

ISL75054x

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 ISL75054x family (ISL75054SLH and ISL75054M) of low dropout linear regulators. This test, conducted on samples of the ISL75054M, but is applicable to all versions of this part on various flows (Rad Tolerant Plastic, Rad Hard Plastic, and Rad Hard Hermetic), and was completed to determine the sensitivity of the part to displacement damage (DD) caused by neutron or proton environments. Neutron fluences ranged from $5 \times 10^{11} \text{ n/cm}^2$ to $1 \times 10^{13} \text{ n/cm}^2$.

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 ISL75054x features excellent noise performance and PSRR for radiation tolerant LDOs, with ultra-low RMS noise of $3.9 \mu\text{VRMS}$ from 10Hz to 100kHz and ultra-high PSRR of 104dB at 120Hz. Detailed Electrical Specifications for these devices are contained in the datasheet.

The ISL75054x is fabricated on a Silicon-On Insulator (SOI) process, which makes it latch-up free. It is offered in either a 16 lead heatsink thin shrink small outline (HTSSOP) or a 10 Lead Ceramic Metal Seal Flatpack (CDFP) packages and operates across the full military temperature range of -55°C to $+125^\circ\text{C}$. A block diagram is shown in [Figure 1](#).

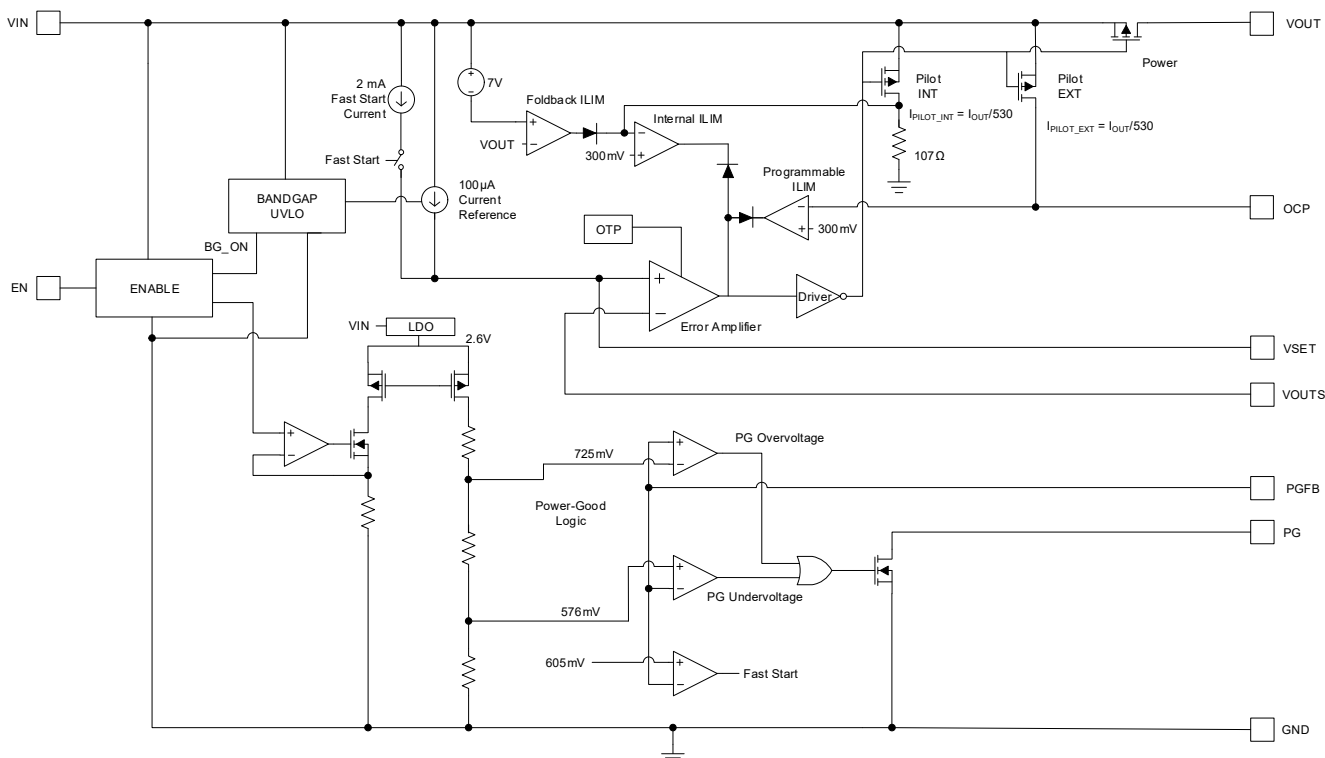


Figure 1. Block Diagram

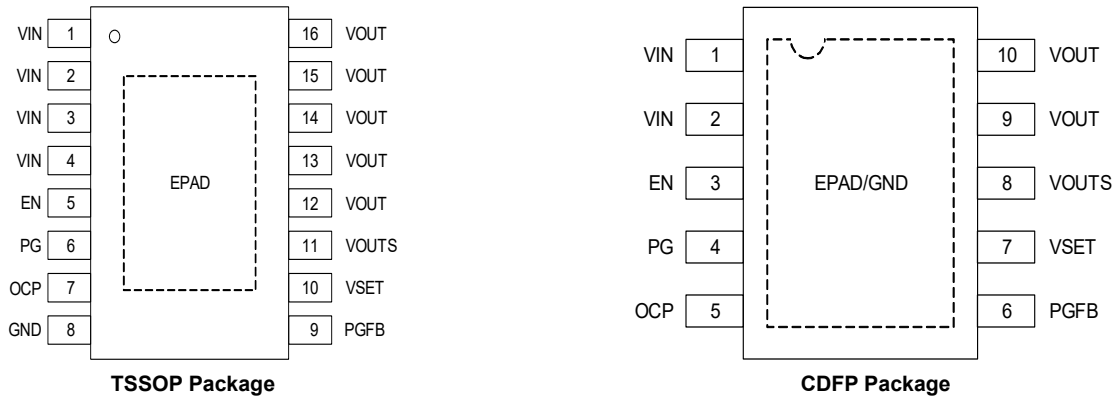


Figure 2. Pin Assignments

Related Literature

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

- [ISL75054M](#), [ISL75054SLH](#) device pages
- 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 $5 \times 10^{11} \text{n/cm}^2$, $2 \times 10^{12} \text{n/cm}^2$, and $1 \times 10^{13} \text{n/cm}^2$. 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 $41 \pm 5.3\% \text{krad(Si)/hr}$ 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 $5 \times 10^{11} \text{n/cm}^2$, five to be irradiated at $2 \times 10^{12} \text{n/cm}^2$, and five to be irradiated at $1 \times 10^{13} \text{n/cm}^2$. The actual levels achieved, which are shown in Table 1, were $6.12 \times 10^{11} \text{n/cm}^2$, $2.38 \times 10^{12} \text{n/cm}^2$, and $1.19 \times 10^{13} \text{n/cm}^2$. 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 ISL75054x 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 ISL75054x 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 5×10¹¹n/cm² exposure (6.12×10¹¹n/cm² actual) but all failed at least one datasheet parameter after the 2×10¹²n/cm² exposure, although they stayed fully functional. All five units failed after the 1×10¹³n/cm² exposure.

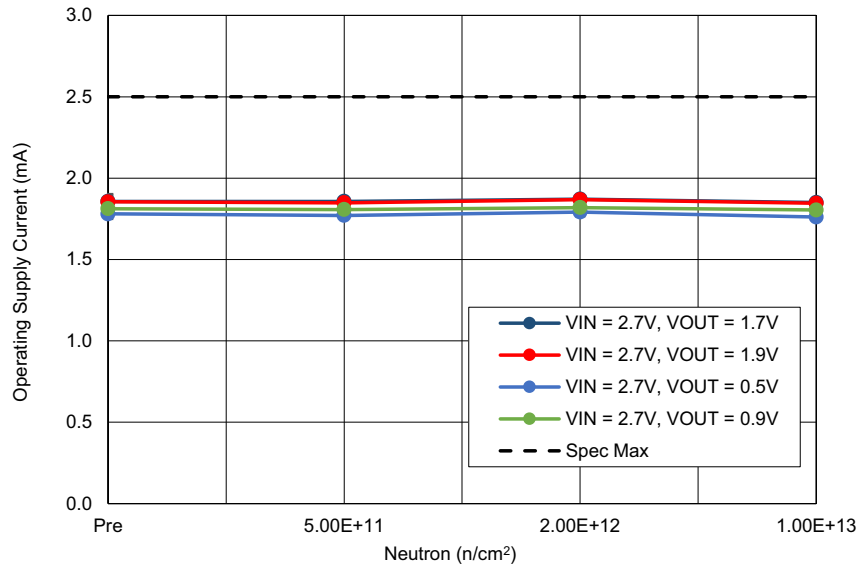


Figure 3. ISL75054x average operating supply current at V_{IN} = 2.7V; V_{OUT} = 0.5V, 0.9V, 1.7V, and 1.9V, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limit is 2.5mA maximum.

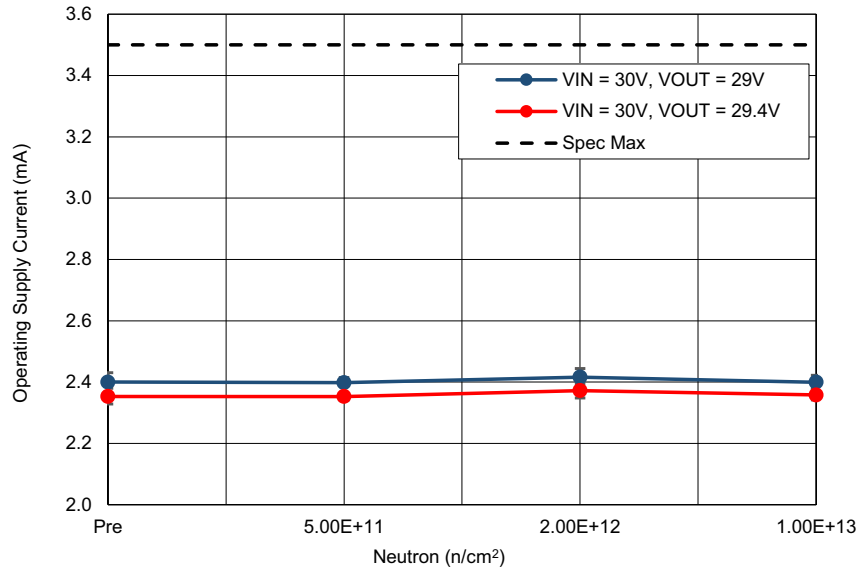


Figure 4. ISL75054x average operating supply current at $V_{IN} = 30V$, with $V_{OUT} = 29V$ and $29.4V$, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limit is 3.5mA maximum.

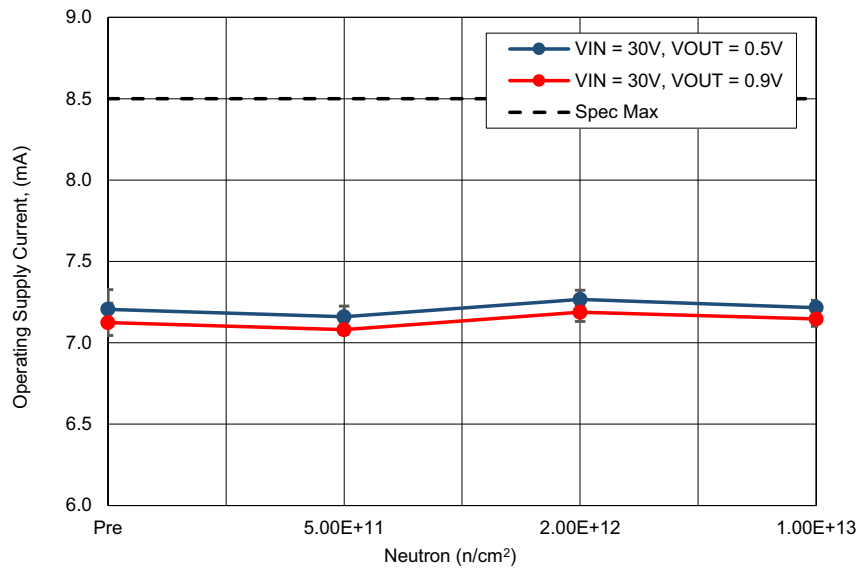


Figure 5. ISL75054x average operating supply current at $V_{IN} = 30V$, $V_{OUT} = 0.5V$, and $V_{IN} = 30V$, $V_{OUT} = 0.9V$, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limit is 8.5mA maximum.

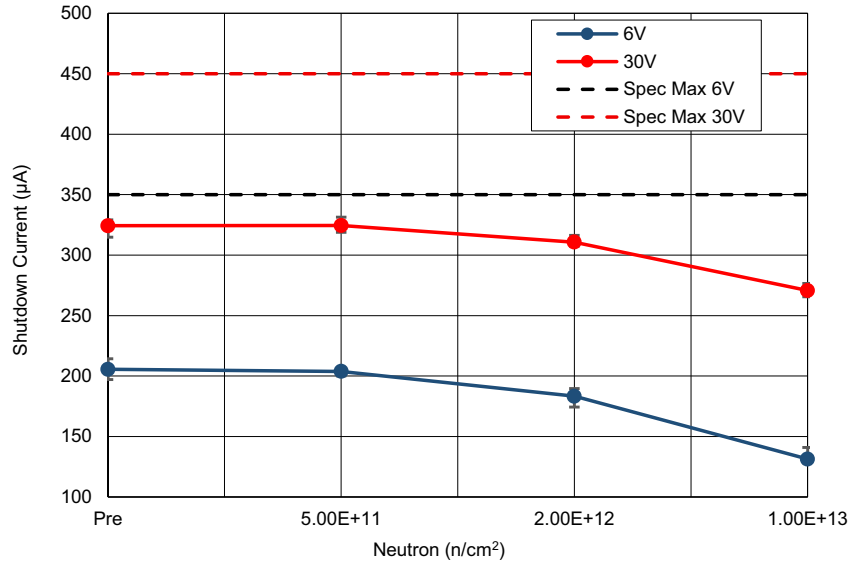


Figure 6. ISL75054x average shutdown supply current at $V_{CC} = 6V$ and $30V$, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limits are $350\mu A$ maximum at $6V$ and $450\mu A$ maximum at $30V$.

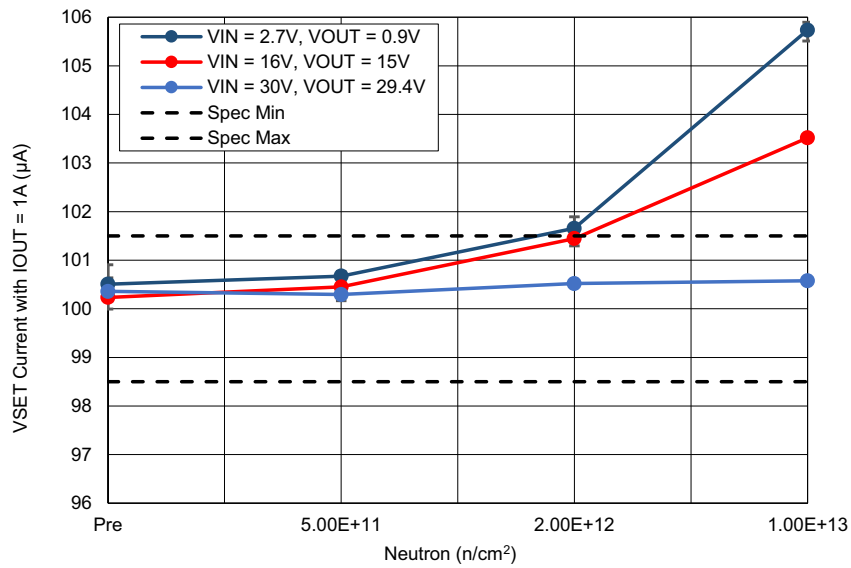


Figure 7. ISL75054x average V_{SET} current with $I_{OUT} = 1A$; $V_{IN} = 2.7V$, $V_{OUT} = 0.9V$, $V_{IN} = 16V$, $V_{OUT} = 15V$ and $V_{IN} = 30V$, $V_{OUT} = 29.4V$, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limits are $98.5\mu A$ minimum and $101.5\mu A$ maximum.

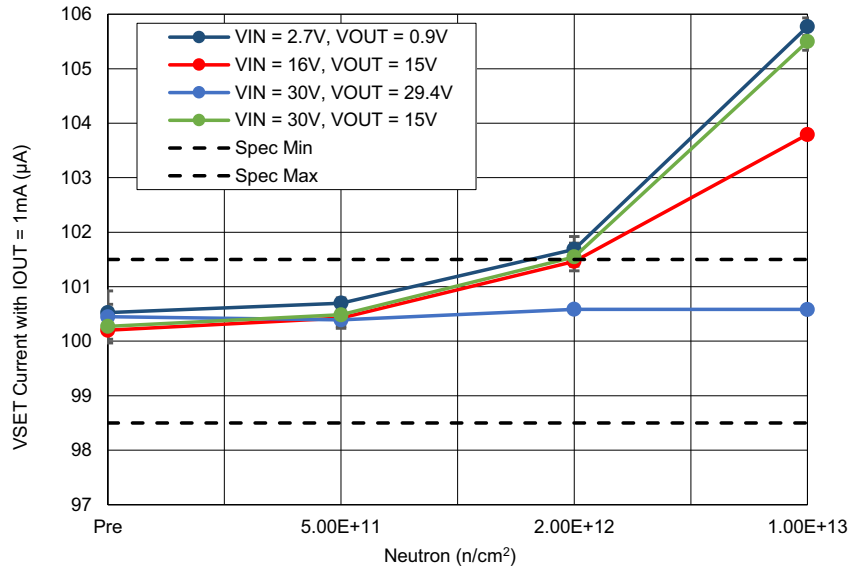


Figure 8. ISL75054x average V_{SET} current with $I_{OUT} = 1mA$; $V_{IN} = 2.7V$, $V_{OUT} = 0.9V$, $V_{IN} = 16V$, $V_{OUT} = 15V$, $V_{IN} = 30V$, $V_{OUT} = 29.4V$ and $V_{IN} = 30V$, $V_{OUT} = 15V$, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limits are $98.5\mu A$ minimum and $101.5\mu A$ maximum.

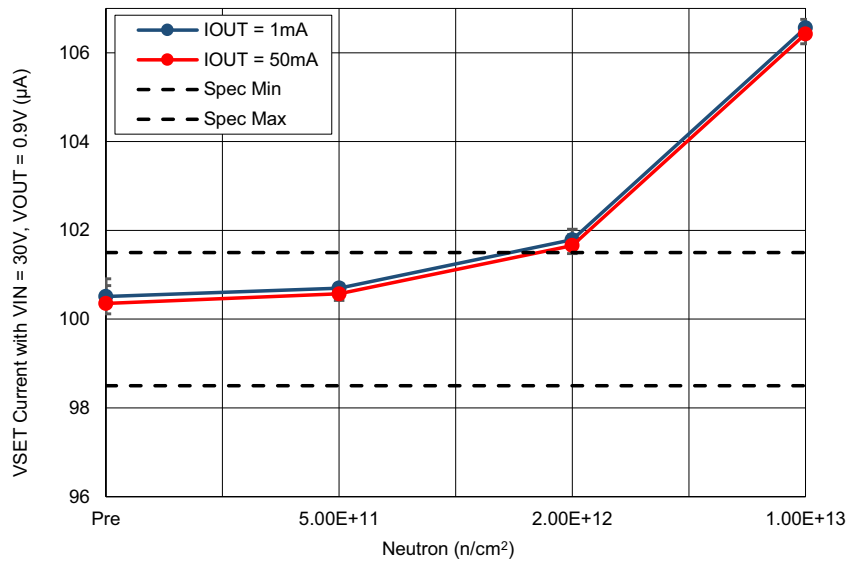


Figure 9. ISL75054x average V_{SET} current with $V_{OUT} = 0.9V$; $V_{IN} = 2.7V$, $I_{OUT} = 1mA$ and $1A$, $V_{IN} = 30V$, $I_{OUT} = 1mA$ and $50mA$, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limits are $98.5\mu A$ minimum and $101.5\mu A$ maximum.

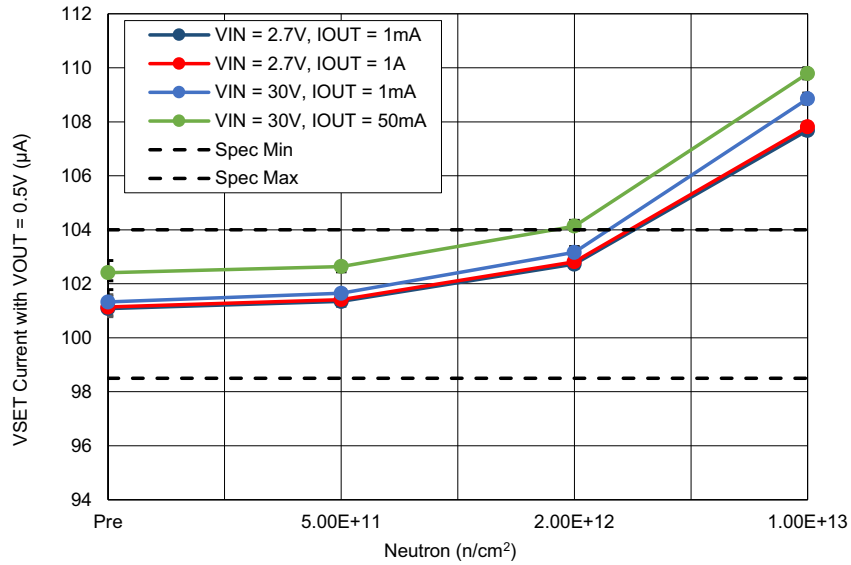


Figure 10. ISL75054x average V_{SET} current with $V_{IN} = 30V$ and $V_{OUT} = 0.9V$; $I_{OUT} = 1mA$ and $50mA$, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limits are $98.5\mu A$ minimum and $104\mu A$ maximum.

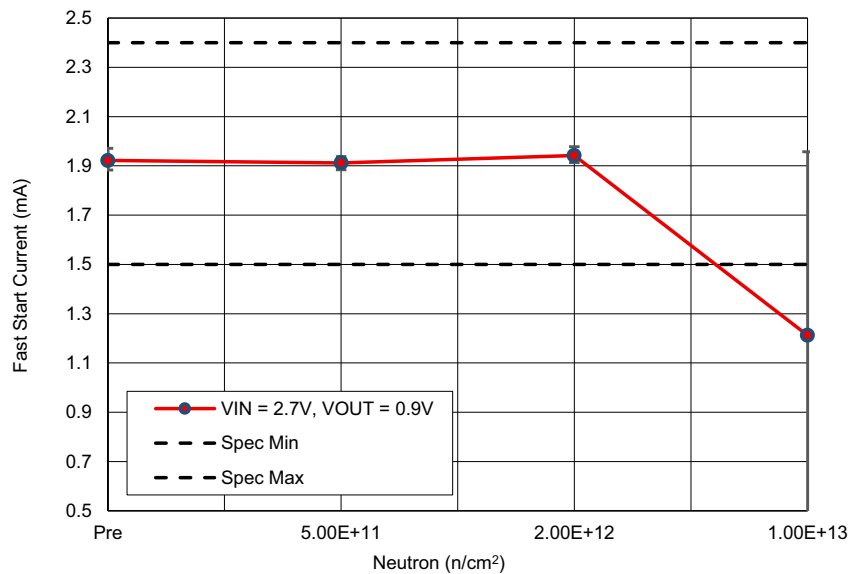


Figure 11. ISL75054x average V_{SET} fast start current with $V_{IN} = 2.7V$, $V_{OUT} = 0.9V$, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limits are $1.5mA$ minimum and $2.4mA$ maximum.

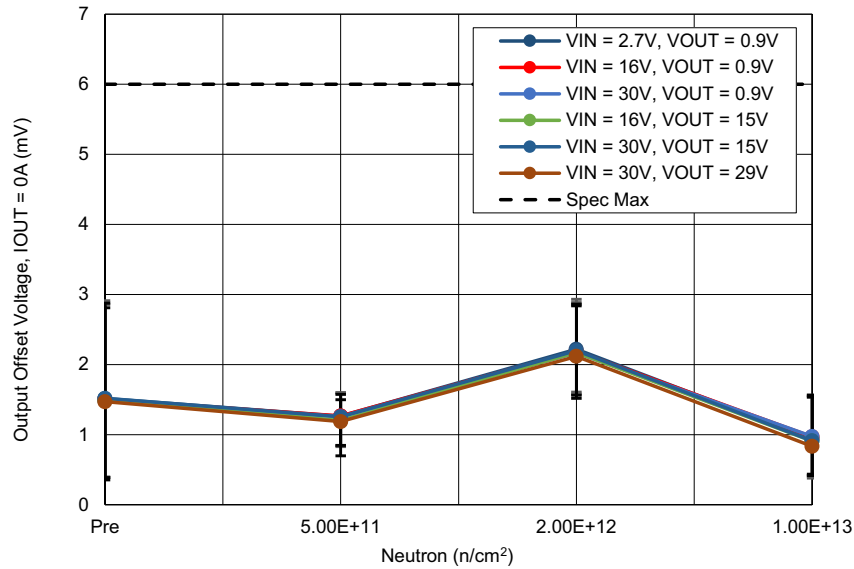


Figure 12. ISL75054x average output offset voltage with $I_{OUT} = 0A$; $V_{IN} = 2.7V$, $V_{OUT} = 0.9V$, $V_{IN} = 16V$, $V_{OUT} = 0.9V$, $V_{IN} = 30V$, $V_{OUT} = 0.9V$, $V_{IN} = 16V$, $V_{OUT} = 15V$ and $V_{IN} = 30V$, $V_{OUT} = 15V$, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limit is 6mV maximum.

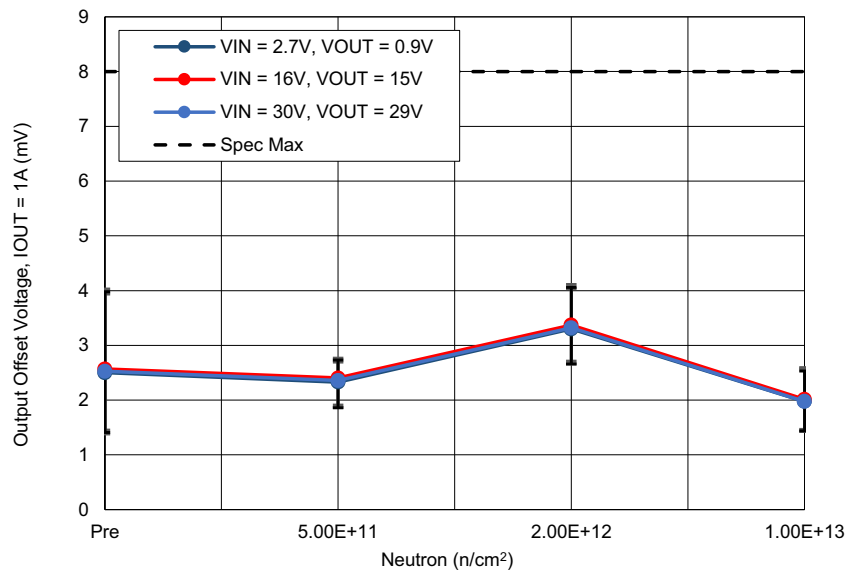


Figure 13. ISL75054x average output offset voltage with $I_{OUT} = 1A$; $V_{IN} = 2.7V$, $V_{OUT} = 0.9V$, $V_{IN} = 16V$, $V_{OUT} = 15V$ and $V_{IN} = 30V$, $V_{OUT} = 29V$, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limit is 8mV maximum.

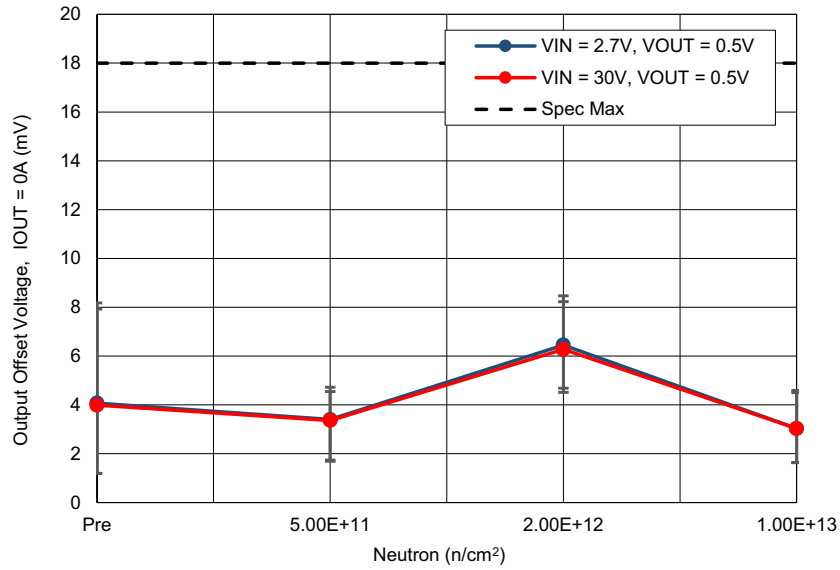


Figure 14. ISL75054x average output offset voltage with $V_{OUT} = 0.5V$ and $I_{OUT} = 0A$; $V_{IN} = 2.7V$ and $30V$, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limit is $18mV$ maximum.

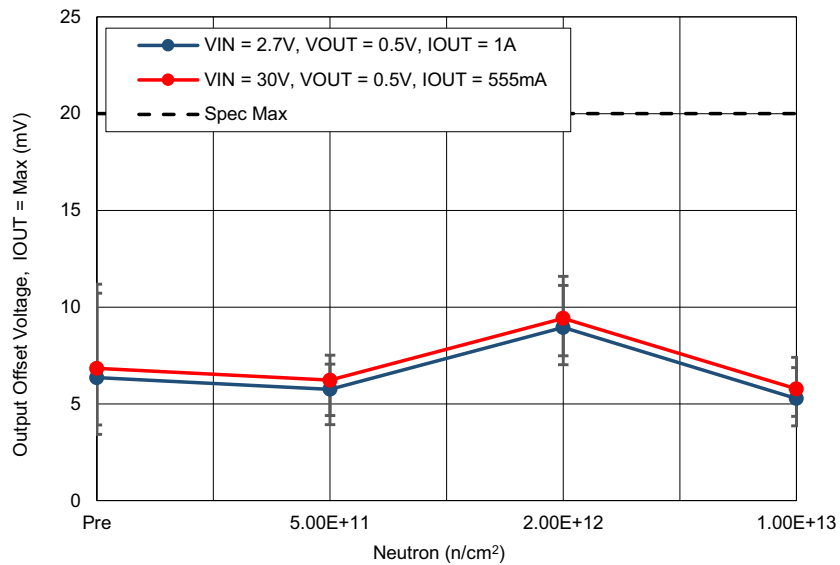


Figure 15. ISL75054x average output offset voltage with $V_{OUT} = 0.5V$ and $I_{OUT} = Max$; $V_{IN} = 2.7V, I_{OUT} = 1A$ and $V_{IN} = 30V, I_{OUT} = 555mA$, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limit is $20mV$ maximum.

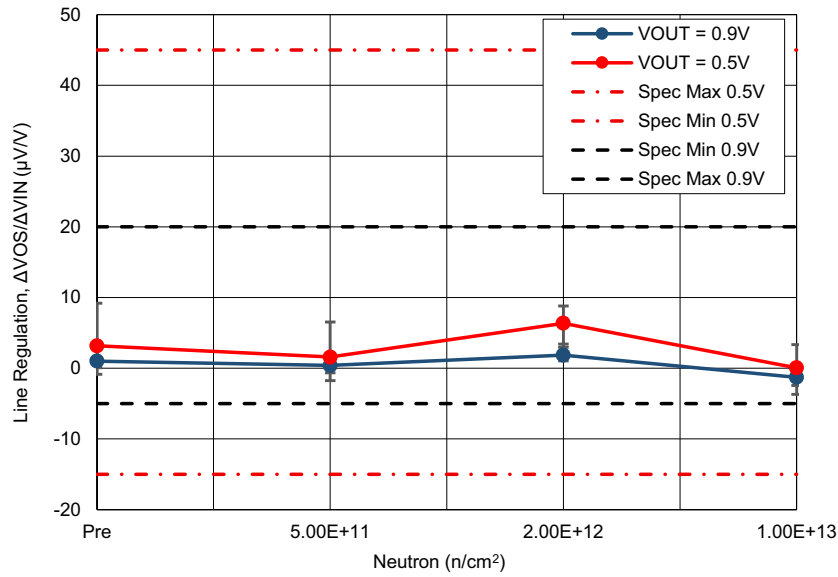


Figure 16. ISL75054x average line regulation ($\Delta V_{OS}/\Delta V_{IN}$), at $V_{OUT} = 0.9V$ and $0.5V$, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limits are $-15\mu V/V$ minimum and $45\mu V/V$ maximum for $V_{OUT} = 0.5V$ and $-0.5\mu V/V$ minimum and $20\mu V/V$ maximum for $V_{OUT} = 0.9V$.

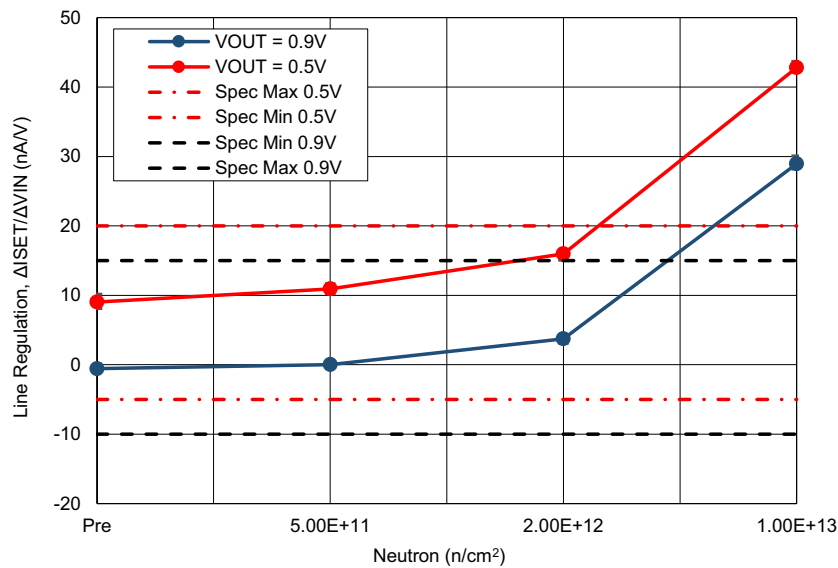


Figure 17. ISL75054x average line regulation ($\Delta I_{SET}/\Delta V_{IN}$), at $V_{OUT} = 0.9V$ and $0.5V$, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limits are $-5nA/V$ minimum and $20nA/V$ maximum for $V_{OUT} = 0.5V$ and $-10nA/V$ minimum and $15nA/V$ maximum for $V_{OUT} = 0.9V$.

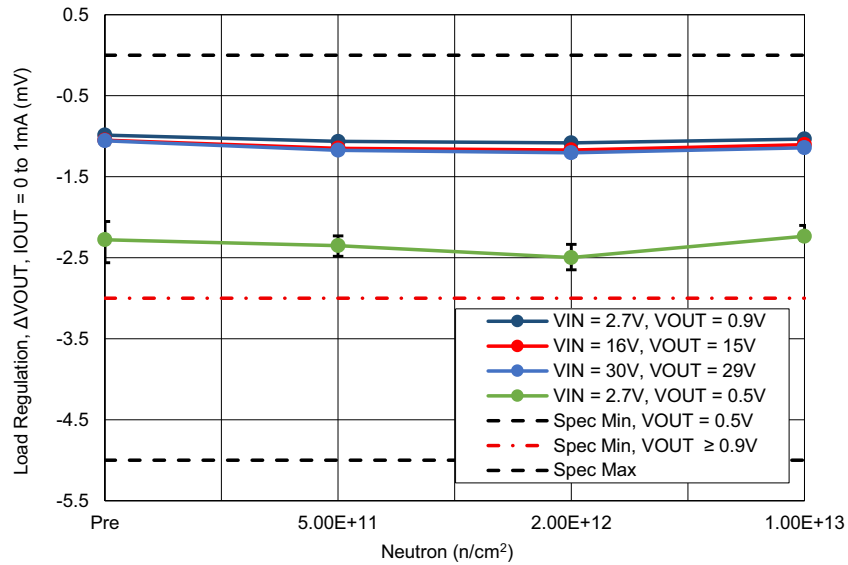


Figure 18. ISL75054x average load regulation (ΔV_{OUT}), at $I_{OUT} = 0$ to 1mA ; $V_{IN} = 2.7\text{V}$, $V_{OUT} = 0.9\text{V}$, $V_{IN} = 16\text{V}$, $V_{OUT} = 15\text{V}$, $V_{IN} = 30\text{V}$, $V_{OUT} = 29\text{V}$ and $V_{IN} = 2.7\text{V}$, $V_{OUT} = 0.5\text{V}$, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limits are -5mV minimum and 0mV maximum for $V_{OUT} = 0.5\text{V}$, and -3mV minimum and 0mV maximum for $V_{OUT} = 0.9\text{V}$.

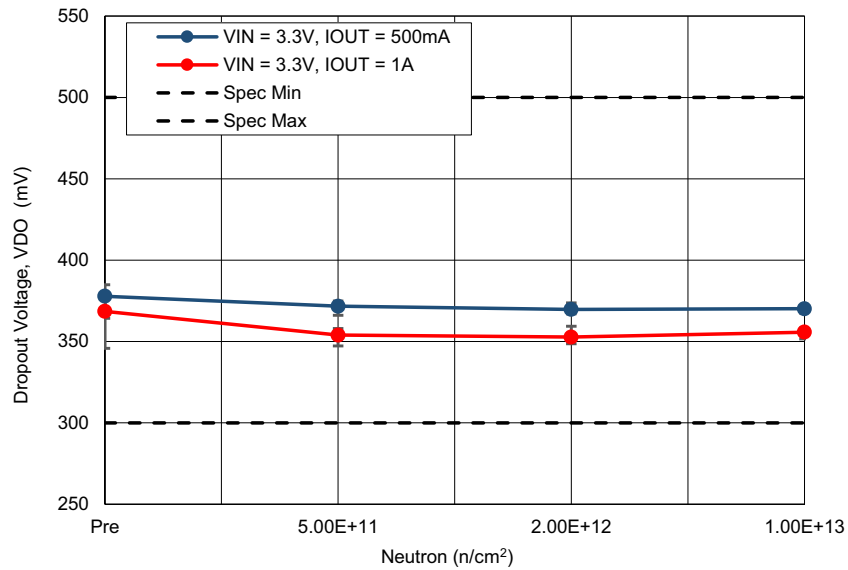


Figure 19. ISL75054x average dropout voltage at $V_{IN} = 3.3\text{V}$ with $I_{OUT} = 500\text{mA}$ and 1A , as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limits are 300mV minimum and 500mV maximum.

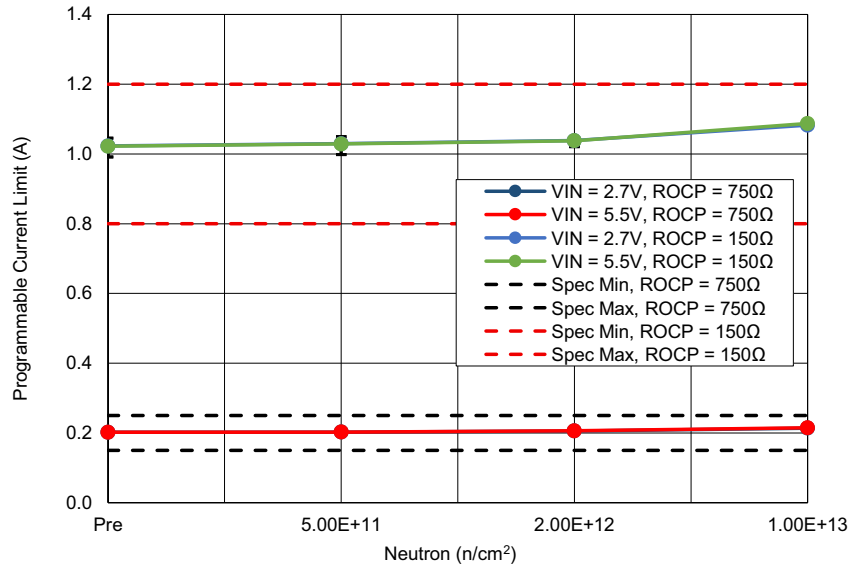


Figure 20. ISL75054x programmable current limit at $V_{IN} = 2.7V$ and $5.5V$ with $R_{OCP} = 150\Omega$ and 750Ω , as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limits are $0.15A$ minimum and $0.25A$ maximum for $R_{OCP} = 750\Omega$ and $0.8A$ minimum and $1.2A$ maximum for $R_{OCP} = 150\Omega$.

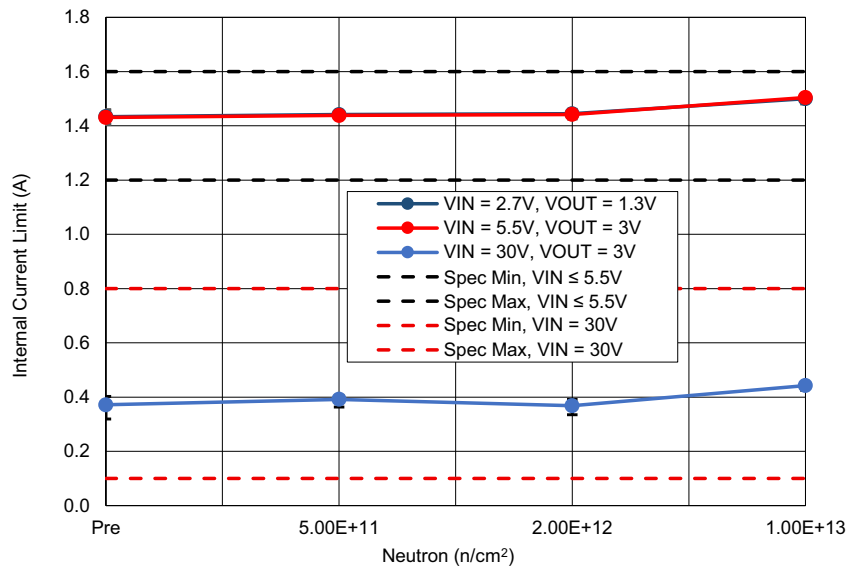


Figure 21. ISL75054x average internal current limit with $V_{IN} = 2.7V$, $V_{OUT} = 1.3V$, $V_{IN} = 5.5V$, $V_{OUT} = 3V$ and $V_{IN} = 30V$, $V_{OUT} = 3V$, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limits are $1.2A$ minimum and $1.6A$ maximum for $V_{IN} \leq 5.5V$ and $0.1A$ minimum and $0.8A$ maximum for $V_{IN} = 30V$.

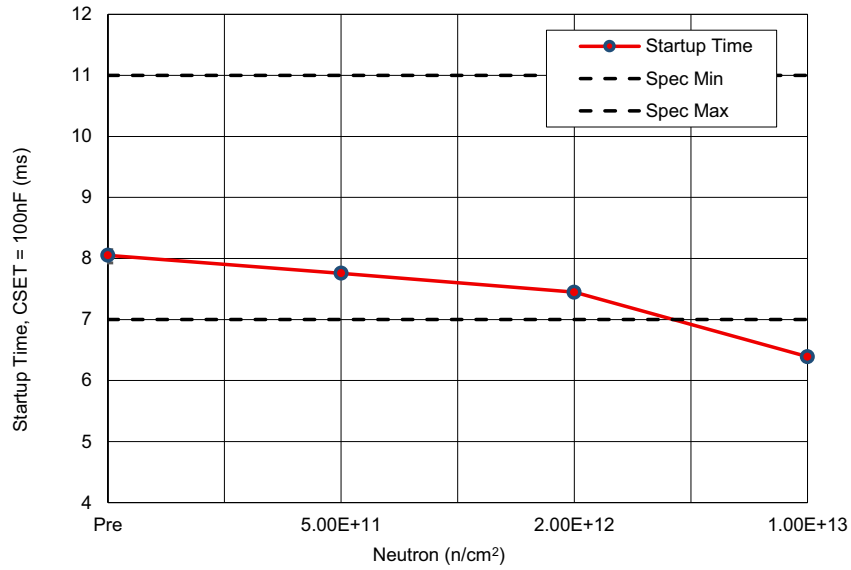


Figure 22. ISL75054x average Startup Time with $C_{SET} = 100nF$ as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limits are 7ms minimum and 11ms maximum.

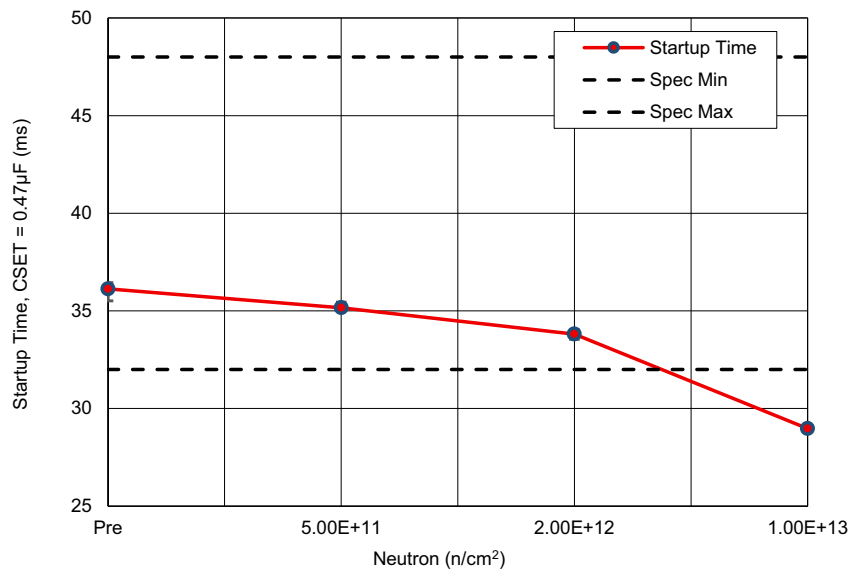


Figure 23. ISL75054x average Startup Time with $C_{SET} = 0.47\mu F$ as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limits are 32ms minimum and 48ms maximum.

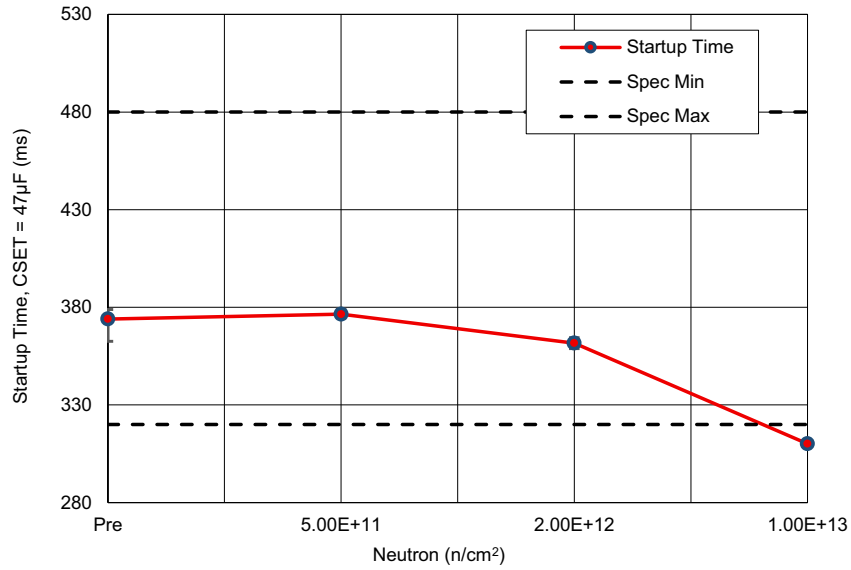


Figure 24. ISL75054x average Startup Time with C_{SET} = 47µF as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limits are 320ms minimum and 480ms maximum.

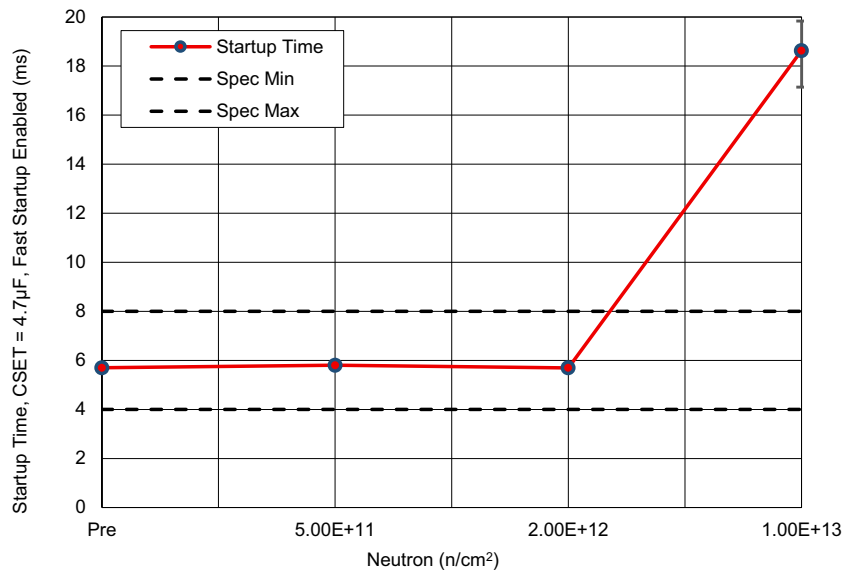


Figure 25. ISL75054x average Startup Time with C_{SET} = 4.7µF and Fast Startup Enabled as a function of neutron fluence. The error bars represent the minimum and maximum measured values (one measurement exceeded 20ms, which was the maximum allowed measurement). The datasheet limits are 4ms minimum and 8ms maximum.

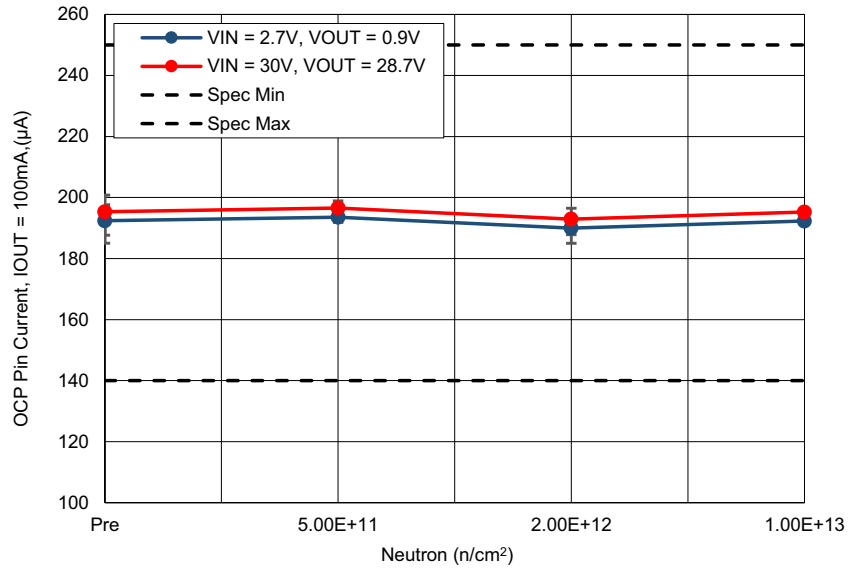


Figure 26. ISL75054x average OCP pin current with I_{OUT} = 100mA, V_{IN} = 2.7V, V_{OUT} = 0.9V and V_{IN} = 30V, V_{OUT} = 28.7V, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limits are 140µA minimum and 250µA maximum.

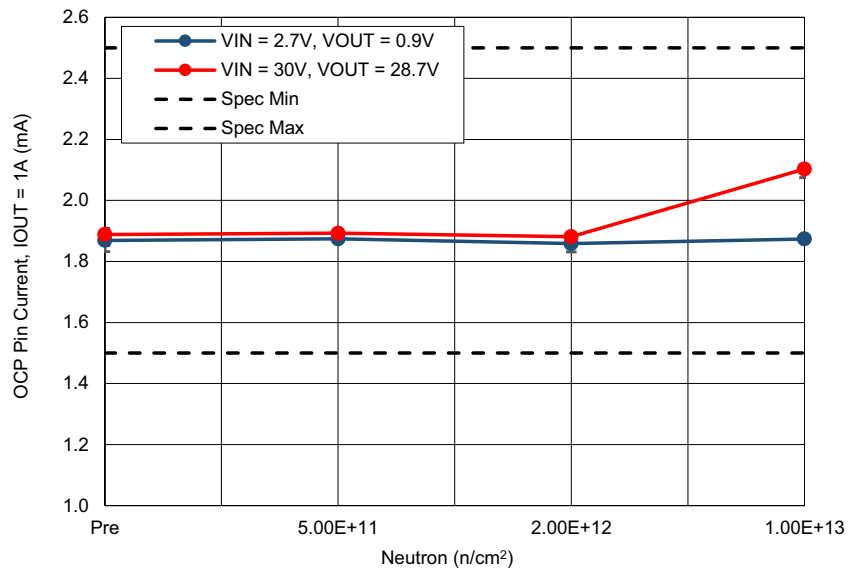


Figure 27. ISL75054x average OCP pin current with I_{OUT} = 1A, V_{IN} = 2.7V, V_{OUT} = 0.9V and V_{IN} = 30V, V_{OUT} = 28.7V, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limits are 1.5mA minimum and 2.5mA maximum.

3. Discussion and Conclusion

The results of 1MeV equivalent neutron testing of the ISL75054M radiation-tolerant low dropout linear regulator have been reported. This report is applicable to all versions of this part on various flows (Rad Tolerant Plastic, Rad Hard Plastic, and Rad Hard Hermetic). Parts were tested after actual fluences of $6.12 \times 10^{11} \text{n/cm}^2$, $2.38 \times 10^{12} \text{n/cm}^2$ and $1.19 \times 10^{13} \text{n/cm}^2$. 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 all parts remained functional to $1.19 \times 10^{13} \text{n/cm}^2$, some began showing parametric failures at $2.38 \times 10^{12} \text{n/cm}^2$. The parameters that failed were VSET current, startup time, and line regulation. The process that the part is built on is a $0.15 \mu\text{m}$ 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
1.01	Oct 21, 2025	Updated Figure 25. Updated the following sections: Introduction, Product Description, Key Parameter Variables Data, and Discussion and Conclusion.
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 $30V; V_{OUT} = 0.5V; \text{Maximum } I_{OUT}$	-	20	mV
16	Line Regulation, $\Delta V_{OS}/\Delta V_{IN}$	$V_{OUT} = 0.9V$	-5	20	$\mu V/V$
		$V_{OUT} = 0.5V$	-15	45	$\mu V/V$
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 $V_{IN} = 3.3V; R_{SET} = 33k\Omega; I_{OUT} = 1mA$	300	500	mV
		$V_{IN} - V_{OUT}$ for $V_{IN} = 3.3V; R_{SET} = 33k\Omega; I_{OUT} = 500mA$			
		$V_{IN} - V_{OUT}$ for $V_{IN} = 3.3V; R_{SET} = 33k\Omega; I_{OUT} = 1A$			
20	Programmable Current Limit	$V_{IN} = 2.7V$ to $5.5V; R_{OCP} = 750\Omega$	0.15	0.25	A
		$V_{IN} = 2.7V$ to $5.5V; R_{OCP} = 150\Omega$	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		$V_{IN} = 5V$; $V_{OUT} = 3.3V$; $C_{SET} = 0.47\mu F$; $I_{OUT} = 500mA$; Fast Start-Up Disabled	32	48	ms
24		$V_{IN} = 5V$; $V_{OUT} = 3.3V$; $C_{SET} = 4.7\mu F$; $I_{OUT} = 500mA$; Fast Start-Up Disabled	320	480	ms
25		$V_{IN} = 5V$; $V_{OUT} = 3.3V$; $C_{SET} = 4.7\mu F$; $I_{OUT} = 500mA$; 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	OCP Pin Current	$V_{IN} = 2.7V$; $V_{OUT} = 0.9V$; $I_{OUT} = 1A$	1.5	2.5	mA
		$V_{IN} = 30V$; $V_{OUT} = 28.7V$; $I_{OUT} = 100mA$			

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Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,
Koto-ku, Tokyo 135-0061, Japan
www.renesas.com

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