ISL70419SEH

Neutron Testing

TR038
Rev 0.00
October 12, 2016

Introduction

This report summarizes results of 1MeV equivalent neutron testing of the ISL70419SEH quad operational amplifier. 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 $2x10^{12}n/cm^2$ to $1x10^{14}n/cm^2$. This project was carried out in collaboration with Boeing (El Segundo, CA), whose support is gratefully acknowledged.

Related Literature

- For a full list of related documents please visit our website
  - ISL70419SEH product page

Part Description

The ISL70419SEH is a quad operational amplifier featuring a competitive combination of low noise vs power consumption. Low offset voltage, low input bias current, and low temperature drift makes the ISL70419SEH a good choice for applications requiring both high DC accuracy and AC performance. The combination of precision, low noise, low power, and a small footprint provides the user with outstanding value and flexibility relative to competitive parts. Applications include precision active filters, power supply controls, and industrial controls. The ISL70419SEH is offered in a 14 Ld hermetic ceramic flatpack. The device uses an industry standard pin configuration and operates across the extended temperature range from -55°C to +125°C.

Specifications for radiation hardened QML devices are controlled by the Defense Logistics Agency Land and Maritime (DLA).

The ISL70419SRH is acceptance tested on a wafer-by-wafer basis to a total dose level of 300krad(Si) at high dose rate (50-300rad(Si)/s). The ISL70419SEH is acceptance tested to a total dose level of 300krad(Si) at high dose rate (50-300rad(Si)/s) and to 50krad(Si) at low dose rate (<0.01rad(Si)/s). The SMD rates both parts at 300krad(Si) at high dose rate (50-300rad(Si)/s) and at 50krad(Si) at low dose rate (< 0.01rad(Si)/s).

TABLE 1. ISL70419SEH PIN ASSIGNMENTS

TERMINAL NUMBER	TERMINAL SYMBOL	TERMINAL NUMBER	TERMINAL SYMBOL
1	OUT_A	8	OUT_C
2	-IN_A	9	-IN_C
3	+IN_A	10	+IN_C
4	V+	11	V-
5	+IN_B	12	+IN_D
6	-IN_B	13	-IN_D
7	OUT_B	14	OUT_D

Test Description

Irradiation Facilities

1MeV equivalent neutron irradiation was performed at the White Sands Missile Range fast burst reactor (White Sands Missile Range, NM 88002). Dosimetry data can be furnished upon request. Parts were tested in an unbiased configuration with all leads shorted together in general accordance with TM1017 of MIL-STD-883. Samples exposed at the higher neutron levels required considerable ‘cooldown’ time before being shipped back to Intersil for electrical testing.

Test Fixturing

No formal irradiation test fixturing was involved. These DD tests are informally termed ‘bag tests’ as the samples 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 Palm Bay, FL Automated Test Equipment (ATE). All electrical testing was performed at room temperature.

Experimental Matrix

The experimental matrix consisted of five samples irradiated at $2x10^{12}n/cm^2$, five irradiated at $1x10^{13}n/cm^2$, five irradiated at $3x10^{13}n/cm^2$, and five irradiated at $1x10^{14}n/cm^2$. Five control units were used. ISL70419SEHF/PROTO samples were drawn from fabrication lot X0H6DACA and were packaged in the standard 14 Ld ceramic production package. Samples were screened to the SMD limits over temperature before the start of neutron testing.

Results

The ISL70419SEH neutron testing 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. ISL70419SEH ATTRIBUTES DATA

PART	SERIAL	SAMPLE SIZE	FLUENCE, (n/cm^2)	PASS (Note 1)	FAIL	NOTES
ISL70419SEH	1-5	5	2x10^{12}	5	0	All passed
ISL70419SEH	6-10	5	1x10^{13}	5	0	All passed
ISL70419SEH	11-15	5	3x10^{13}	5	0	All passed
ISL70419SEH	16-20	5	1x10^{14}	0	5	All failed open-loop gain but were functional

NOTE:

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

Variables Data

The plots in Figures 1 through 29 show data plots for key parameters before and after irradiation to each level. The reported parameters and their datasheet limits are shown in “Appendix” on page 17. This appendix contains a considerable number of figures, but we chose to go into some detail for the critical input parameters, which are of great interest in any operational amplifier test. We plotted these channel-by-channel to determine if any channel sensitivity exists. Other parameters were plotted as averages of all four channels, an approach which does not work for critical parameters such as input offset voltage, which may show significant, uncorrelated variation. For these cases, we plotted each channel individually.

The plots show the population median of each parameter as a function of neutron irradiation as well as the population minimum and maximum. We chose to plot the median because of the small sample sizes (five per cell) involved. We also show the applicable post-total dose electrical limits as taken from the SMD. It should be noted that these limits are provided for *guidance only* as the ISL70419SEH 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 limited collaborative neutron testing for customer guidance.

Variables Data Plots

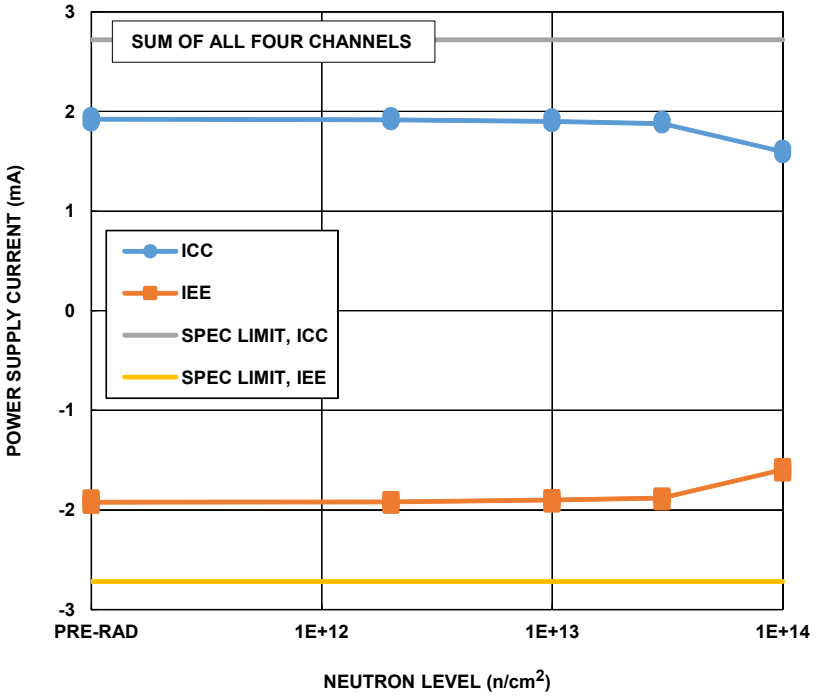

FIGURE 1. ISL70419SEH positive and negative supply current, sum of all four channels, as a function of 1MeV equivalent neutron irradiation at 2x10^{12}n/cm^2, 1x10^{13}n/cm^2, 3x10^{13}n/cm^2, and 1x10^{14}n/cm^2. The plot shows the population median, minimum, and maximum at each downpoint. Sample size for each cell was five. The post-total dose irradiation SMD limits are 2.72mA maximum (ICC) and -2.72mA maximum (IEE).

Variables Data Plots (Continued)

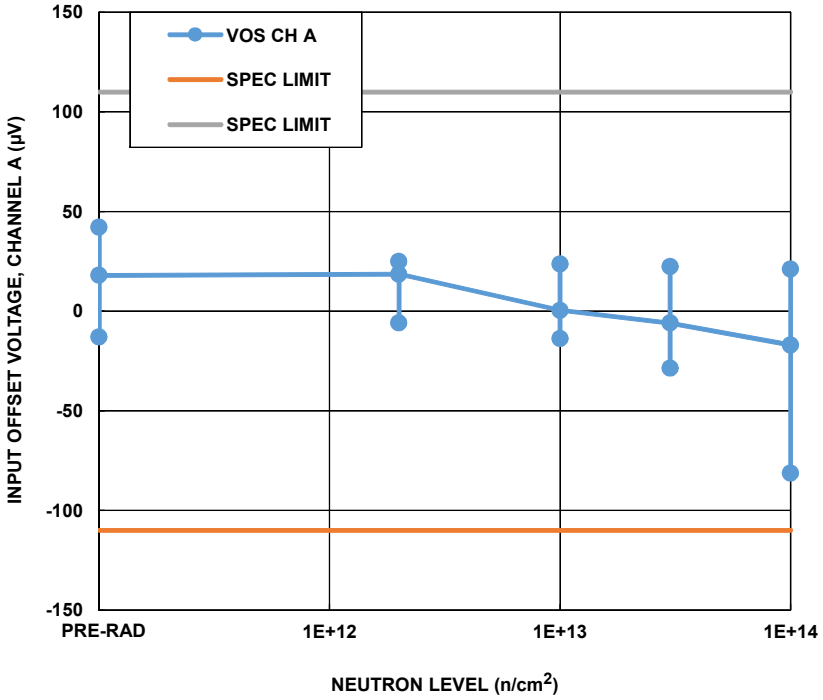

FIGURE 2. ISL70419SEH input offset voltage, Channel A, as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$, and $1x10^{14}n/cm^2$. The plot shows the population median, minimum, and maximum at each downpoint. Sample size for each cell was five. The post-total dose irradiation SMD limits are -110µV to 110µV.

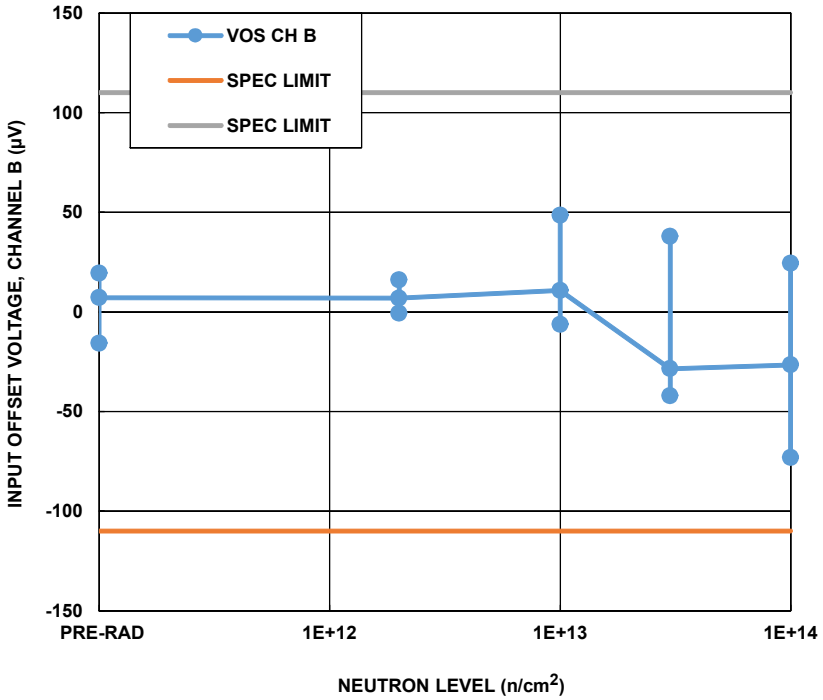

FIGURE 3. ISL70419SEH input offset voltage, Channel B, as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$, and $1x10^{14}n/cm^2$. The plot shows the population median, minimum, and maximum at each downpoint. Sample size for each cell was five. The post-total dose irradiation SMD limits are -110µV to 110µV.

Variables Data Plots (Continued)

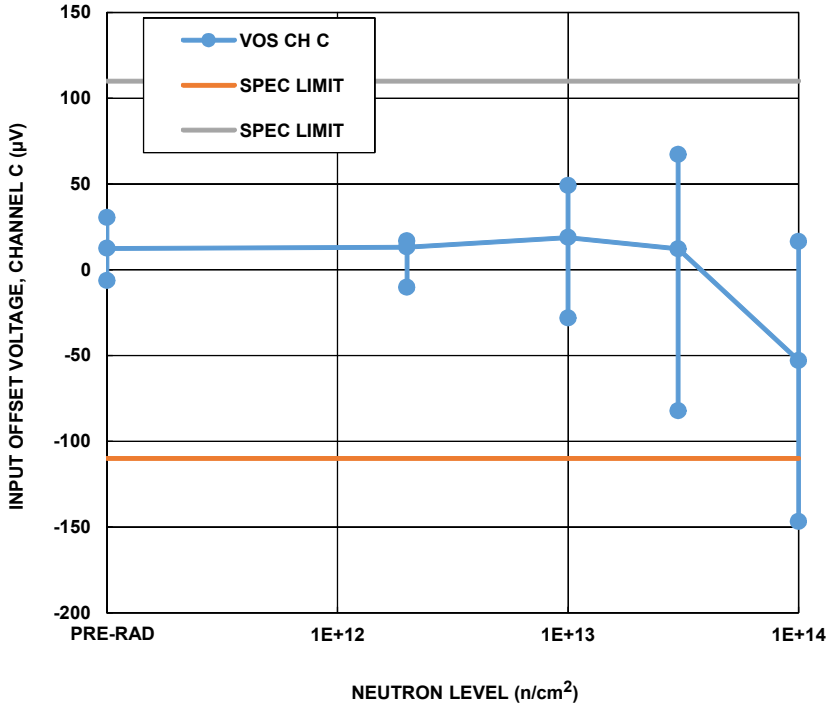

FIGURE 4. ISL70419SEH input offset voltage, Channel C, as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$, and $1x10^{14}n/cm^2$. The plot shows the population median, minimum, and maximum at each downpoint. Sample size for each cell was five. The post-total dose irradiation SMD limits are -110µV to 110µV.

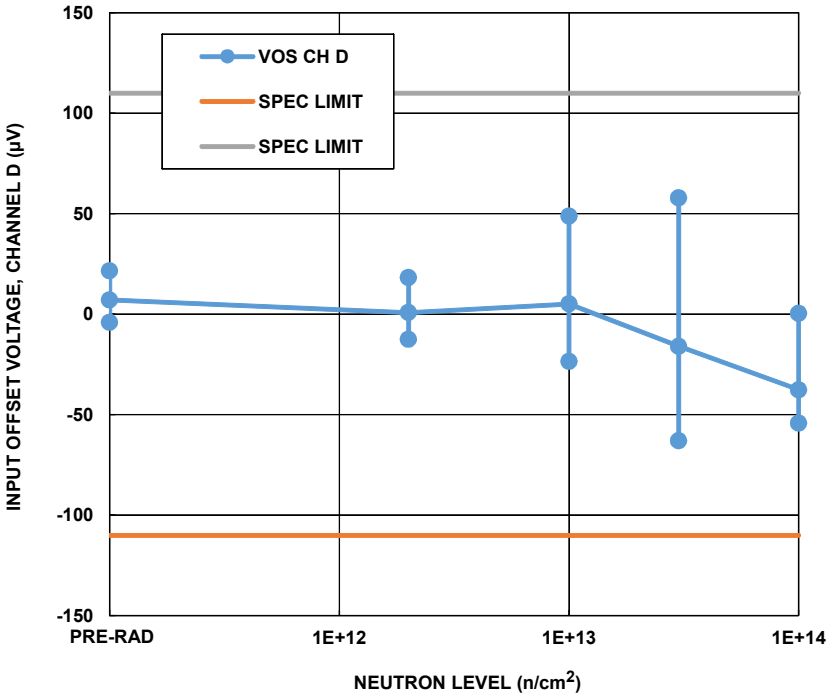

FIGURE 5. ISL70419SEH input offset voltage, Channel D, as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$, and $1x10^{14}n/cm^2$. The plot shows the population median, minimum, and maximum at each downpoint. Sample size for each cell was five. The post-total dose irradiation SMD limits are -110µV to 110µV.

Variables Data Plots (Continued)

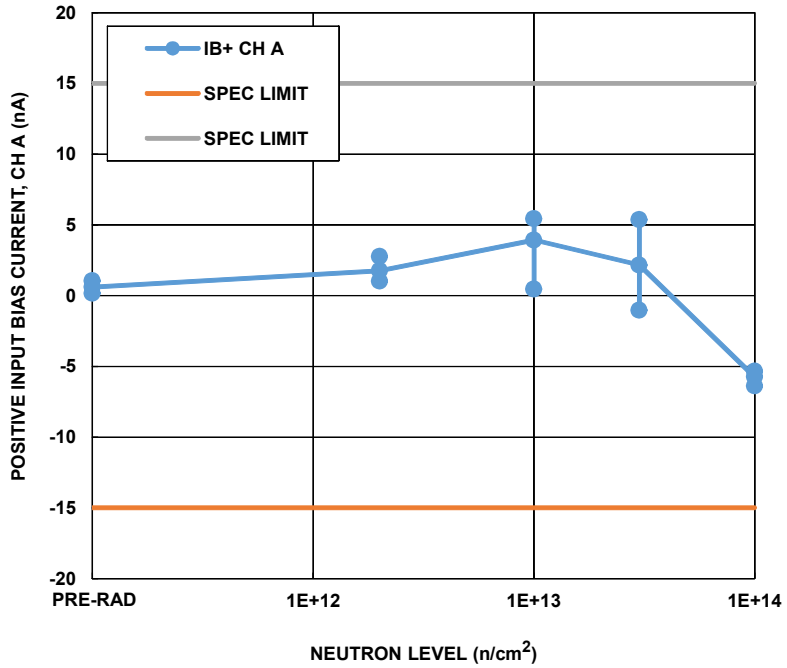

FIGURE 6. ISL70419SEH positive input bias current, Channel A, as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$, and $1x10^{14}n/cm^2$. The plot shows the population median, minimum, and maximum at each downpoint. Sample size for each cell was five. The post-total dose irradiation SMD limits are -15nA to 15nA.

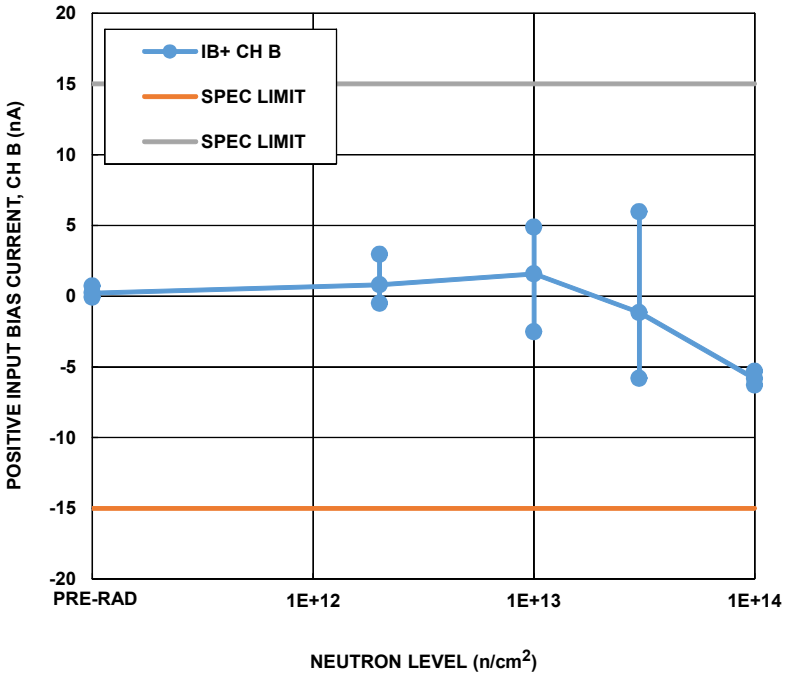

FIGURE 7. ISL70419SEH positive input bias current, Channel B, as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$, and $1x10^{14}n/cm^2$. The plot shows the population median, minimum, and maximum at each downpoint. Sample size for each cell was five. The post-total dose irradiation SMD limits are -15nA to 15nA.

Variables Data Plots (Continued)

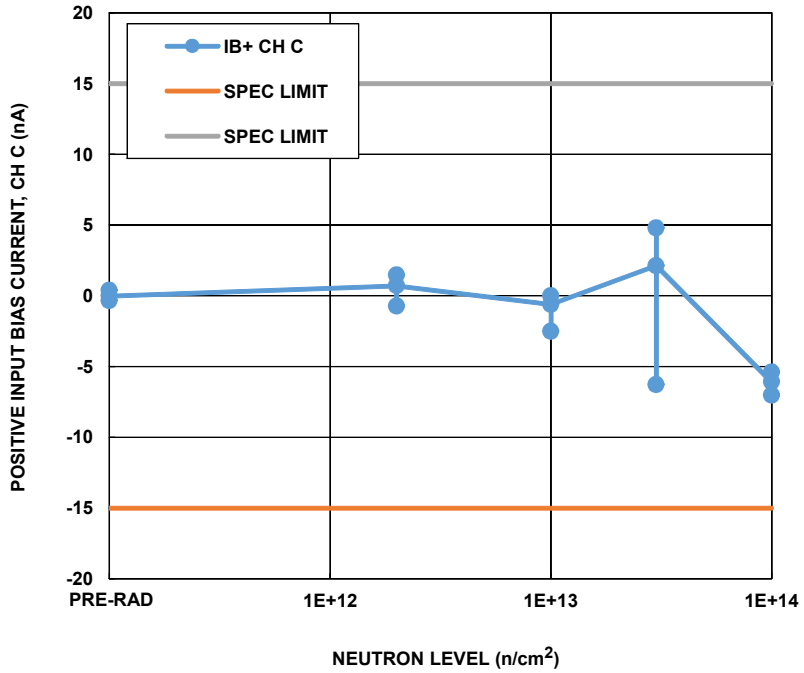

FIGURE 8. ISL70419SEH positive input bias current, Channel C, as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$, and $1x10^{14}n/cm^2$. The plot shows the population median, minimum, and maximum at each downpoint. Sample size for each cell was five. The post-total dose irradiation SMD limits are -15nA to 15nA.

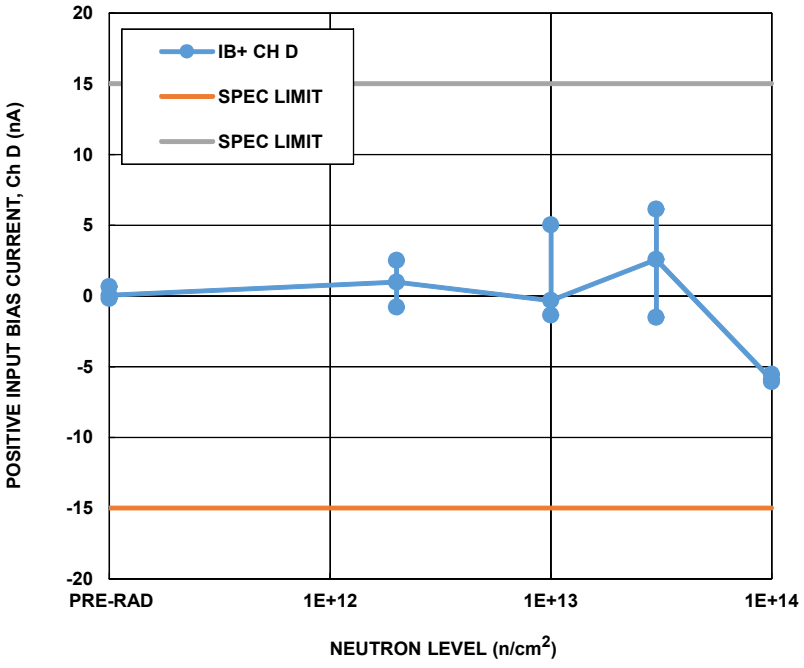

FIGURE 9. ISL70419SEH positive input bias current, Channel D, as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$, and $1x10^{14}n/cm^2$. The plot shows the population median, minimum, and maximum at each downpoint. Sample size for each cell was five. The post-total dose irradiation SMD limits are -15nA to 15nA.

Variables Data Plots (Continued)

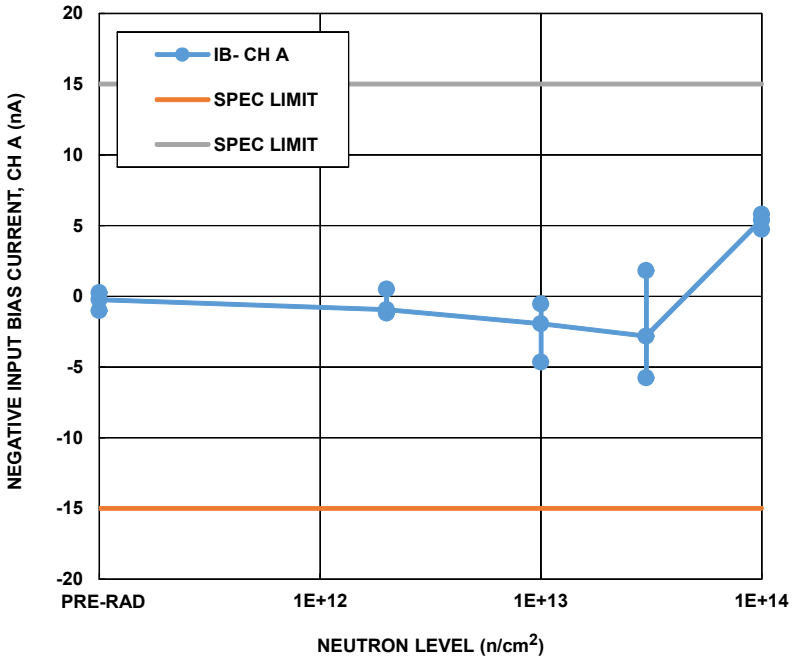

FIGURE 10. ISL70419SEH negative input bias current, Channel A, as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$, and $1x10^{14}n/cm^2$. The plot shows the population median, minimum, and maximum at each downpoint. Sample size for each cell was five. The post-total dose irradiation SMD limits are -15nA to 15nA.

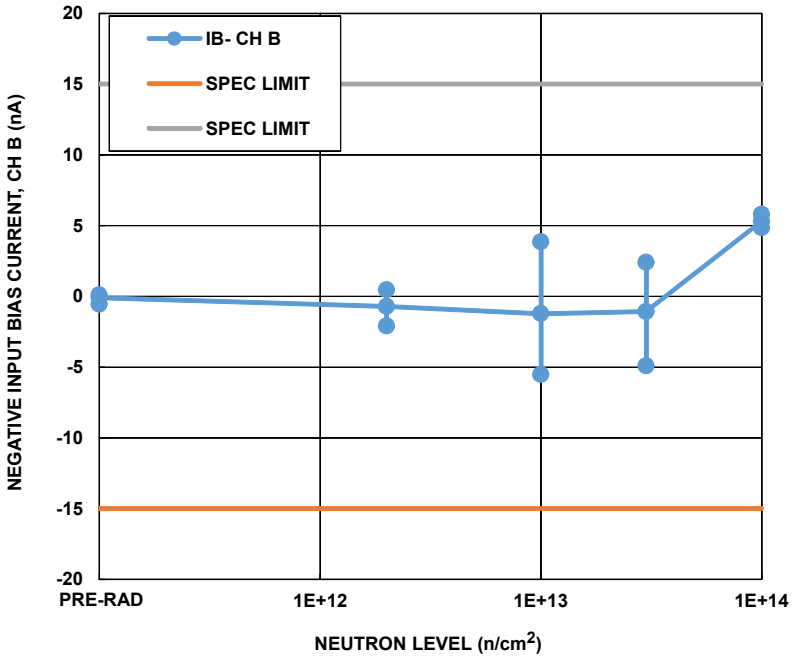

FIGURE 11. ISL70419SEH negative input bias current, Channel B, as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$, and $1x10^{14}n/cm^2$. The plot shows the population median, minimum, and maximum at each downpoint. Sample size for each cell was five. The post-total dose irradiation SMD limits are -15nA to 15nA.

Variables Data Plots (Continued)

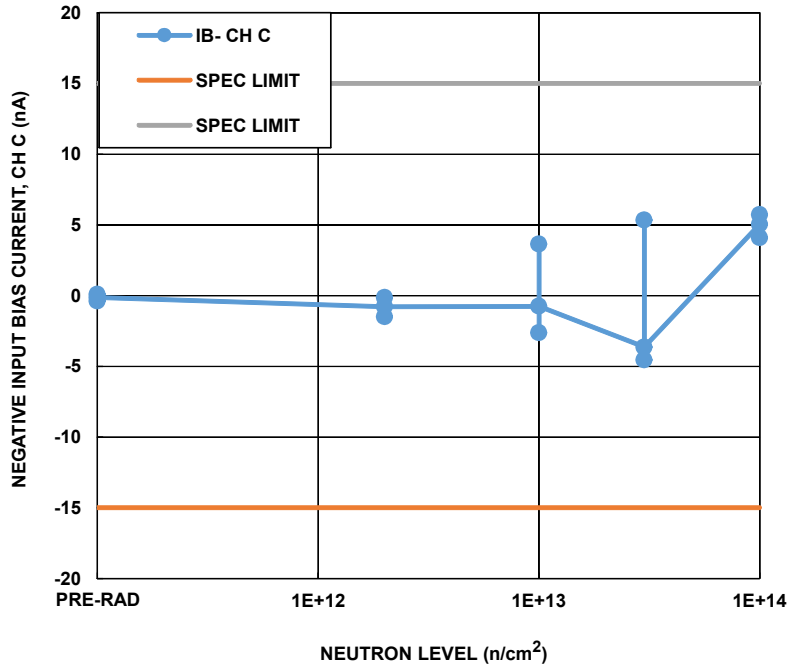

FIGURE 12. ISL70419SEH negative input bias current, Channel C, as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$, and $1x10^{14}n/cm^2$. The plot shows the population median, minimum, and maximum at each downpoint. Sample size for each cell was five. The post-total dose irradiation SMD limits are –15nA to 15nA.

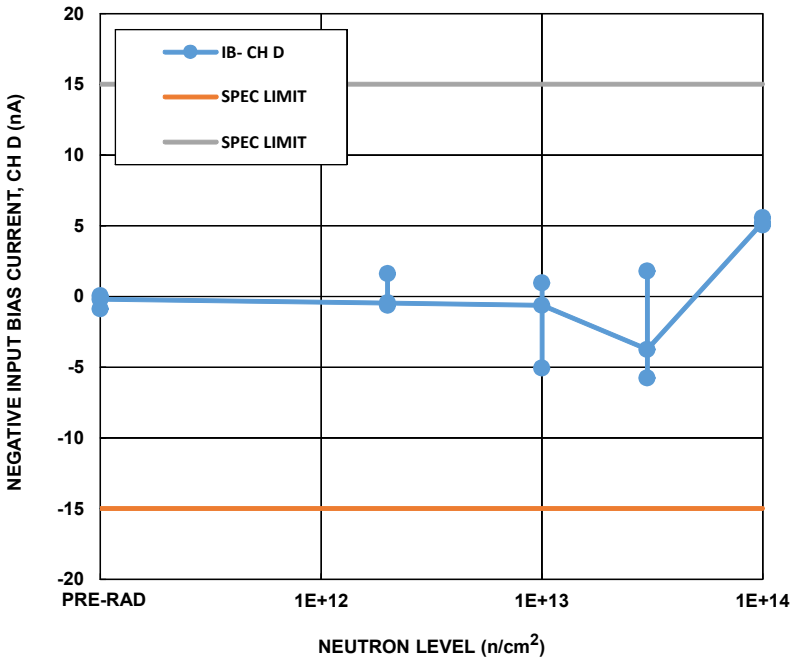

FIGURE 13. ISL70419SEH negative input bias current, Channel D, as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$, and $1x10^{14}n/cm^2$. The plot shows the population median, minimum, and maximum at each downpoint. Sample size for each cell was five. The post-total dose irradiation SMD limits are -15nA to 15nA.

Variables Data Plots (Continued)

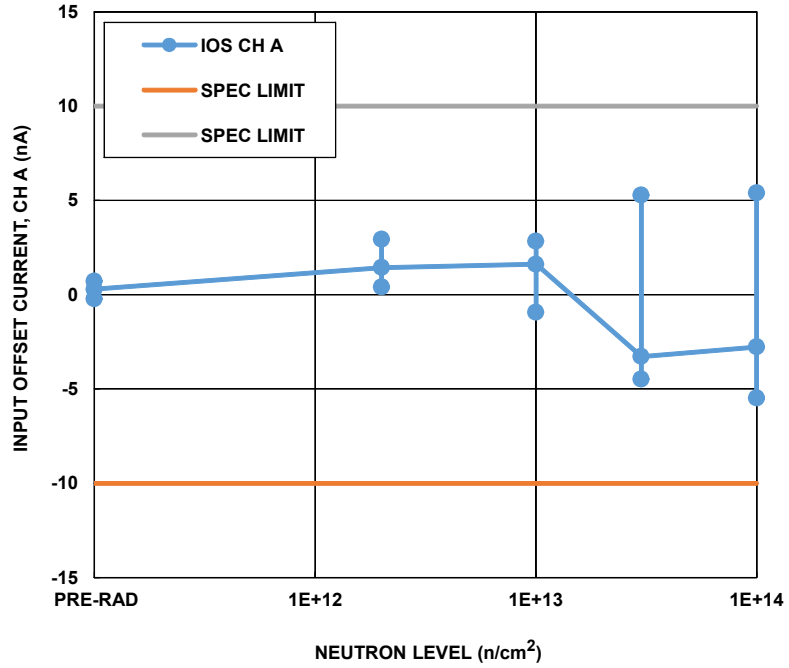

FIGURE 14. ISL70419SEH input offset current, Channel A, as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$, and $1x10^{14}n/cm^2$. The plot shows the population median, minimum, and maximum at each downpoint. Sample size for each cell was five. The post-total dose irradiation SMD limits are -10nA to 10nA.

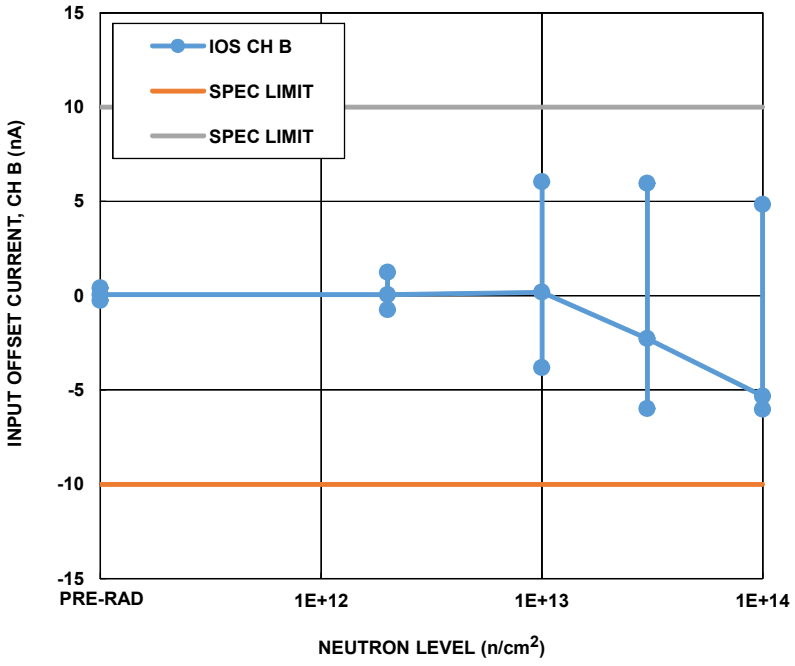

FIGURE 15. ISL70419SEH input offset current, Channel B, as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$, and $1x10^{14}n/cm^2$. The plot shows the population median, minimum, and maximum at each downpoint. Sample size for each cell was five. The post-total dose irradiation SMD limits are -10nA to 10nA.

Variables Data Plots (Continued)

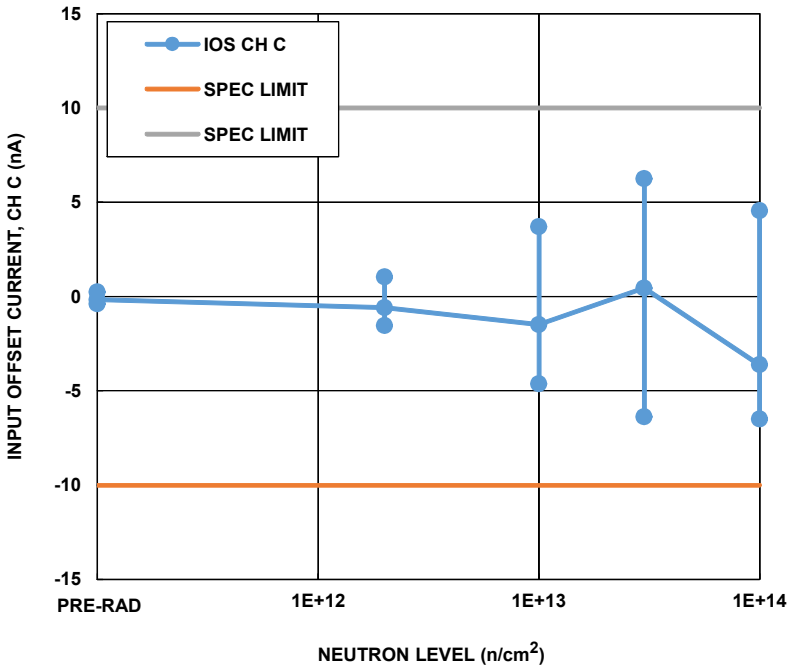

FIGURE 16. ISL70419SEH input offset current, Channel C, as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$, and $1x10^{14}n/cm^2$. The plot shows the population median, minimum, and maximum at each downpoint. Sample size for each cell was five. The post-total dose irradiation SMD limits are -10nA to 10nA.

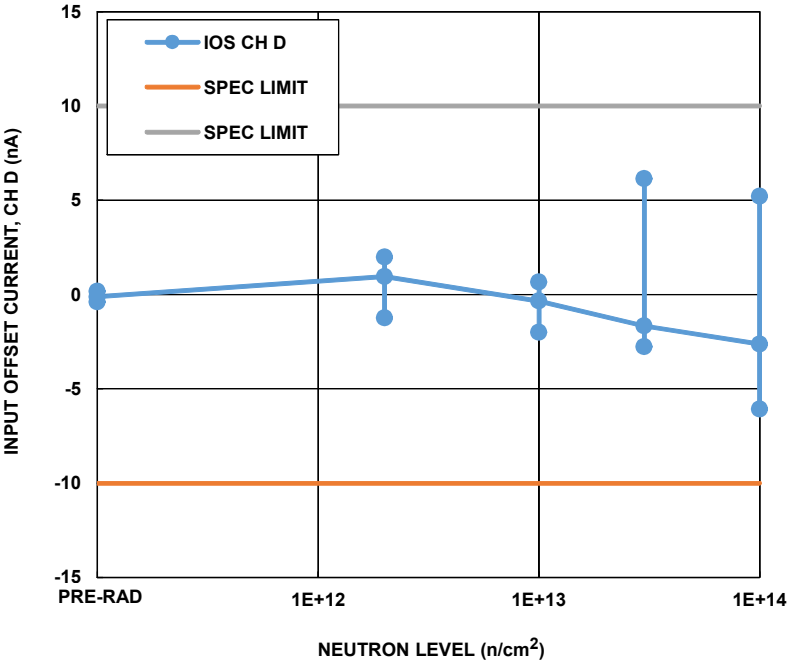

FIGURE 17. ISL70419SEH input offset current, Channel D, as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$, and $1x10^{14}n/cm^2$. The plot shows the population median, minimum, and maximum at each downpoint. Sample size for each cell was five. The post-total dose irradiation SMD limits are -10nA to 10nA.

Variables Data Plots (Continued)

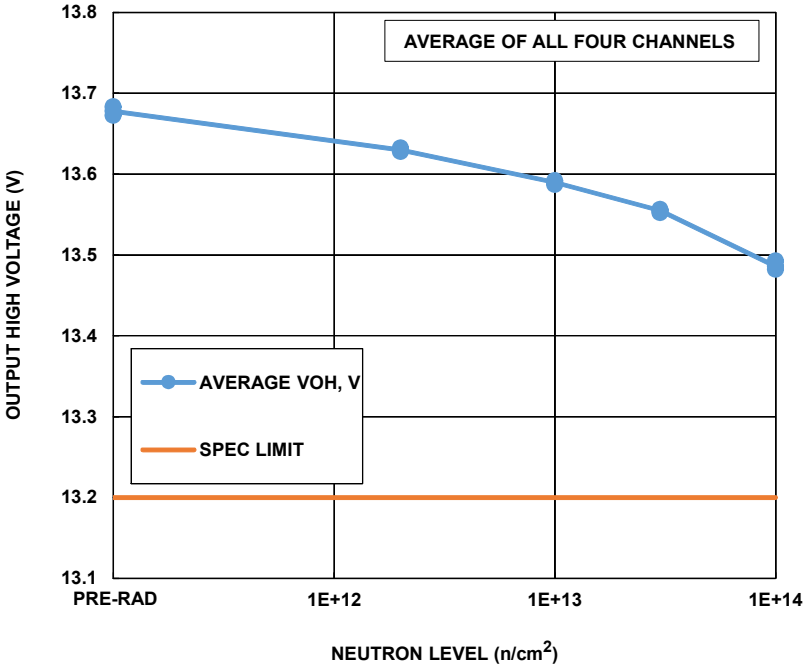

FIGURE 18. ISL70419SEH output HIGH voltage, average of all four channels, as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$, and $1x10^{14}n/cm^2$. The plot shows the population median, minimum, and maximum at each downpoint. Sample size for each cell was five. The post-total dose irradiation SMD limit is 13.2V minimum.

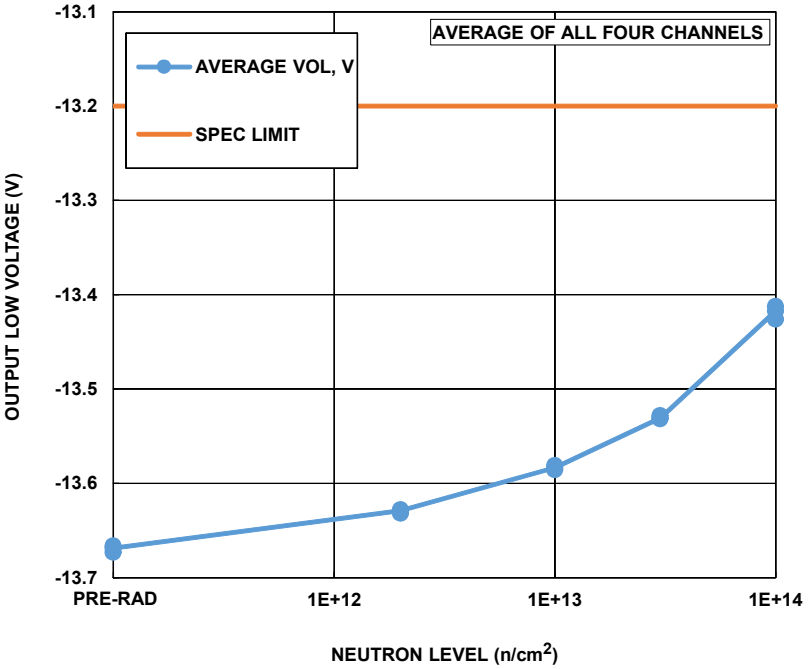

FIGURE 19. ISL70419SEH output LOW voltage, average of all four channels, as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$, and $1x10^{14}n/cm^2$. The plot shows the population median, minimum, and maximum at each downpoint. Sample size for each cell was five. The post-total dose irradiation SMD limit is -13.2V maximum.

Variables Data Plots (Continued)

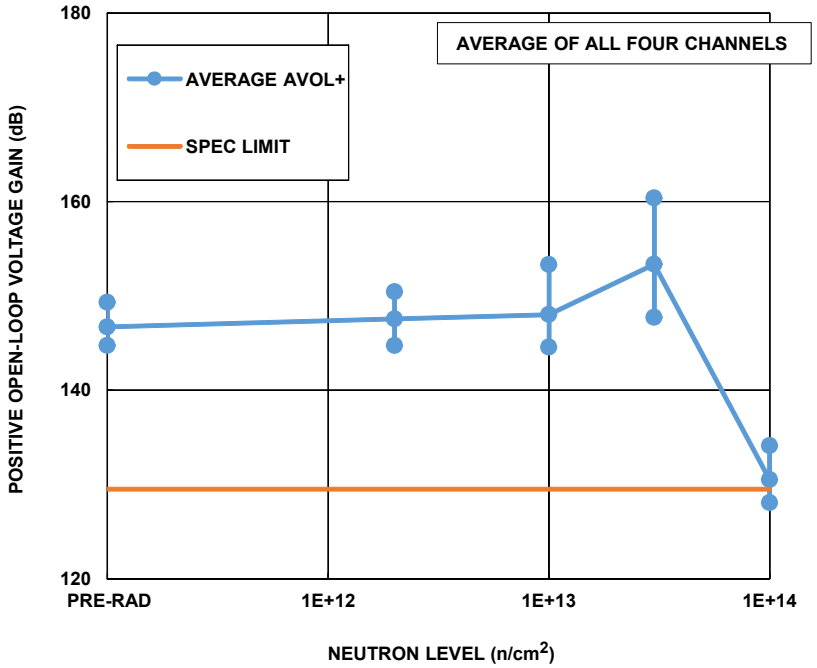

FIGURE 20. ISL70419SEH positive open-loop gain, average of all four channels, as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$, and $1x10^{14}n/cm^2$. The plot shows the population median, minimum, and maximum at each downpoint. Sample size for each cell was five. The post-total dose irradiation SMD limit is 129.5dB minimum.

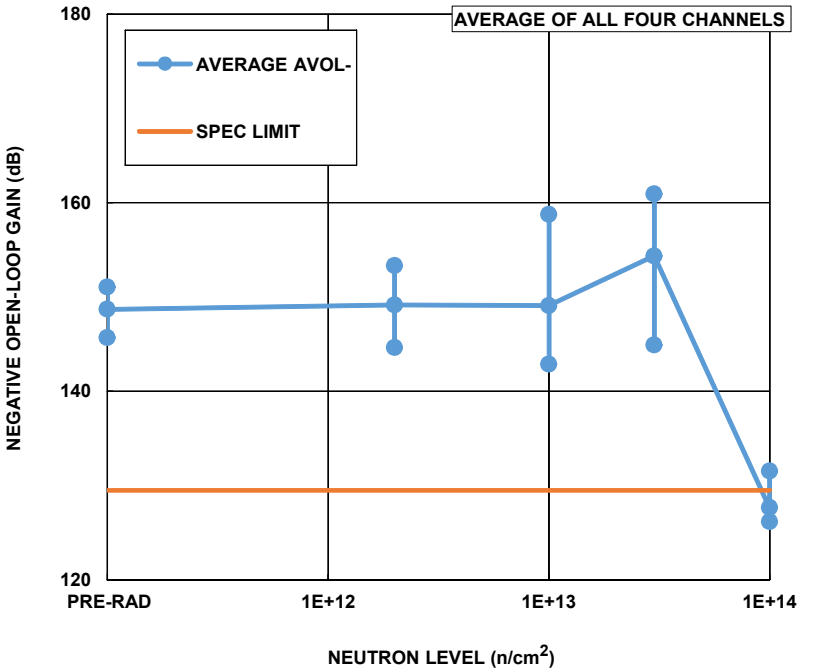

FIGURE 21. ISL70419SEH negative open-loop gain, average of all four channels, as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$, and $1x10^{14}n/cm^2$. The plot shows the population median, minimum, and maximum at each downpoint. Sample size for each cell was five. The post-total dose irradiation SMD limit is 129.5dB minimum.

Variables Data Plots (Continued)

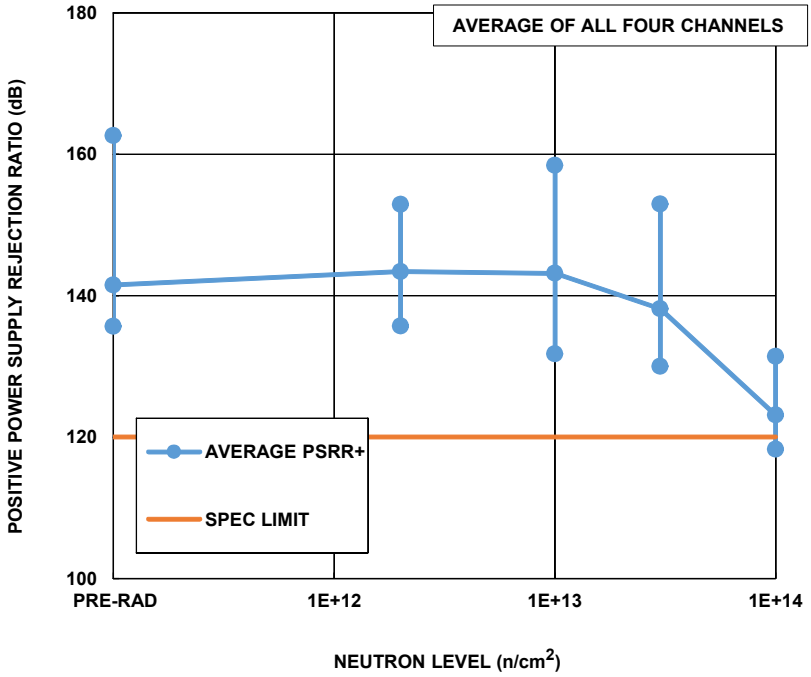

FIGURE 22. ISL70419SEH positive power supply rejection ratio, average of all four channels, as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$, and $1x10^{14}n/cm^2$. The plot shows the population median, minimum, and maximum at each downpoint. Sample size for each cell was five. The post-total dose irradiation SMD limit is 120dB minimum.

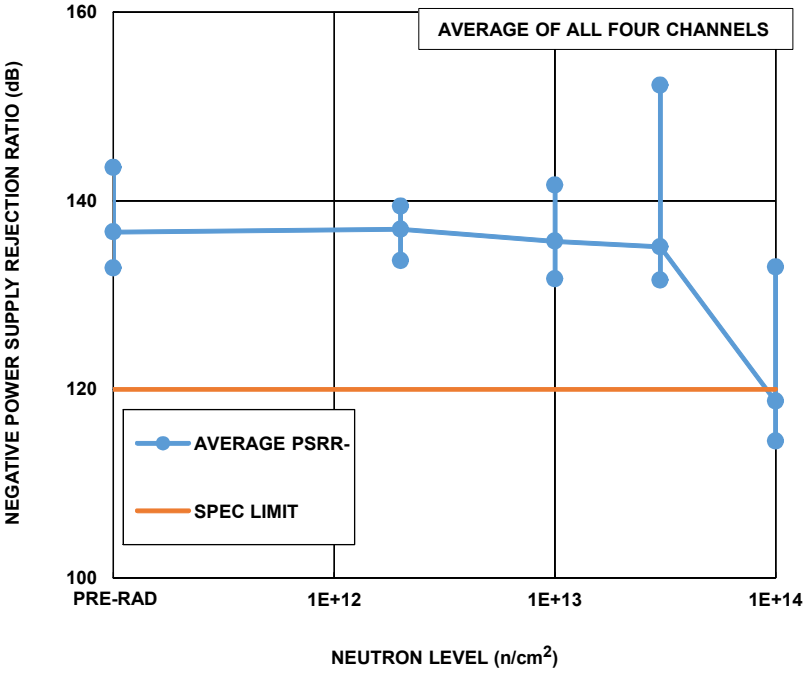

FIGURE 23. ISL70419SEH negative power supply rejection ratio, average of all four channels, as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$, and $1x10^{14}n/cm^2$. The plot shows the population median, minimum, and maximum at each downpoint. Sample size for each cell was five. The post-total dose irradiation SMD limit is 120dB minimum.

Variables Data Plots (Continued)

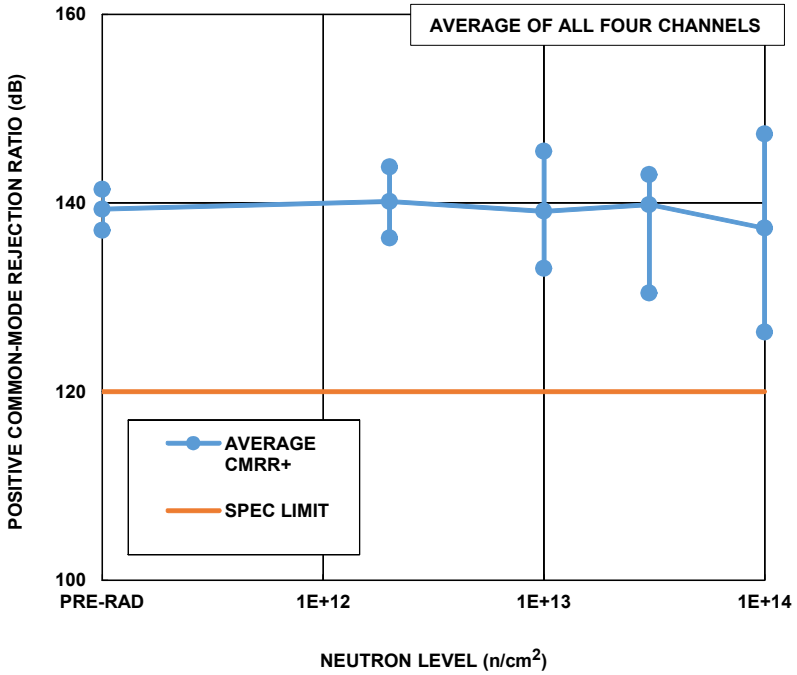

FIGURE 24. ISL70419SEH positive common-mode rejection ratio, average of all four channels, as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$, and $1x10^{14}n/cm^2$. The plot shows the population median, minimum, and maximum at each downpoint. Sample size for each cell was five. The post-total dose irradiation SMD limit is 120dB minimum.

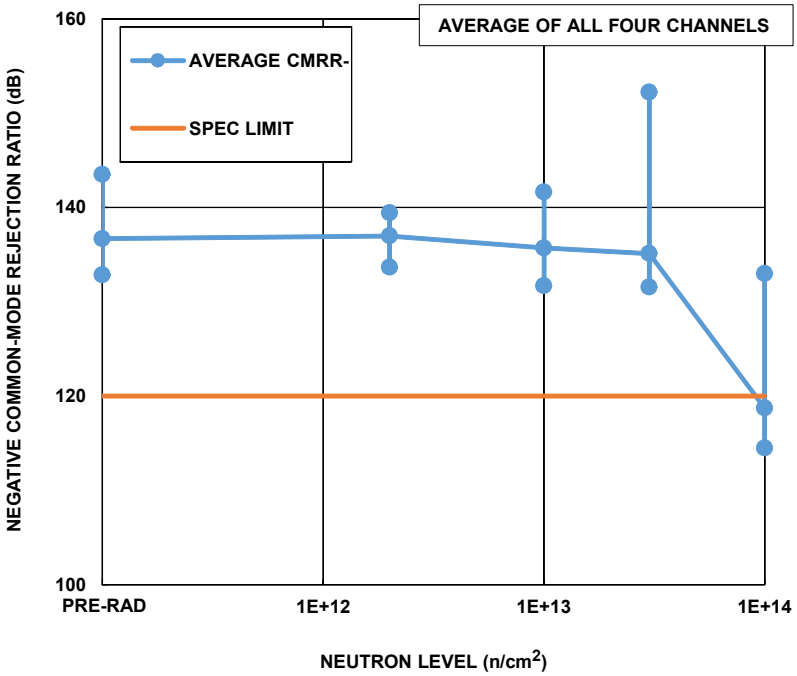

FIGURE 25. ISL70419SEH negative common-mode rejection ratio, average of all four channels, as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$, and $1x10^{14}n/cm^2$. The plot shows the population median, minimum, and maximum at each downpoint. Sample size for each cell was five. The post-total dose irradiation SMD limit is 120dB minimum.

Variables Data Plots (Continued)

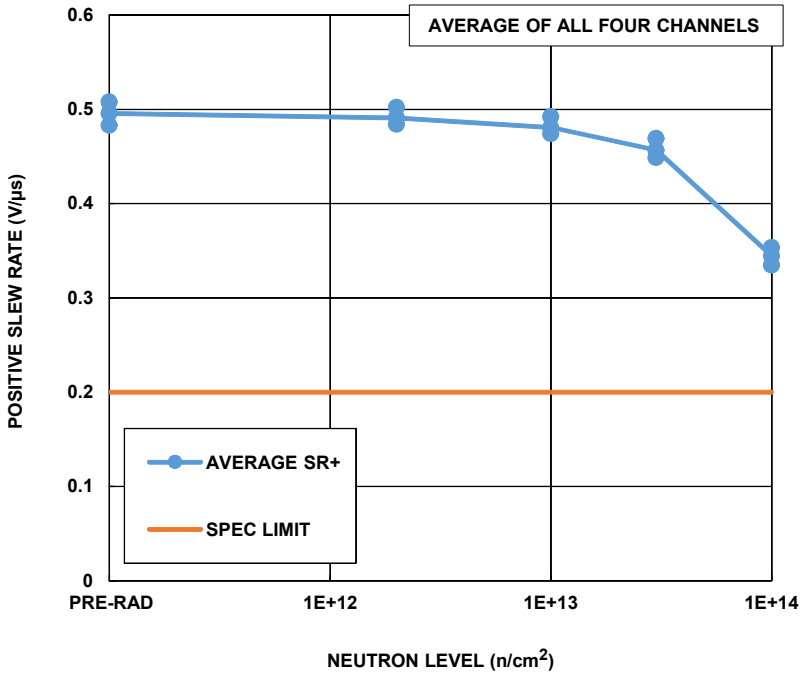

FIGURE 26. ISL70419SEH positive slew rate, average of all four channels, as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$, and $1x10^{14}n/cm^2$. The plot shows the population median, minimum, and maximum at each downpoint. Sample size for each cell was five. The post-total dose irradiation SMD limit is 0.2V/µs minimum.

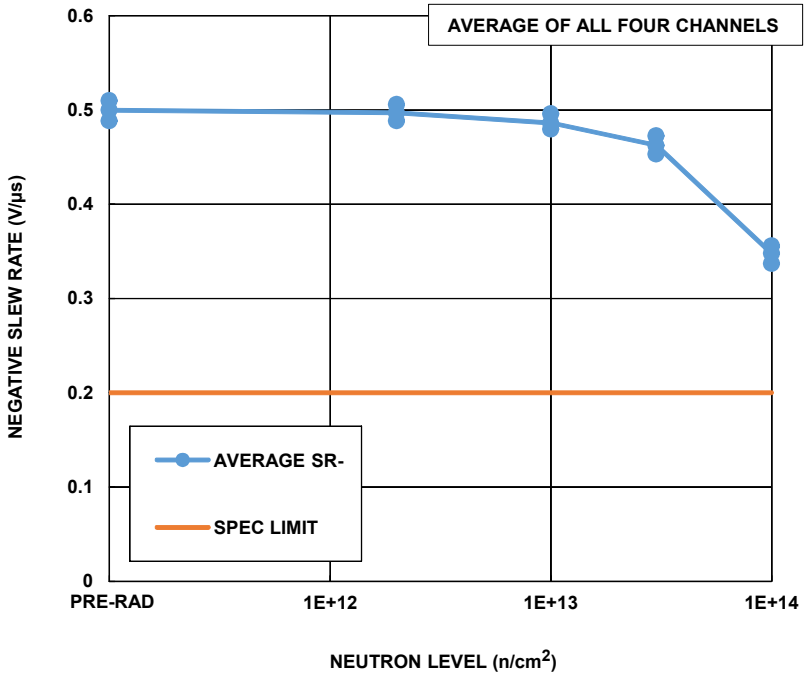

FIGURE 27. ISL70419SEH negative slew rate, average of all four channels, as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$, and $1x10^{14}n/cm^2$. The plot shows the population median, minimum, and maximum at each downpoint. Sample size for each cell was five. The post-total dose irradiation SMD limit is 0.2V/µs minimum.

Variables Data Plots (Continued)

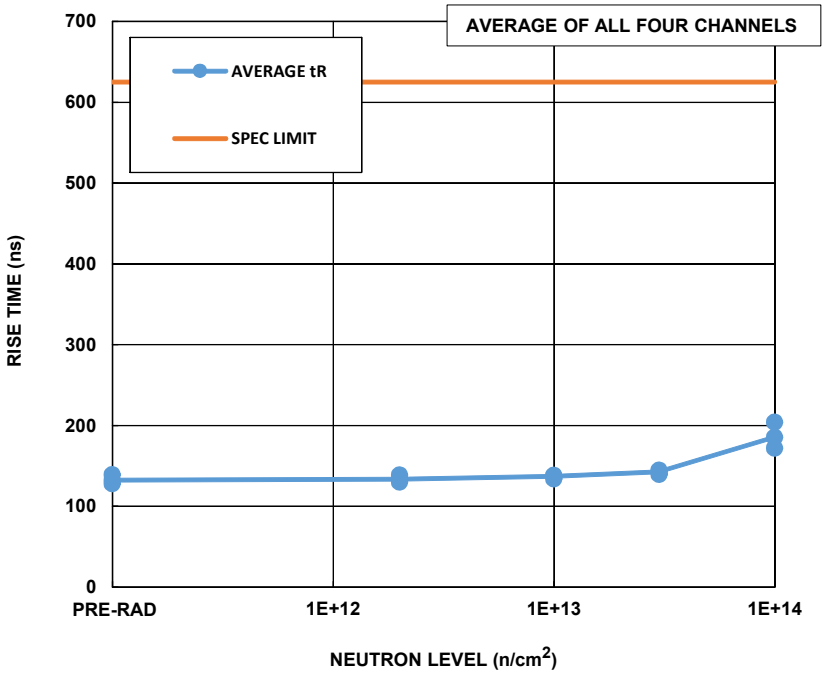

FIGURE 28. ISL70419SEH rise time, average of all four channels, as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$, and $1x10^{14}n/cm^2$. The plot shows the population median, minimum, and maximum at each downpoint. Sample size for each cell was five. The post-total dose irradiation SMD limit is 625ns maximum.

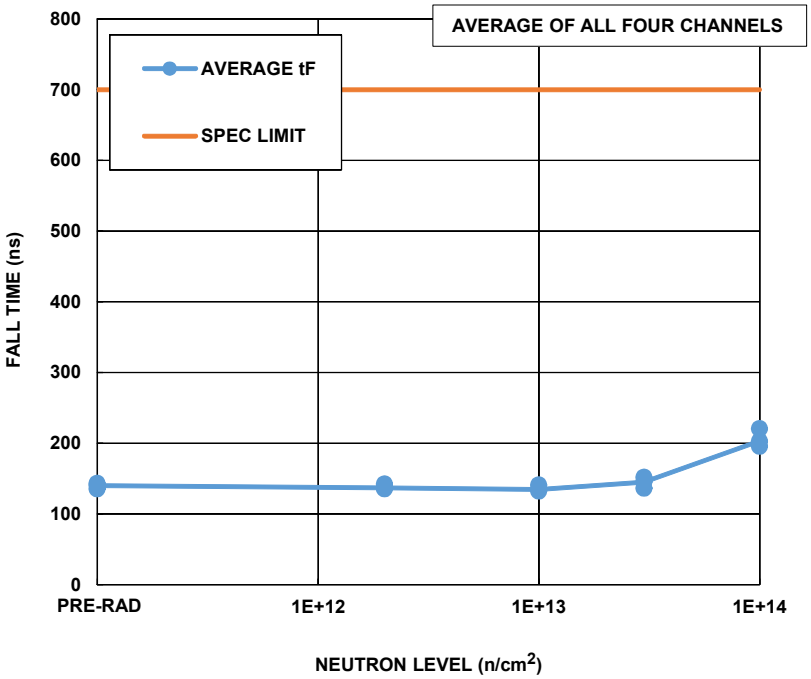

FIGURE 29. ISL70419SEH fall time, average of all four channels, as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$, and $1x10^{14}n/cm^2$. The plot shows the population median, minimum, and maximum at each downpoint. Sample size for each cell was five. The post-total dose irradiation SMD limit is 700ns maximum.

Conclusion

This report summarizes results of 1MeV equivalent neutron testing of the ISL70419SEH quad operational amplifier. 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 $2x10^{12}n/cm^2$ to $1x10^{14}n/cm^2$. This test was carried out as part of a collaborative project with Boeing (El Segundo, CA), whose support is gratefully acknowledged.

In the figures, we plotted critical input parameters channel-by-channel to determine if any channel sensitivity exists. Other parameters were plotted as averages of all four channels.

The $2x10^{11}n/cm_2$, $1x10^{13}n/cm^2$, and $3x10^{13}n/cm^2$ samples met all SMD and datasheet specifications (Bin 1) after irradiation. All $1x10^{14}n/cm^2$ samples failed the open-loop gain parameter after irradiation, but remained functional.

Appendix

Reported Parameters

Reported parameters are shown below. The limits are taken from the applicable SMD and are provided for guidance only as the part is not designed or guaranteed for the neutron environment.

TABLE 3. REPORTED PARAMETERS

FIGURE	PARAMETER	LIMIT, LOW	LIMIT, HIGH	UNITS	NOTES
1	Supply current, positive	-	2.72	mA	Sum of four channels
	Supply current, negative	-2.72	-	mA	Sum of four channels
2	Input offset voltage	-110	110	µV	Channel A
3	Input offset voltage	-110	110	µV	Channel B
4	Input offset voltage	-110	110	µV	Channel C
5	Input offset voltage	-110	110	µV	Channel D
6	Positive input bias current	-15	15	nA	Channel A
7	Positive input bias current	-15	15	nA	Channel B
8	Positive input bias current	-15	15	nA	Channel C
9	Positive input bias current	-15	15	nA	Channel D
10	Negative input bias current	-15	15	nA	Channel A
11	Negative input bias current	-15	15	nA	Channel B
12	Negative input bias current	-15	15	nA	Channel C
13	Negative input bias current	-15	15	nA	Channel D
14	Input offset current	-10	10	nA	Channel A
15	Input offset current	-10	10	nA	Channel B
16	Input offset current	-10	10	nA	Channel C
17	Input offset current	-10	10	nA	Channel D
18	Output HIGH voltage	-	13.2	V	Average of four channels
19	Output LOW voltage	-13.2	-	V	Average of four channels
20	Positive open-loop gain	129.5	-	dB	Average of four channels
21	Negative open-loop gain	129.5	-	dB	Average of four channels
22	Positive power supply rejection ratio	120	-	dB	Average of four channels
23	Negative power supply rejection ratio	120	-	dB	Average of four channels
24	Positive common mode rejection ratio	120	-	dB	Average of four channels
25	Negative common mode rejection ratio	120	-	dB	Average of four channels
26	Positive slew rate	0.2	-	V/µs	Average of four channels
27	Negative slew rate	0.2	-	V/µs	Average of four channels
28	Rise time	-	625	ns	Average of four channels
29	Fall time	-	700	ns	Average of four channels

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