} = 2.7V to 30V; V_{OUT} = 0.5V; I_{OUT} = 0mA	-	18	mV
15		V_{IN} = 2.7V to 30V; V_{OUT} = 0.5V; Maximum I_{OUT}	-	20	mV
16	Line Regulation, $\Delta V_{OS}/\Delta V_{IN}$	V_{OUT} = 0.9V	-5	20	µV/V
		V_{OUT} = 0.5V	-15	45	µV/V
17	Line Regulation, $\Delta I_{SET}/\Delta V_{IN}$	V_{OUT} = 0.9V	-10	15	nA/V
		V_{OUT} = 0.5V	-5	20	nA/V
18	Load Regulation, ΔV_{OUT}	V_{IN} = 2.7V; V_{OUT} = 0.9V; I_{OUT} = 0mA to 1A	-3	0	mV
		V_{IN} = 16V; V_{OUT} = 15V; I_{OUT} = 0mA to 1A			
		V_{IN} = 2.7V; V_{OUT} = 0.5V; I_{OUT} = 0mA to 1A	-5	0	mV
		V_{IN} = 30V; V_{OUT} = 29V; I_{OUT} = 0mA to 1A			
19	Dropout Voltage, V_{DO}	V_{IN} - V_{OUT} for V_{IN} = 3.3V; R_{SET} = 33kΩ; I_{OUT} = 1mA	300	500	mV
		V_{IN} - V_{OUT} for V_{IN} = 3.3V; R_{SET} = 33kΩ; I_{OUT} = 500mA			
		V_{IN} - V_{OUT} for V_{IN} = 3.3V; R_{SET} = 33kΩ; I_{OUT} = 1A			
20	Programmable Current Limit	V_{IN} = 2.7V to 5.5V; R_{OCP} = 750Ω	0.15	0.25	A
		V_{IN} = 2.7V to 5.5V; R_{OCP} = 150Ω	0.8	1.2	A
21	Internal Current Limit	V_{IN} = 2.7V; V_{OUT} = 0V; OCP = 0V	1.2	1.6	A
		V_{IN} = 30V; V_{OUT} = 0V; OCP = 0V; V_{IN} - V_{OUT} foldback limiting	0.1	0.8	A

Table 3. Key Parameters (TA = 25°C)

Fig.	Parameter	Conditions	Min	Max	Units
22	Start-Up Time	V_{IN} = 5V; V_{OUT} = 3.3V; C_{SET} = 100nF; I_{OUT} = 500mA; Fast Start-Up Disabled	7	11	ms
23		V_{IN} = 5V; V_{OUT} = 3.3V; C_{SET} = 0.47µF; I_{OUT} = 500mA; Fast Start-Up Disabled	32	48	ms
24		V_{IN} = 5V; V_{OUT} = 3.3V; C_{SET} = 4.7µF; I_{OUT} = 500mA; Fast Start-Up Disabled	320	480	ms
25		V_{IN} = 5V; V_{OUT} = 3.3V; C_{SET} = 4.7µF; I_{OUT} = 500mA; Fast Start-Up Enabled	4	8	ms
26	OCP Pin Current	V_{IN} = 2.7V; V_{OUT} = 0.9V; I_{OUT} = 100mA	140	250	µA
		V_{IN} = 30V; V_{OUT} = 28.7V; I_{OUT} = 100mA			
27		V_{IN} = 2.7V; V_{OUT} = 0.9V; I_{OUT} = 1A	1.5	2.5	mA
		V_{IN} = 30V; V_{OUT} = 28.7V; I_{OUT} = 100mA			

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