ISL70517SEH, ISL70617SEH

Neutron Testing of the ISL70517SEH and ISL70617SEH Radiation Hardened Instrumentation Amplifiers

Introduction

This report summarizes results of 1MeV equivalent neutron testing of the ISL70517SEH and ISL70617SEH instrumentation amplifiers. The test was conducted to determine the sensitivity of the part to Displacement Damage (DD) caused by neutron or proton environments. Neutron fluences ranged from $5x10^{11}n/cm^2$ to $1x10^{14}n/cm^2$. This project was carried out in collaboration with Honeywell Aerospace in Clearwater, FL, and their support is gratefully acknowledged.

Product Description

The ISL70517SEH is a differential input, single-ended output instrumentation amplifier designed for precision analog to digital applications. The ISL70617SEH is a differential input, differential output instrumentation amplifier, differing only in a metal mask option.

Both parts operate across a supply range of 8V (±4V) to 36V (±18V) and feature a differential input voltage range of ±30V. The output stages have rail-to-rail output drive capability optimized for ADC driver applications. The gain of the ISL70x17SEH can be programmed from 0.1 to 10,000 using two external resistors, RIN and RFB. The gain accuracy is determined by the matching of RIN and RFB. The gain resistors use Kelvin sensing, which removes gain error terms due to PC trace resistance. The input and output stages have individual power supply pins, which enable input signals riding on a high common-mode voltage to be level shifted to a low voltage device, such as an A/D converter. The rail-to-rail output stage can be powered from the same supplies as the ADC, which preserves the ADC maximum input dynamic range and eliminates ADC input overdrive. The ISL70x17SEH is offered in a 24 Ld ceramic flatpack package and is ensured across the -55°C to +125°C temperature range.

Specifications for Rad Hard 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.

Related Literature

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

- ISL70517SEH, ISL70617SEH device pages
- MIL-STD-883 test method 1017

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1. Test Description

1.1 Irradiation Facility

Neutron fluence irradiations were performed on the test samples on June 25, 2018, at the WSMR Fast Burst Reactor (FBR) per Mil-STD-883G, Method 1017.2, with each part unpowered during irradiation and all leads shorted. The target irradiation levels were $5x10^{11}n/cm^2$, $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, and $1x10^{14}n/cm^2$. 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 cool down time before being shipped back to Renesas (Palm Bay, FL) for electrical testing.

1.2 Test Fixturing

No formal irradiation test fixturing is involved, as these DD tests are considered bag tests, which means the parts are irradiated with all leads shorted together.

1.3 Radiation Dosimetry

Table 1 shows the TLD and Sulfur pellet dosimetry from WSMR indicating the total accumulated gamma dose and actual neutron fluence exposure levels for each set of ISL70517SEH samples.

Table 1. ISL70517SEH Neutron Fluence Dosimetry Data

TLD		Sulfur Pellet						
TLD #	cGy(Si)[1]	Pellet #	Distance (inches)	Exposure ID	Flu >3MeV (n/cm^2)	% Unc[2]	Total Fluence (n/cm^2)	1Mev Si (n/cm^2)
289	1.223E+02	6475	26.6	Free Field	7.465E+10	7.1%	6.036E+11	5.192E+11
279	4.304E+02	6415	13.45	Free Field	3.067E+11	7.1%	2.419E+12	2.145E+12
259	2.242E+03	6484	24	Free Field	1.375E+12	7.1%	1.079E+13	9.642E+12
257	1.562E+04	6481	8	Free Field	9.879E+12	7.1%	7.755E+13	6.927E+13

1. 1cGy(Si) = 1rad(Si)
2. The Uncertainty (% Unc) column is applicable only to the Fluence > 3MeV.

Table 2 shows the same parameters for the ISL70617SEH. This dosimetry process is traceable to NIST (IAW ASTM E722).

Table 2. ISL70617SEH Neutron Fluence Dosimetry Data

TLD		Sulfur Pellet						
TLD #	cGy(Si)[1]	Pellet #	Distance (inches)	Exposure ID	Flu >3MeV (n/cm^2)	% Unc[2]	Total Fluence (n/cm^2)	1Mev Si (n/cm^2)
295	1.170E+02	6120	26.6	Free Field	7.750E+10	7.1%	6.267E+11	5.390E+11
277	4.028E+02	6413	13.45	Free Field	2.883E+11	7.1%	2.274E+12	2.017E+12
264	2.022E+03	6489	24	Free Field	1.378E+12	7.1%	1.105E+13	9.567E+12
255	1.677E+04	6470	8	Free Field	1.097E+13	7.1%	8.610E+13	7.692E+13

1. 1cGy(Si) = 1rad(Si)
2. The Uncertainty (% Unc) column is applicable only to the Fluence > 3MeV.

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 planned experimental matrix consisted of five samples irradiated at $5x10^{11}n/cm^2$, five samples irradiated at $2x10^{12}n/cm^2$, five irradiated at $1x10^{13}n/cm^2$, and five irradiated at $1x10^{14}n/cm^2$. Three control units were used.

ISL70517SEH samples were drawn from Lot X4JADA. ISL70617SEH samples were taken from Lot X4J4ABBA. All samples were packaged in the standard hermetic 24 Ld ceramic flatpack, Package Outline Drawing (POD) K24.A. Samples were processed through burn-in before irradiation and were screened to the SMD limits at room, low, and high temperatures before the start of neutron testing.

2. Results

Neutron testing of the ISL70x17SEH 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 3 summarizes the neutron exposure test results. The maximum planned fluence of $1x10^{14}n/cm^2$ was not quite achieved, with the actual maximum fluence only reaching $6.93x10^{13}n/cm^2$ for the ISL70517SEH and $7.70x10^{13}n/cm^2$ for the ISL70617SEH.

Table 3. ISL70517SEH and ISL70617SEH Attributes Data

Fluence, (n/cm^2)			Sample Size	Pass[1]	Fail
Planned	ISL70517SEH Actual	ISL70617SEH Actual			
$5x10^{11}$	$5.20x10^{11}$	$5.40x10^{11}$	5	5	0
$2x10^{12}$	$2.20x10^{12}$	$2.02x10^{12}$	5	5	0
$1x10^{13}$	$9.64x10^{12}$	$9.60x10^{12}$	5	5	0
$1x10^{14}$	$6.93x10^{13}$	$7.70x10^{13}$	5	0	5

1. A Pass indicates a sample that passes all SMD limits.

2.2 Variables Data

The plots in Figure 1 through Figure 30 show data plots for key parameters before and after irradiation to each level. The plots show the mean of each parameter as a function of neutron irradiation. The plots also include error bars at each downpoint, 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 SMD are also shown.

All samples passed the post-irradiation SMD limits after all exposures up to and including $1x10^{13}n/cm^2$, but failed many of the SMD post-irradiation limits after $1x10^{14}n/cm^2$, although they were still functional.

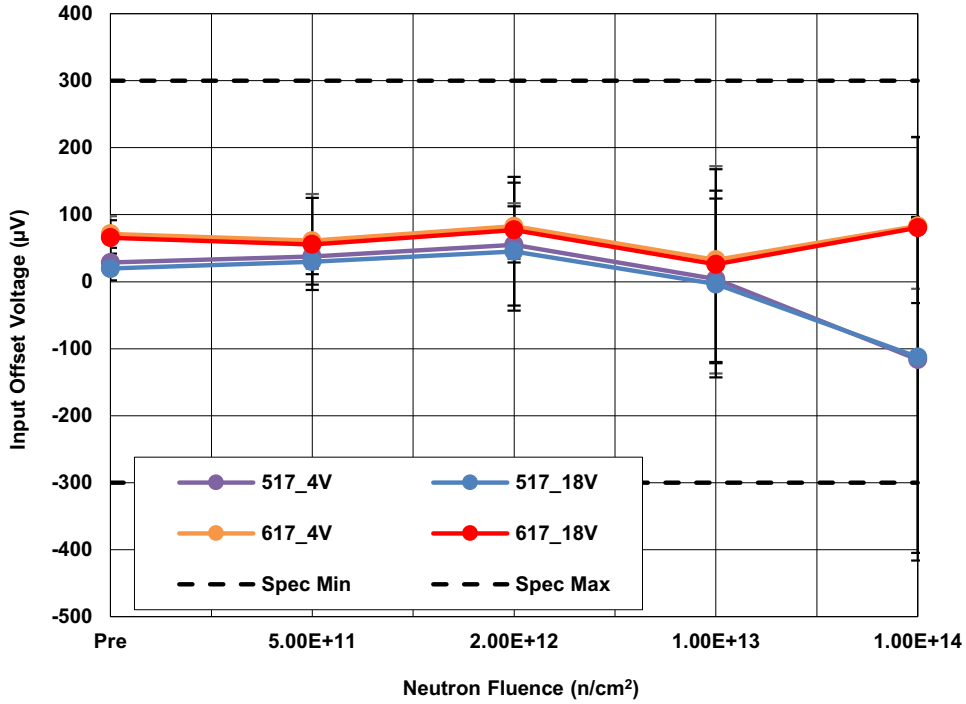

Figure 1. ISL70x17SEH input offset voltage (V_{OS}) at ±4V and ±18V following irradiation to each level. The error bars represent the minimum and maximum measured values. The SMD limits are -300µV minimum and 300µV maximum.

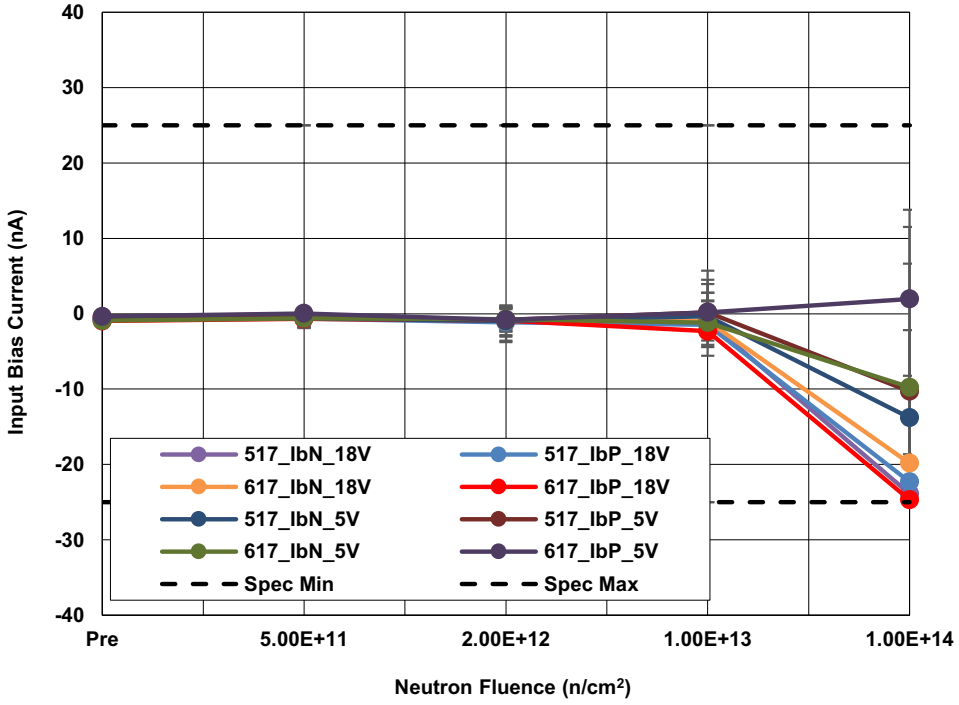

Figure 2. ISL70x17SEH input bias current (I_B) at ±5V and ±18V following irradiation to each level. The error bars represent the minimum and maximum measured values. The SMD limits are -25nA minimum and 25nA maximum.

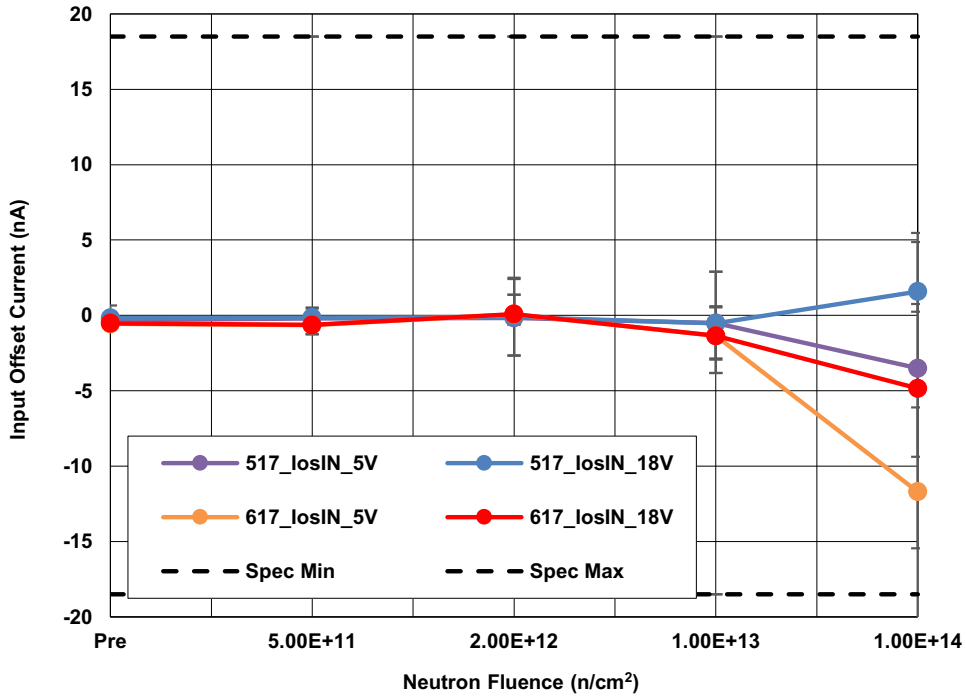

Figure 3. ISL70x17SEH input offset current (I_{OS}) at ±5V and ±18V following irradiation to each level. The error bars represent the minimum and maximum measured values. The SMD limits are -18.5nA minimum and 18.5nA maximum.

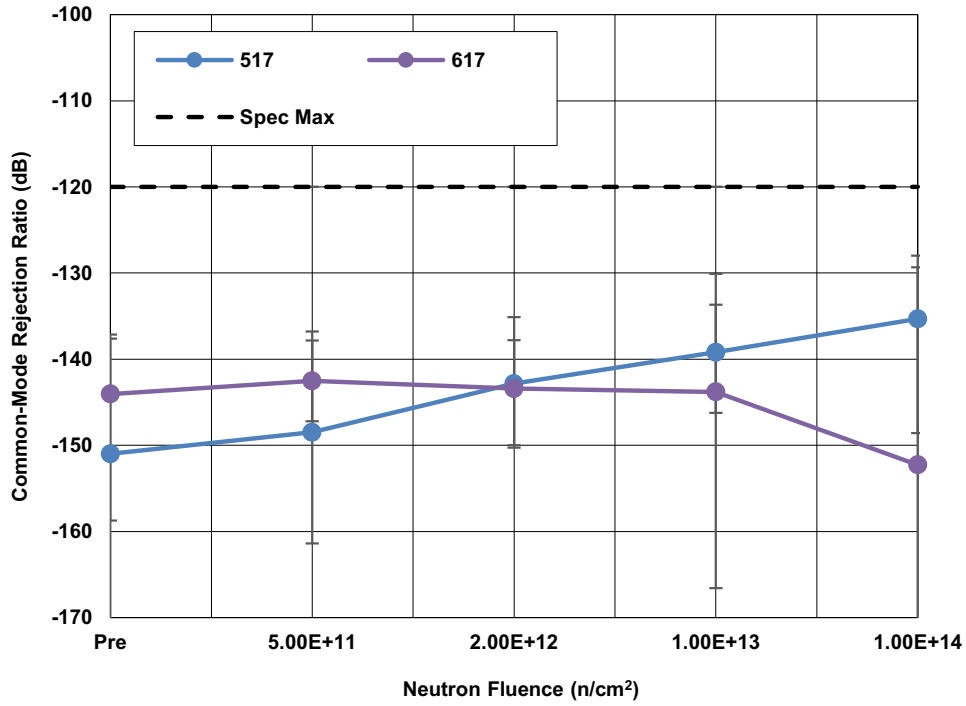

Figure 4. ISL70x17SEH common-mode rejection ratio (CMRR) with Gain = 100, following irradiation to each level. The error bars represent the minimum and maximum measured values. The SMD limit is -120dB maximum.

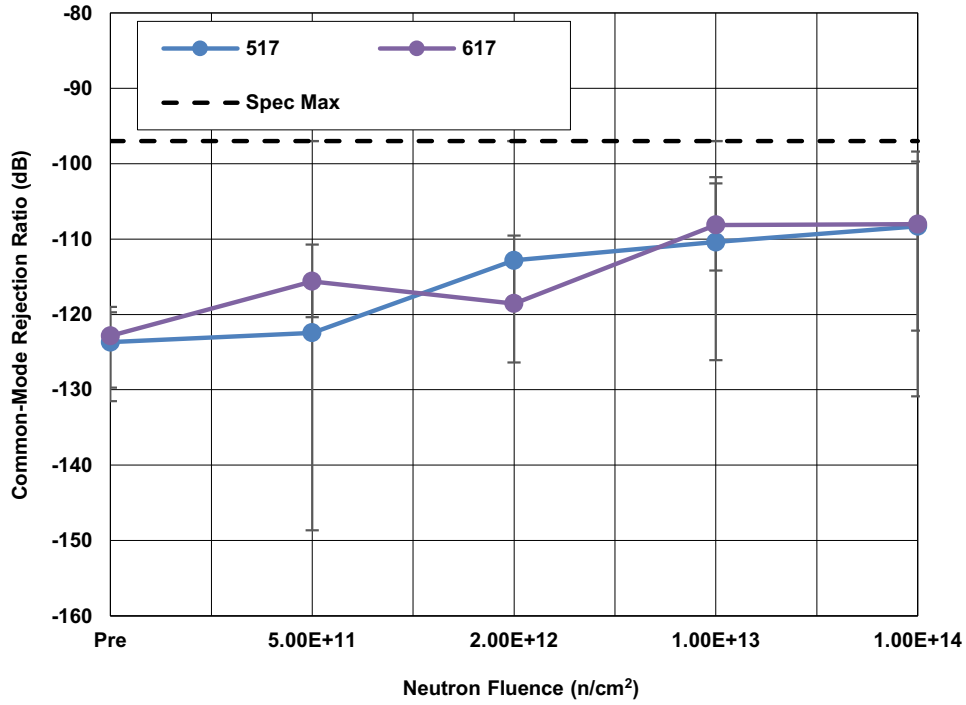

Figure 5. ISL70x17SEH common mode rejection ratio (CMRR) with Gain = 1, following irradiation to each level. The error bars represent the minimum and maximum measured values. The SMD limit is -97dB maximum.

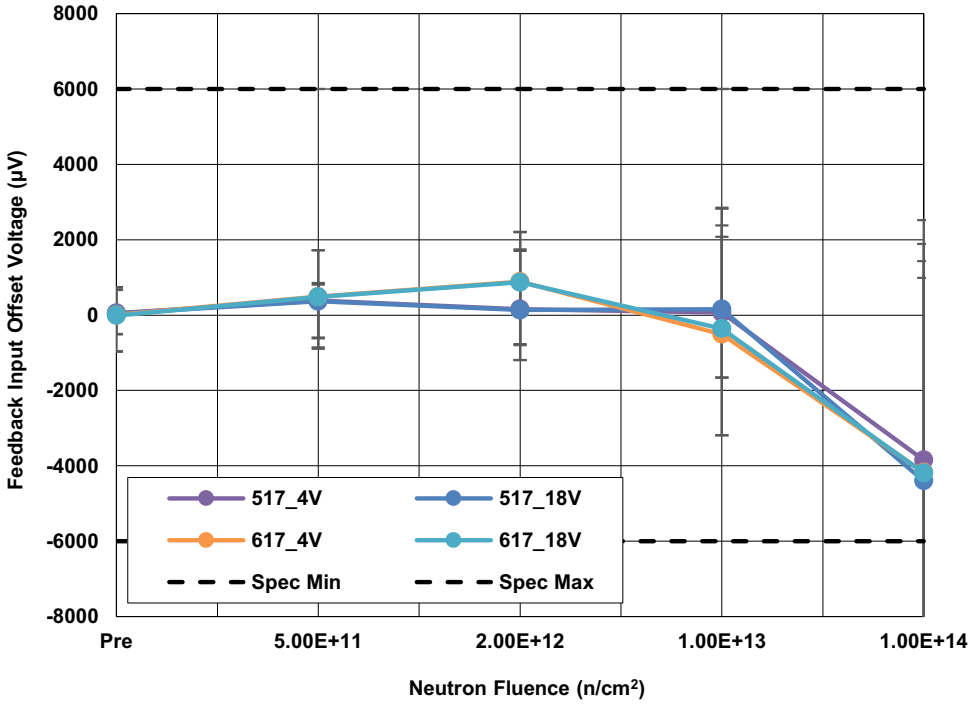

Figure 6. ISL70x17SEH feedback input offset voltage ($V_{OS}FB$) at ±4V and ±18V following irradiation to each level. The error bars represent the minimum and maximum measured values. The SMD limit is -6000µV minimum and 6000µV maximum.

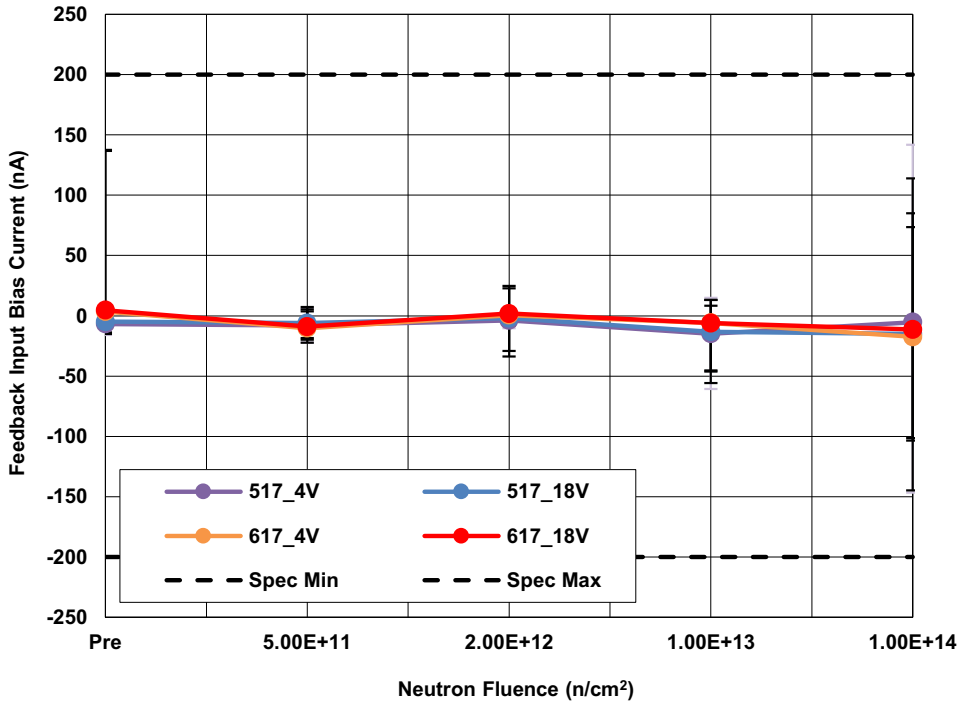

Figure 7. ISL70x17SEH feedback input bias current (I_BV_{FB}) at ±4V and ±18V following irradiation to each level. The error bars represent the minimum and maximum measured values. The SMD limit is -200nA minimum and 200nA maximum.

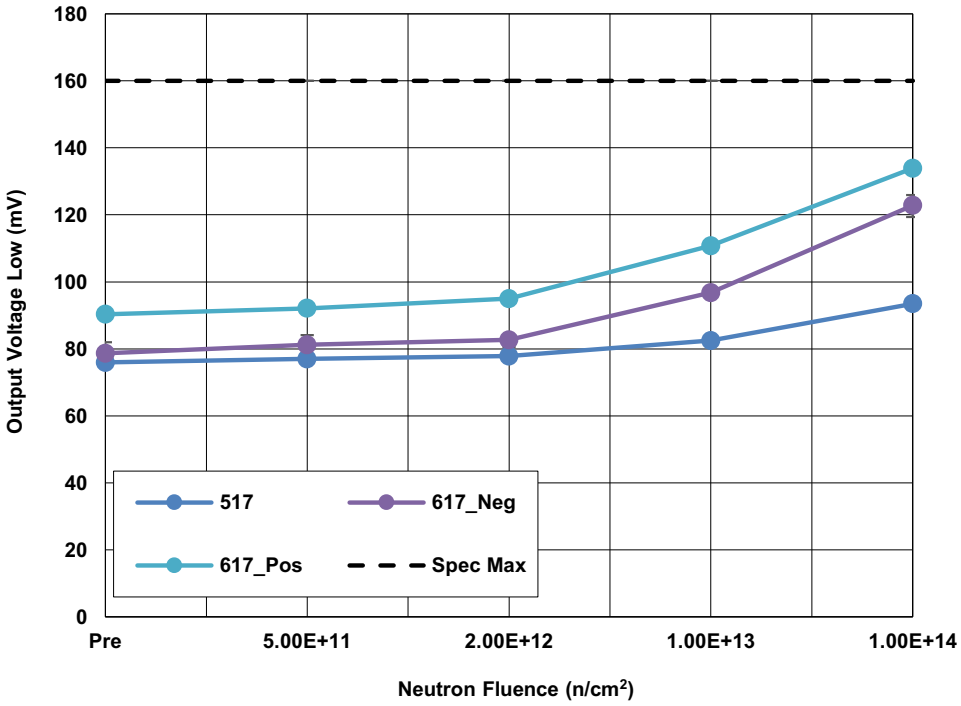

Figure 8. ISL70x17SEH low output voltage (V_{OL}) at ±18V with I_{OUT} = 0mA following irradiation to each level. The error bars represent the minimum and maximum measured values. The SMD limit is 160mV maximum.

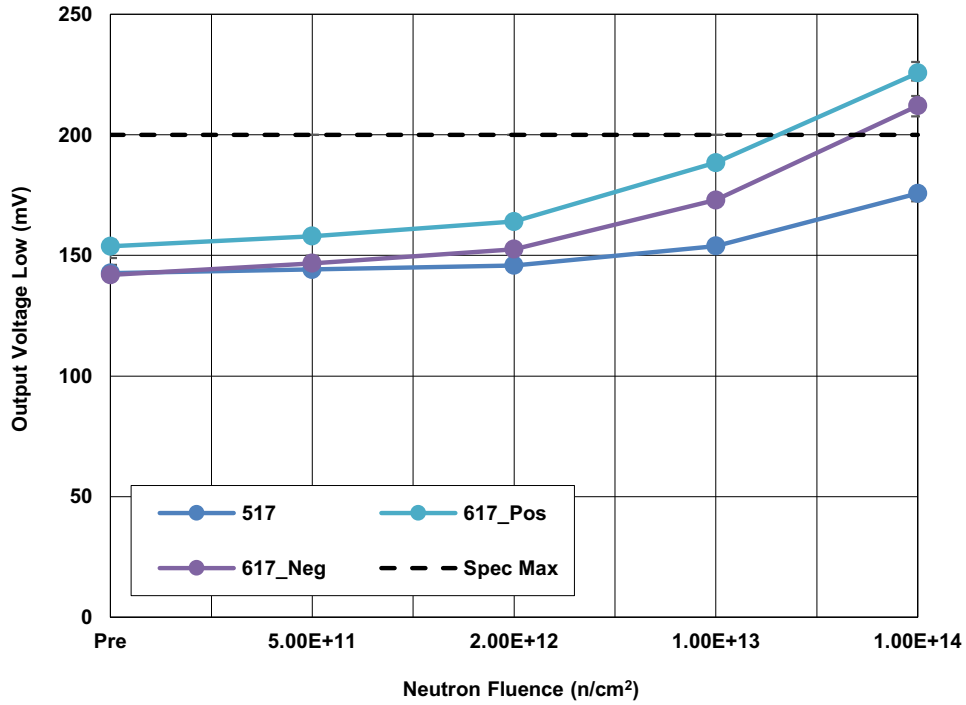

Figure 9. ISL70x17SEH low output voltage (V_{OL}) at ±18V with I_{OUT} = 1.5mA following irradiation to each level. The error bars represent the minimum and maximum measured values. The SMD limit is 200mV maximum.

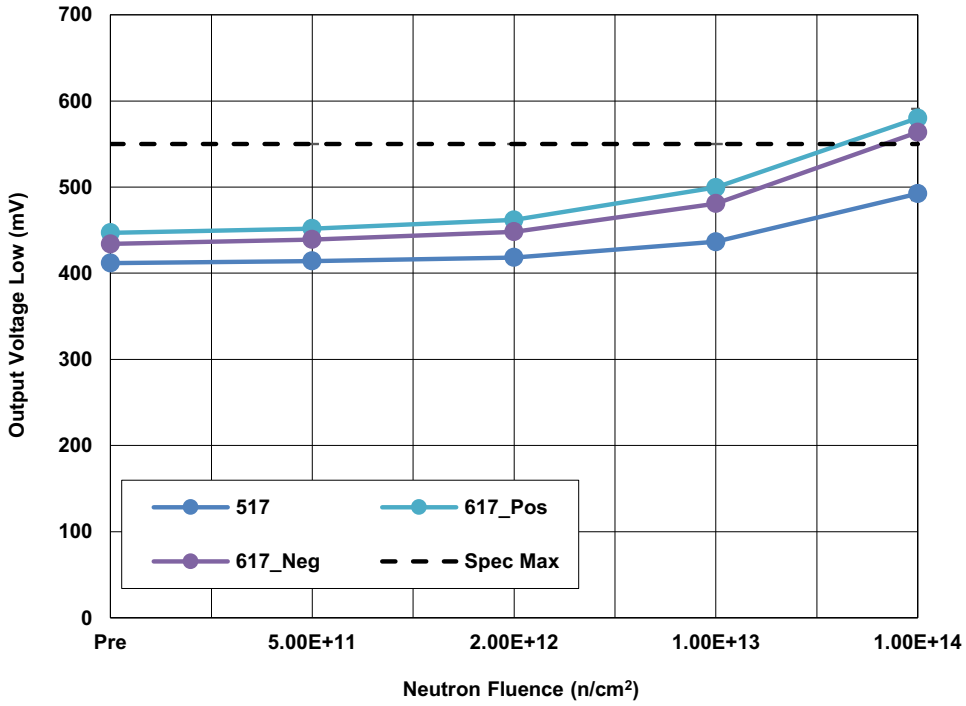

Figure 10. ISL70x17SEH low output voltage (V_{OL}) at ±18V with I_{OUT} = 7.5mA following irradiation to each level. The error bars represent the minimum and maximum measured values. The SMD limit is 550mV maximum.

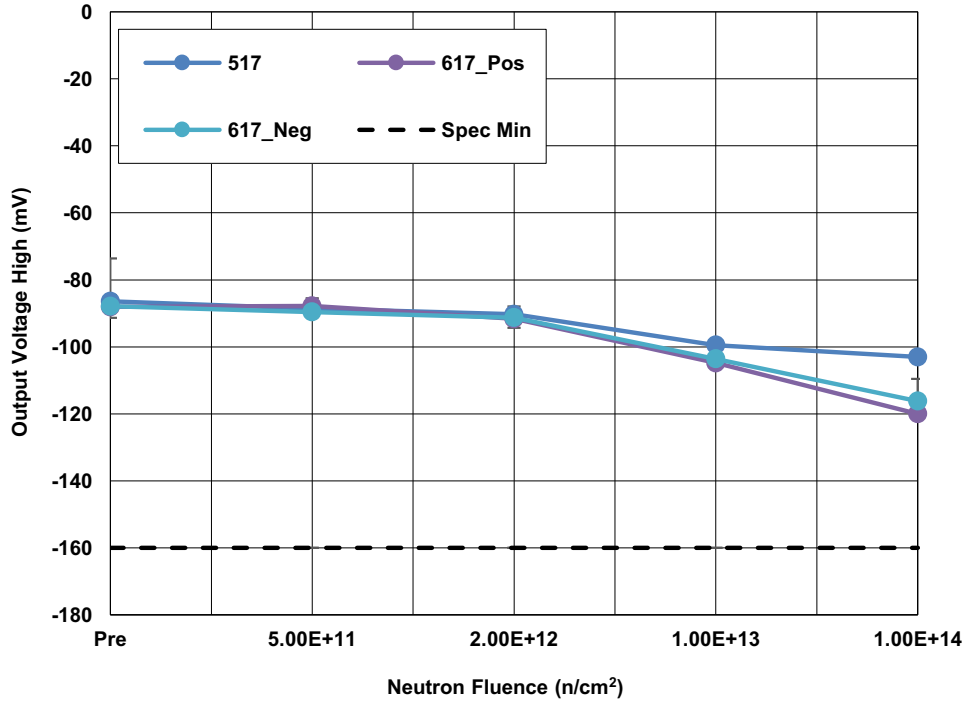

Figure 11. ISL70x17SEH high output voltage (V_{OH}) at ±18V with I_{OUT} = 0mA following irradiation to each level. The error bars represent the minimum and maximum measured values. The SMD limit is -160mV minimum.

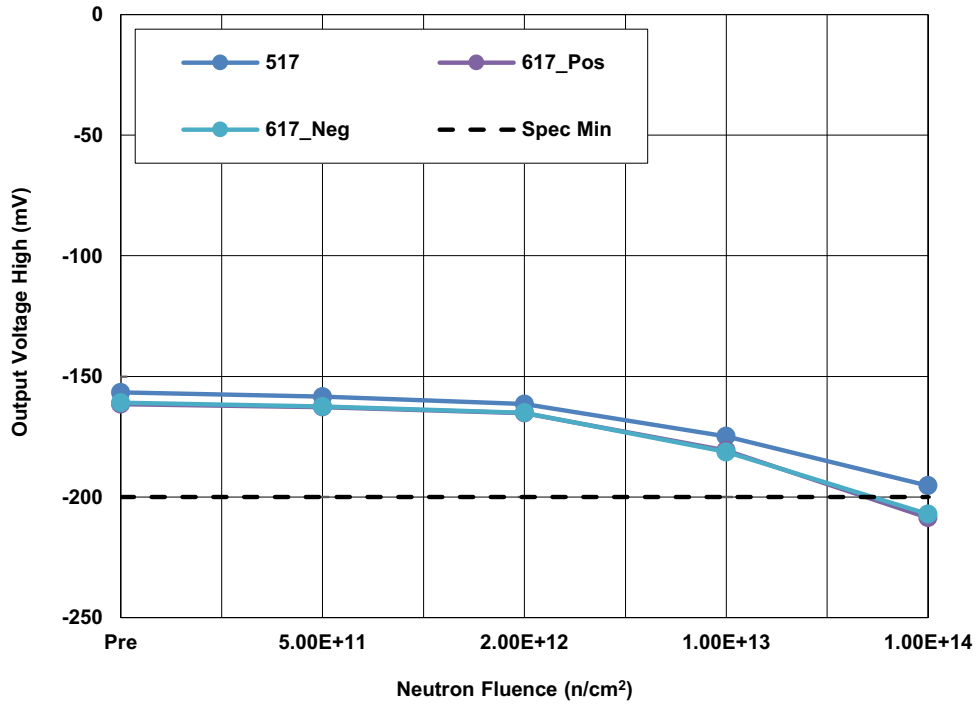

Figure 12. ISL70x17SEH high output voltage (V_{OH}) at ±18V with I_{OUT} = -1.5mA following irradiation to each level. The error bars represent the minimum and maximum measured values. The SMD limit is -200mV maximum.

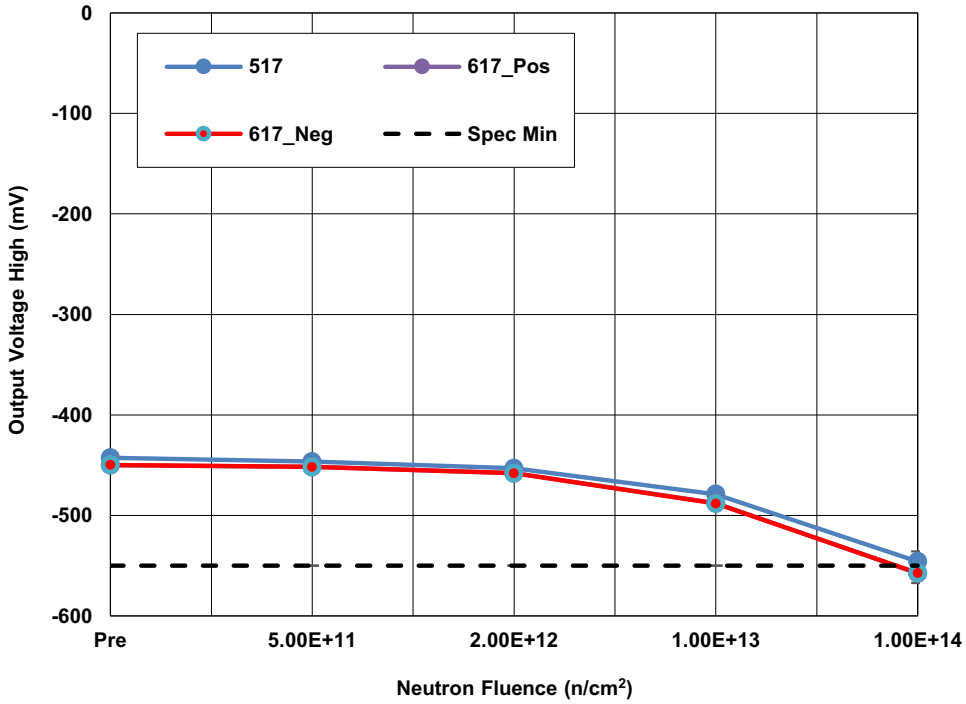

Figure 13. ISL70x17SEH high output voltage (V_{OH}) at ±18V with I_{OUT} = -7.5mA following irradiation to each level. The error bars represent the minimum and maximum measured values. The SMD limit is -550mV maximum.

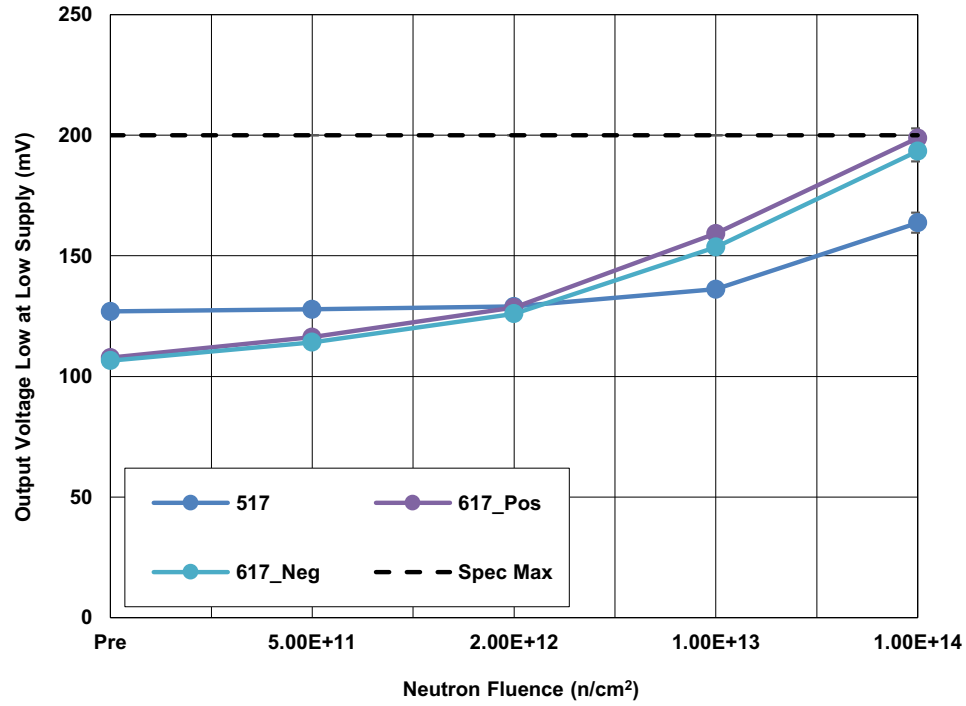

Figure 14. ISL70x17SEH low output voltage (V_{OL}LV) with V_{CC} = 4V, V_{EE} = -4V, V_{CO} = 1.5V, V_{EO} = -1.5V, I_{OUT} = 1.5mA following irradiation to each level. The error bars represent the minimum and maximum measured values. The SMD limit is 200mV maximum.

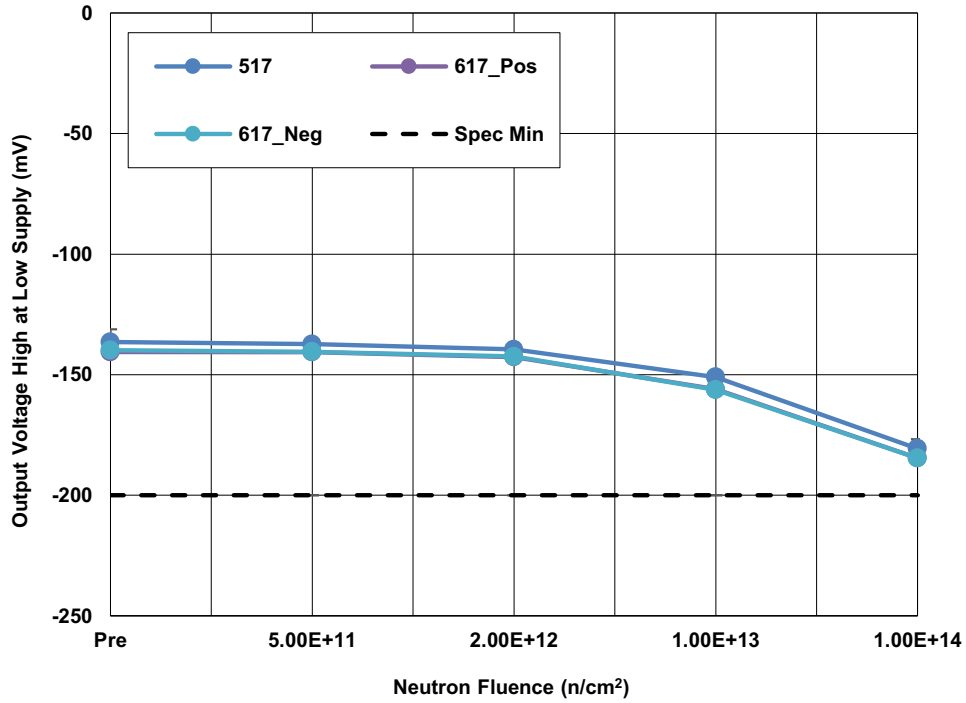

Figure 15. ISL70x17SEH high output voltage ($V_{OH}LV$) with V_{CC} = 4V, V_{EE} = -4V, V_{CO} = 1.5V, V_{EO} = -1.5V, I_{OUT} = 1.5mA following irradiation to each level. The error bars represent the minimum and maximum measured values. The SMD limit is -200mV minimum.

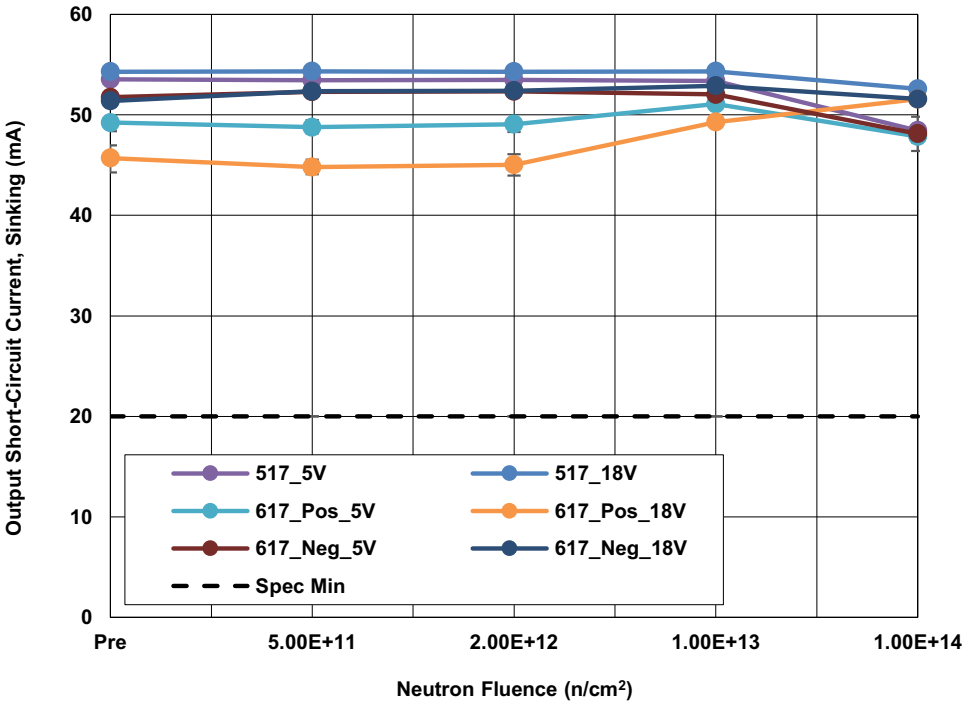

Figure 16. ISL70x17SEH output short-circuit current, sinking (I_{SC}) at ±5V and ±18V following irradiation to each level. The error bars represent the minimum and maximum measured values. The SMD limit is 20mA minimum.

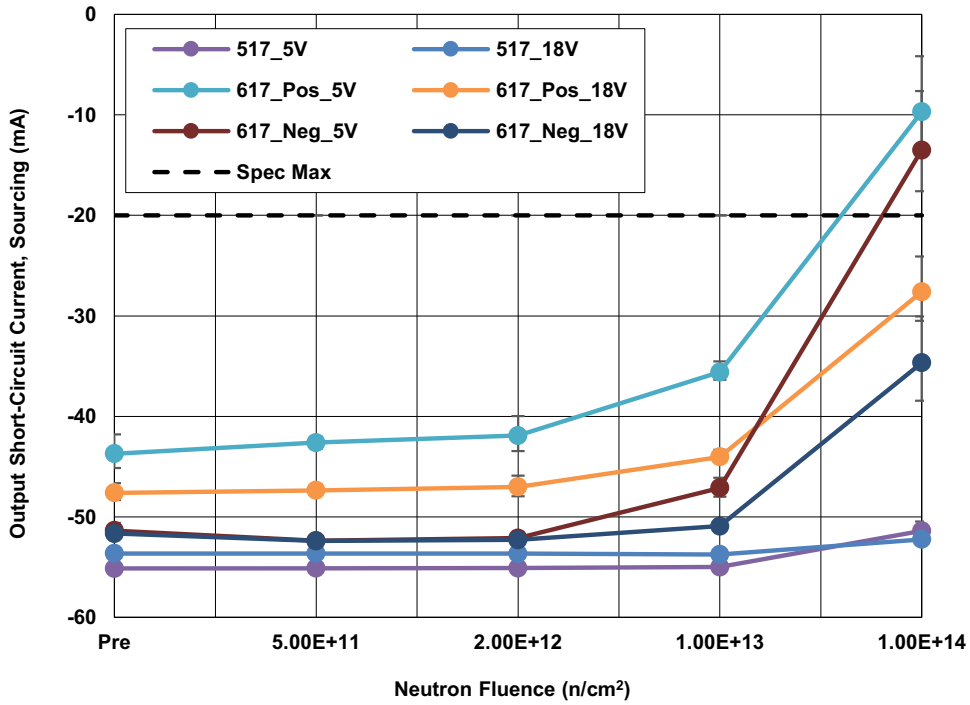

Figure 17. ISL70x17SEH output short-circuit current, sourcing (I_{SC}) at ±5V and ±18V following irradiation to each level. The error bars represent the minimum and maximum measured values. The SMD limit is -20mA maximum.

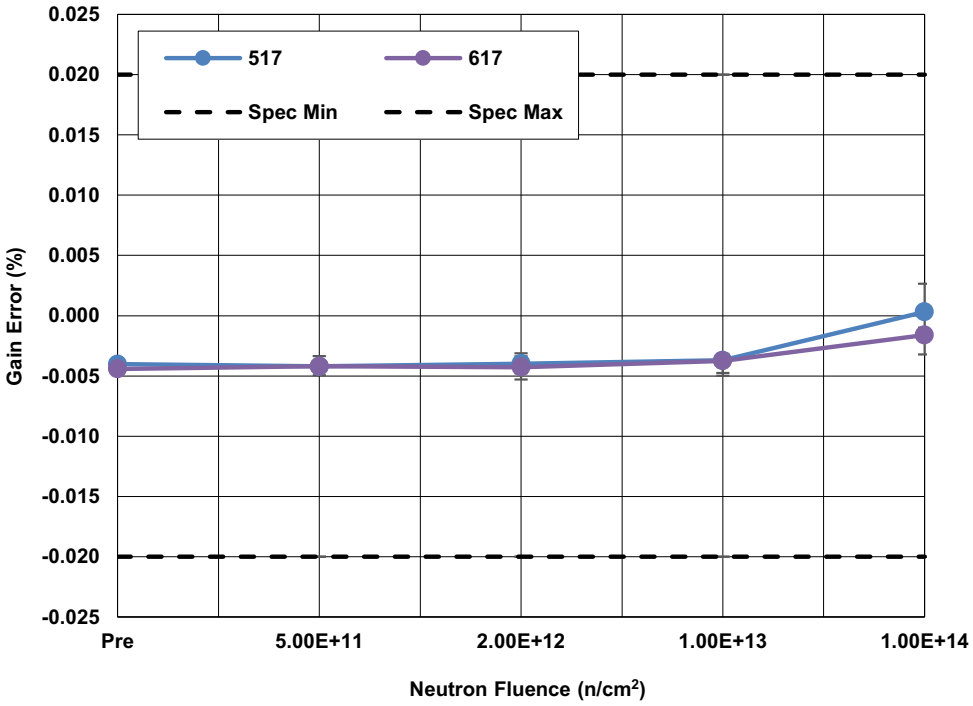

Figure 18. ISL70x17SEH gain error (E_G) with V_{OUT} = ±10V, RFB = 120k, Gain = 1 following irradiation to each level. The error bars represent the minimum and maximum measured values. The SMD limits are -0.02% minimum and 0.02% maximum.

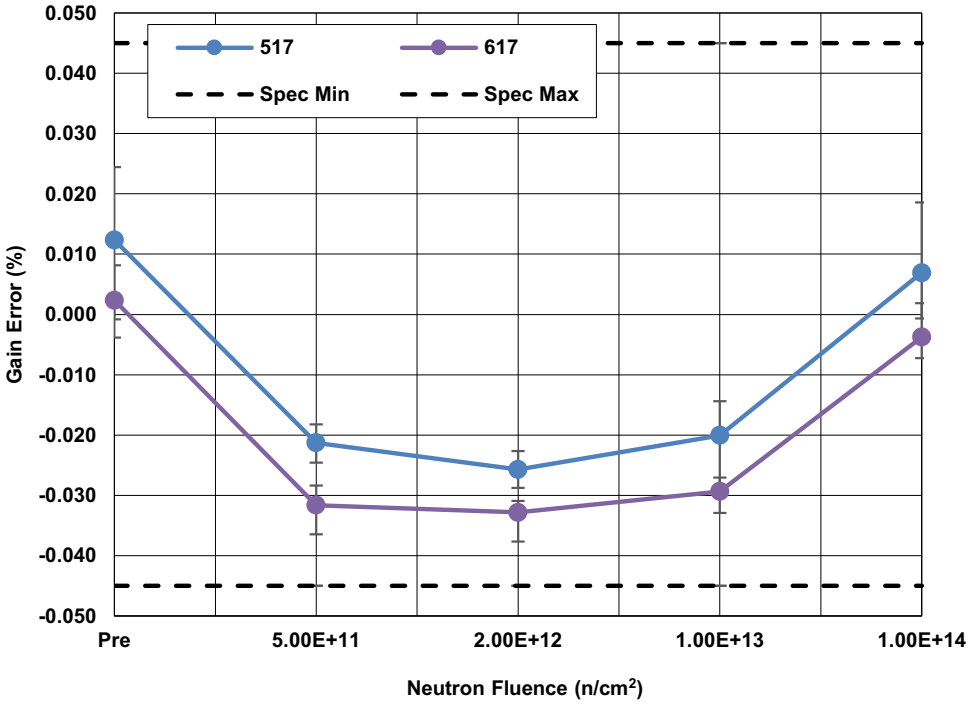

Figure 19. ISL70x17SEH gain error (E_G) with V_{OUT} = ±10V, RFB = 120k, Gain = 100 following irradiation to each level. The error bars represent the minimum and maximum measured values. The SMD limits are -0.045% minimum and 0.045% maximum.

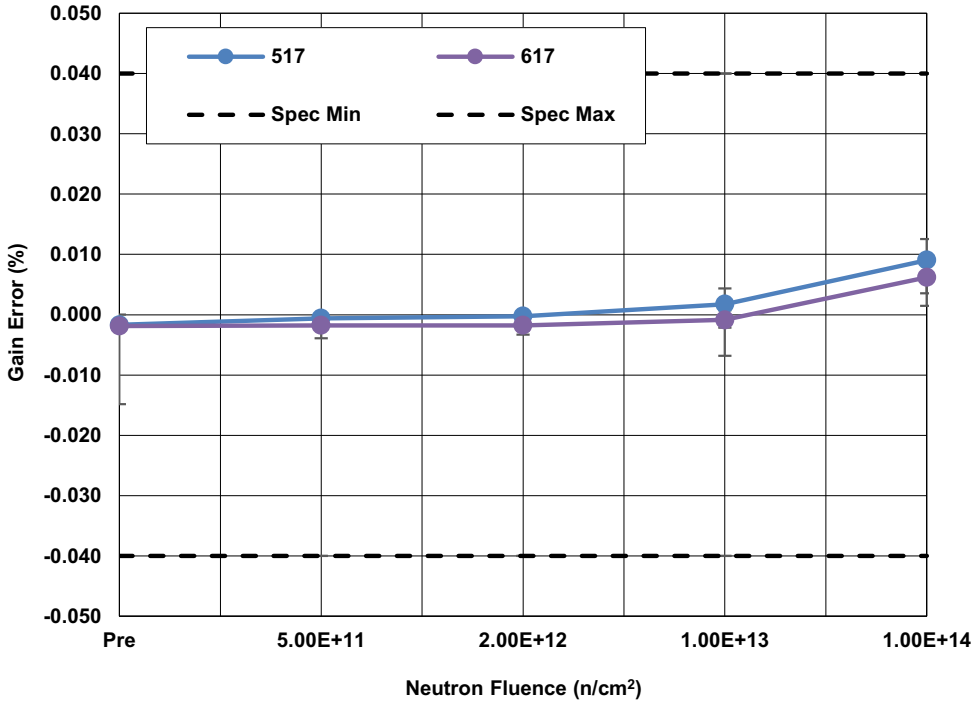

Figure 20. ISL70x17SEH gain error (E_G) with V_{OUT} = ±2.5V, RFB = 30k, Gain = 1 following irradiation to each level. The error bars represent the minimum and maximum measured values. The SMD limits are -0.04% minimum and 0.04% maximum.

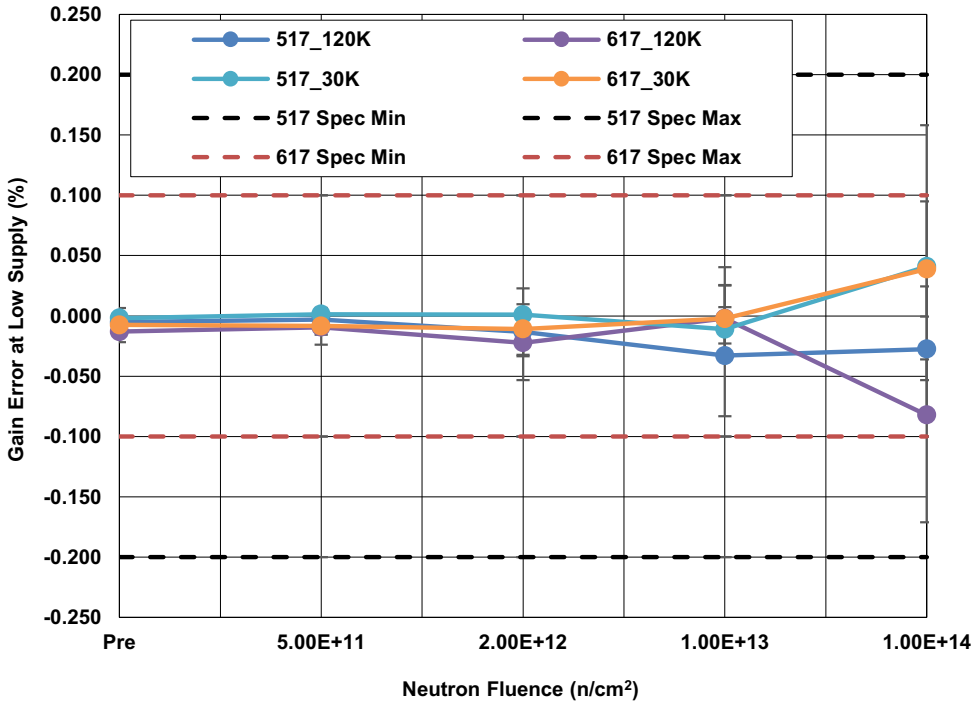

Figure 21. ISL70x17SEH gain error at low supply voltage (E_{GLV}), V_{OUT} = ±0.1V, RFB = 120k, and 30k, G = 1 following irradiation to each level. The error bars represent the minimum and maximum measured values. The SMD limits are -0.2% minimum and 0.2% maximum for the ISL70517SEH and -0.1% minimum and 0.1% maximum for the ISL70617SEH.

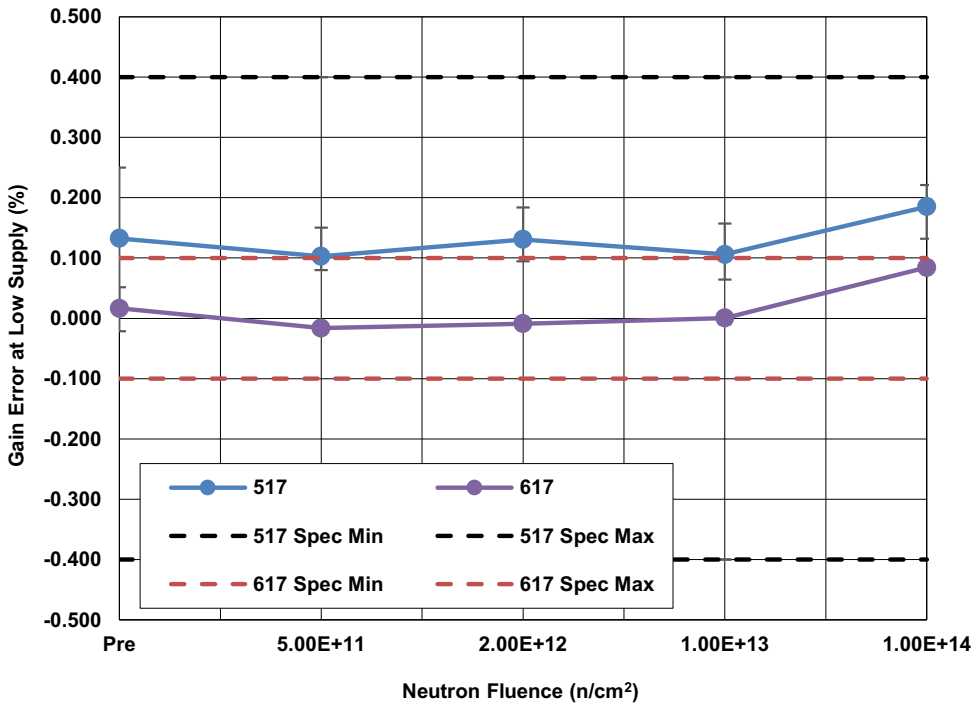

Figure 22. ISL70x17SEH gain error at low supply voltage (E_{GLV}) with V_{OUT} = ±1.25V, RFB = 120k, Gain = 100 following irradiation to each level. The error bars represent the minimum and maximum measured values. The SMD limits are -0.4% minimum and 0.4% maximum for the ISL70517SEH and -0.1% minimum and 0.1% maximum for the ISL70617SEH.

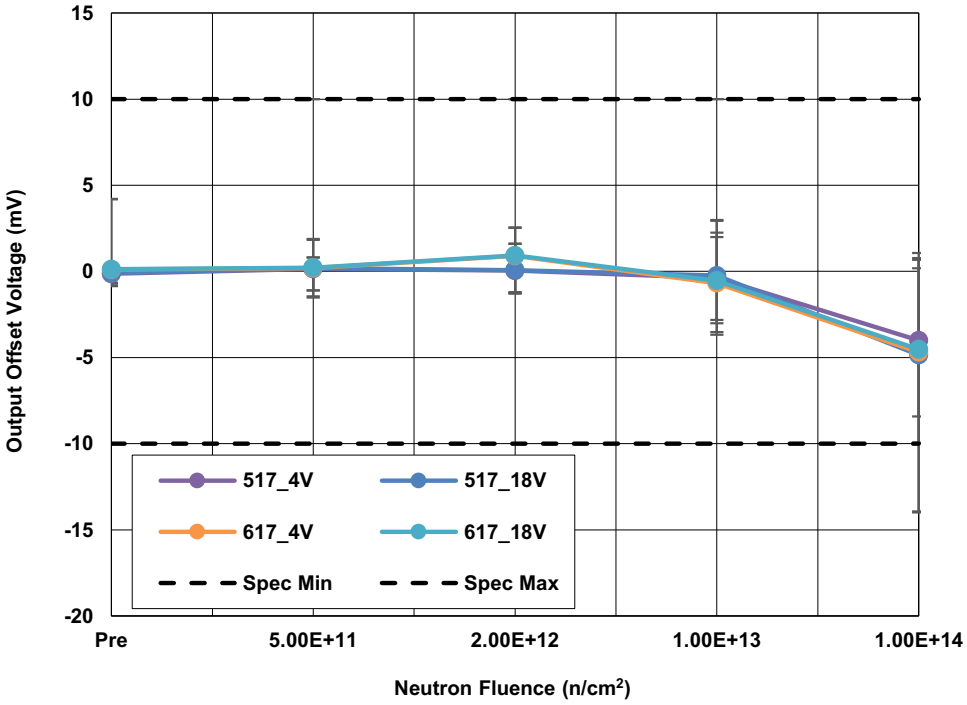

Figure 23. ISL70x17SEH output offset voltage ($V_{OS}OUT$), at ±5V and ±18V, with RFB = 30k following irradiation to each level. The error bars represent the minimum and maximum measured values. The SMD limits are -10mV minimum and 10mV maximum.

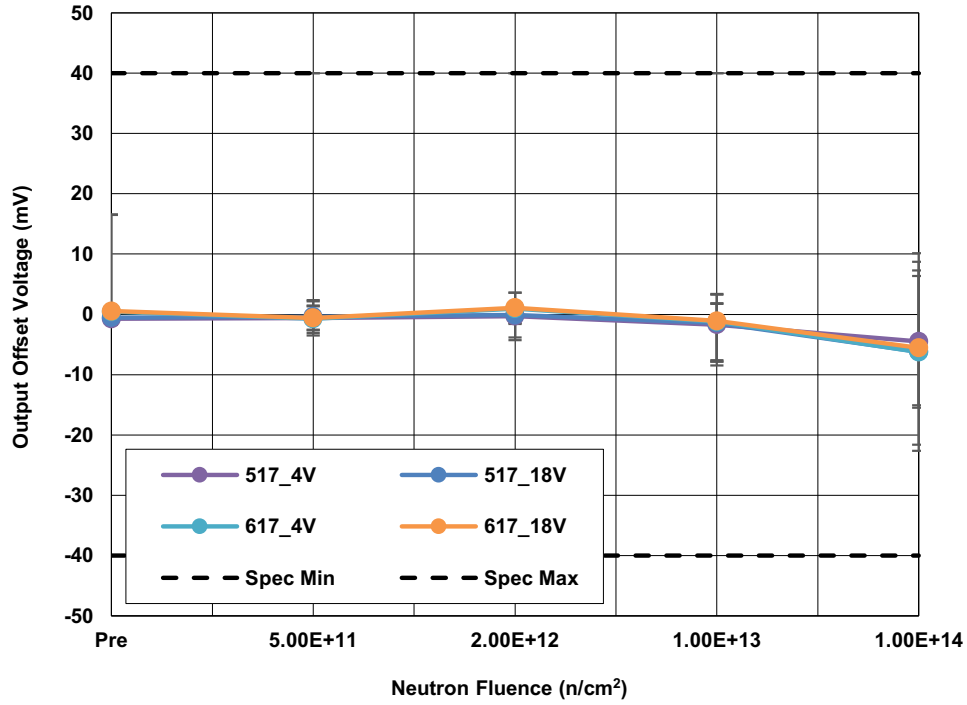

Figure 24. ISL70x17SEH output offset voltage ($V_{OS}OUT$), at ±5V and ±18V, with RFB = 120k following irradiation to each level. The error bars represent the minimum and maximum measured values. The SMD limits are -40mV minimum and 40mV maximum.

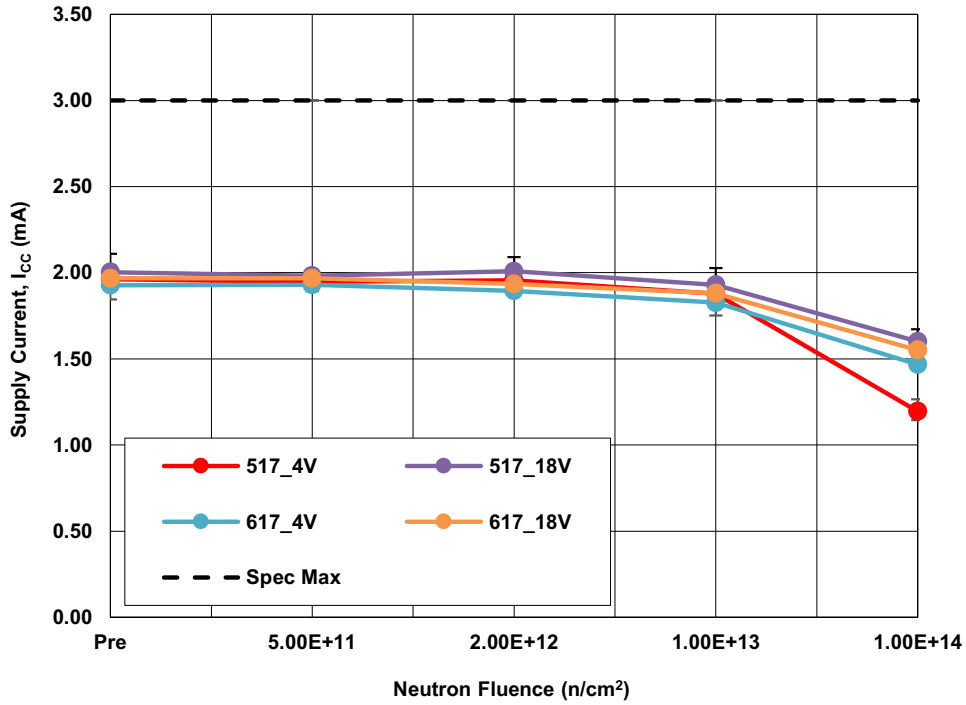

Figure 25. ISL70x17SEH supply current (I_{CC}) at ±4V and ±18V following irradiation to each level. The error bars represent the minimum and maximum measured values. The SMD limit is 3mA maximum.

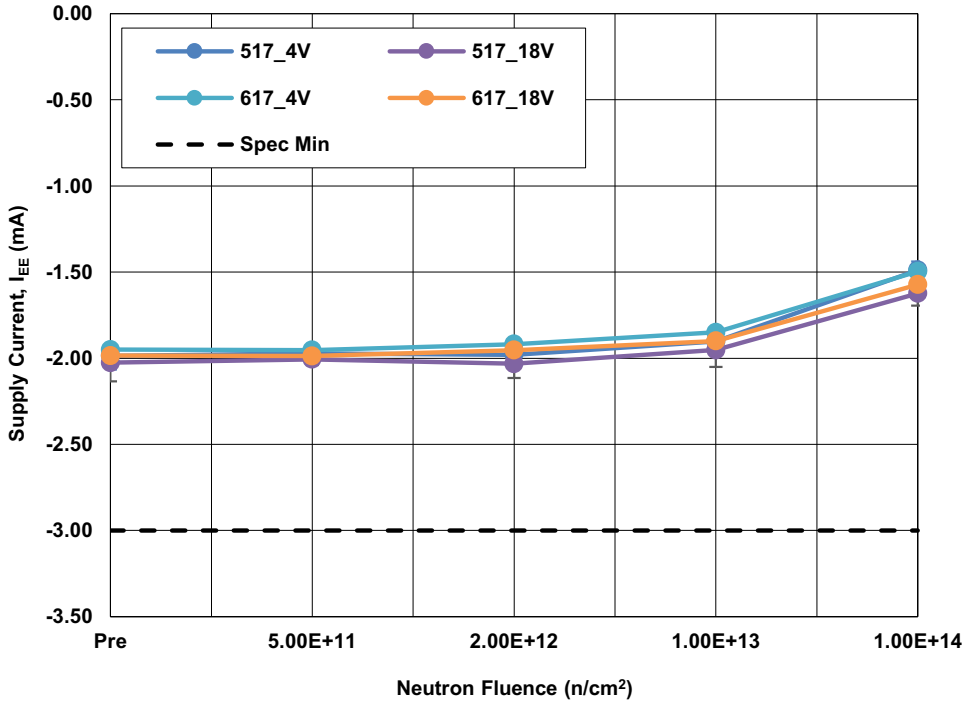

Figure 26. ISL70x17SEH supply current (I_{EE}) at ±4V and ±18V following irradiation to each level. The error bars represent the minimum and maximum measured values. The SMD limit is -3mA minimum.

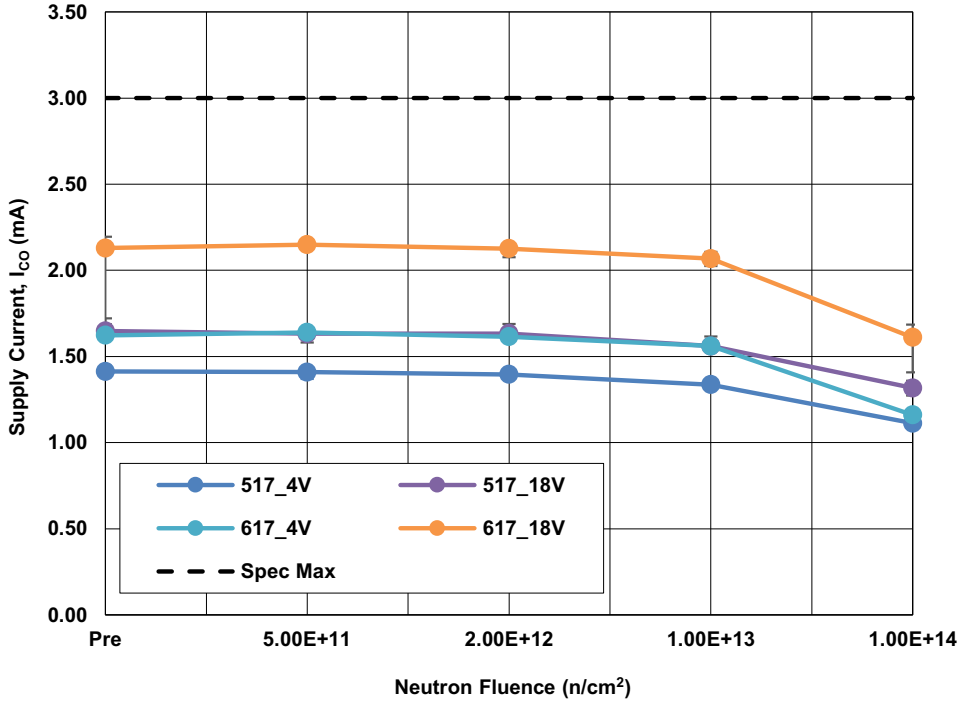

Figure 27. ISL70x17SEH supply current (I_{CO}) at ±4V and ±18V following irradiation to each level. The error bars represent the minimum and maximum measured values. The SMD limit is 3mA maximum.

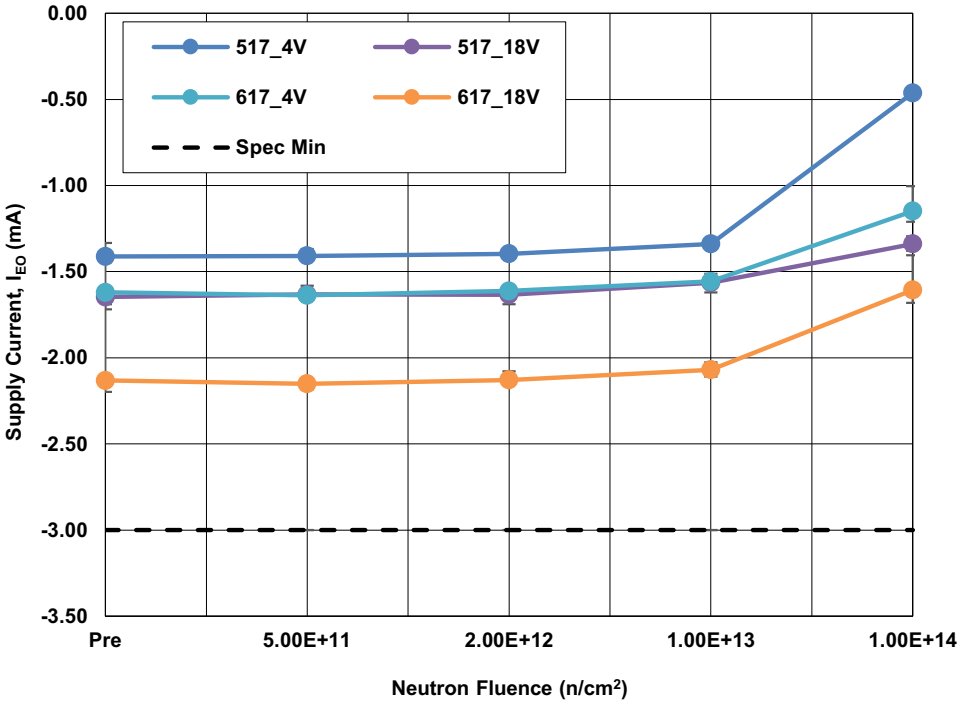

Figure 28. ISL70x17SEH supply current (I_{EO}) at ±4V and ±18V following irradiation to each level. The error bars represent the minimum and maximum measured values. The SMD limit is -3mA minimum.

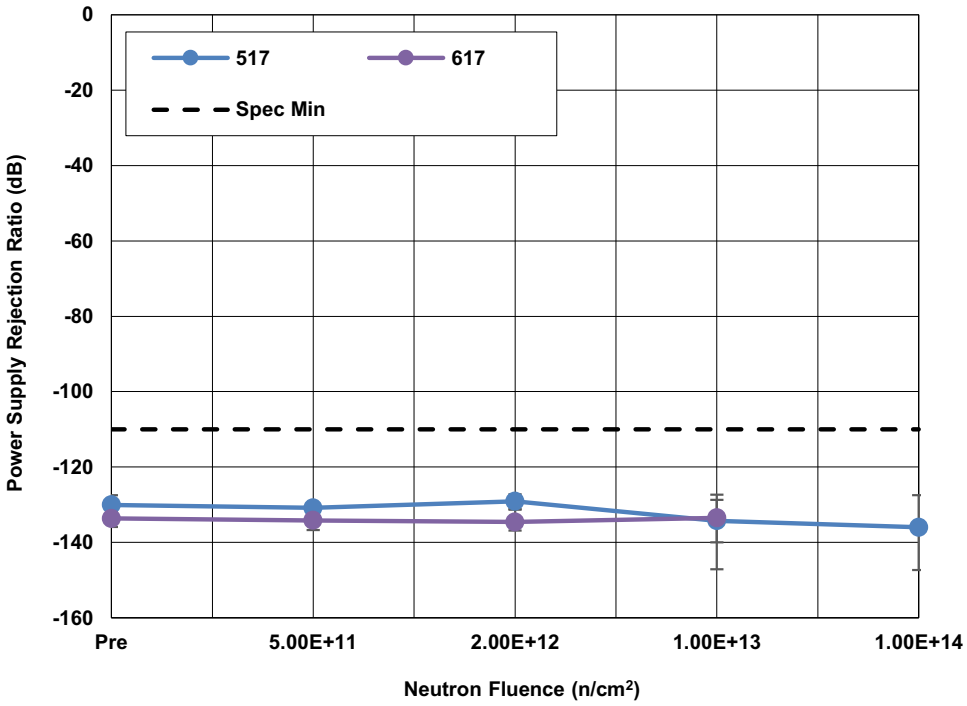

Figure 29. ISL70x17SEH input stage power supply rejection ratio (PSRRI) following irradiation to each level. The error bars represent the minimum and maximum measured values. The SMD limit is -110dB minimum.

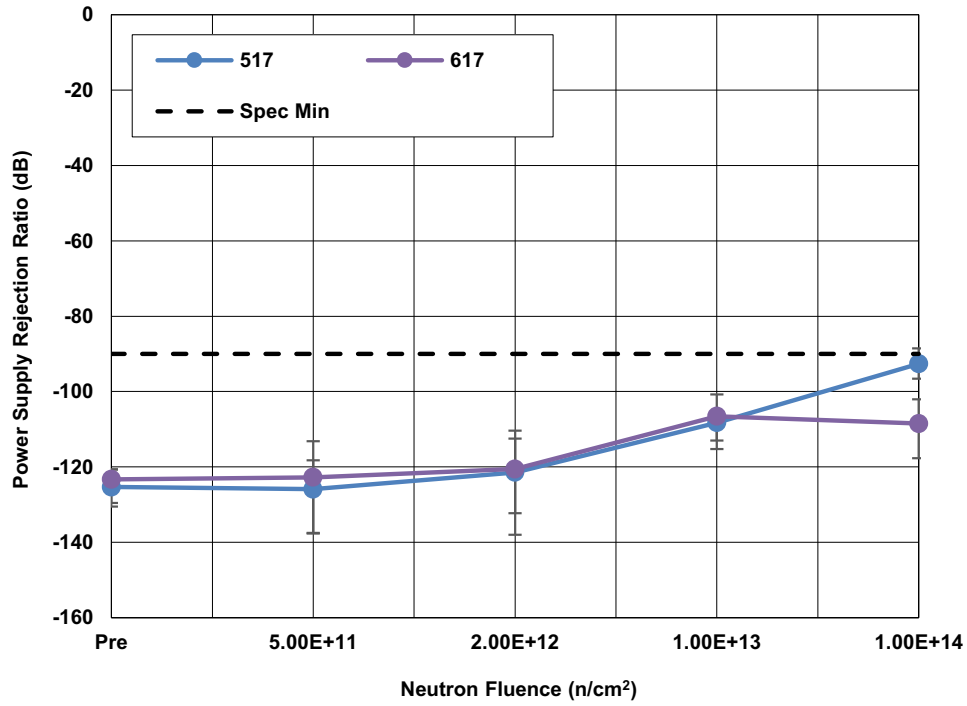

Figure 30. ISL70x17SEH output stage power supply rejection ratio (PSRRO) following irradiation to each level. The error bars represent the minimum and maximum measured values. The SMD limit is -90dB minimum.

3. Discussion and Conclusion

The results of 1MeV equivalent neutron testing of the ISL70517SEH and ISL70617SEH radiation hardened instrumentation amplifiers were reported. Parts were tested at $5x10^{11}n/cm^2$, $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, and $1x10^{14}n/cm^2$. All samples passed the SMD limits after all exposures up to and including $1x10^{13}n/cm^2$, but failed after $1x10^{14}n/cm^2$, although they remained functional. The results of key parameters before and after irradiation to each level are plotted in Figure 1 through Figure 30. 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 SMD.

4. Appendices

4.1 Reported Parameters

Figure	Parameter	Low Limit	High Limit	Unit	Notes
1	Input Offset Voltage	-300	300	µV	±4V; ±18V
2	Input Bias Current	-25	25	nA	±5V; ±18V
3	Input Offset Current	-18.5	18.5	nA	±5V; ±18V
4	Common-Mode Rejection Ratio	-	-120	dB	Gain = 100
5	Common-Mode Rejection Ratio	-	-97	dB	Gain = 1
6	Feedback Input Offset Voltage	-6000	6000	µV	±4V; ±18V
7	Feedback Input Bias Current	-200	200	nA	±4V; ±18V
8	Low Output Voltage	-	160	mV	±18V, I_{OUT} = 0mA
9	Low Output Voltage	-	200	mV	±18V, I_{OUT} = 1.5mA
10	Low Output Voltage	-	550	mV	±18V, I_{OUT} = 7.5mA
11	High Output Voltage	-160	-	mV	±18V, I_{OUT} = 0mA
12	High Output Voltage	-200	-	mV	±18V, I_{OUT} = -1.5mA
13	High Output Voltage	-550	-	mV	±18V, I_{OUT} = -7.5mA
14	Low Output Voltage	-	200	mV	V_{CC} = 4V, V_{EE} = -4V, V_{CO} = 1.5V, V_{EO} = -1.5V, I_{OUT} = 1.5mA
15	High Output Voltage	-200	-	mV	
16	Output Short-Circuit Current, Sinking	20	-	mA	±5V; ±18V
17	Output Short-Circuit Current, Sourcing	-	-20	mA	±5V; ±18V
18	Gain Error	-0.02	0.02	%	V_{OUT} = ±10V, RFB = 120k, G = 1
19	Gain Error	-0.045	0.045	%	V_{OUT} = ±10V, RFB = 120k, G = 100
20	Gain Error	-0.04	0.04	%	V_{OUT} = ±2.5V, RFB = 30k, G = 1
21	Gain Error, Low Supply Voltage (‘517)	-0.2	0.2	%	V_{OUT} = ±0.1V, RFB = 30k, 120k, G = 1
	Gain Error, Low Supply Voltage (‘617)	-0.1	0.1		
22	Gain Error, Low Supply Voltage (‘517)	-0.4	0.4	%	V_{OUT} = ±1.25V, RFB = 120k, G = 100
	Gain Error, Low Supply Voltage (‘617)	-0.1	0.1		
23	Output Offset Voltage	-10	10	mV	±5V; ±18V, RFB = 30k
24	Output Offset Voltage	-40	40	mV	±5V; ±18V, RFB = 120k
25	Supply Current, I_{CC}	-	3.0	mA	±4V; ±18V
26	Supply Current, Iee	-3.0	-	mA	±4V; ±18V
27	Supply Current, Ico	-	3.0	mA	±4V; ±18V
28	Supply Current, Ieo	-3.0	-	mA	±4V; ±18V
29	Power Supply Rejection Ratio	-110	-	dB	Input stage PSRR
30	Power Supply Rejection Ratio	-90	-	dB	Output stage PSRR

5. Revision History

Rev.	Date	Description
1.01	Jun 20, 2025	Applied latest template. Minor updates to Variables Data and Discussion and Conclusion sections.
1.00	Oct 21, 2019	Initial release

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