ISL70227SEH, ISL70227SRH

Total Dose Testing

Introduction

This document reports the results of low and high dose rate total dose testing of the ISL70227SEH dual operational amplifier. The test was conducted to provide an assessment of total dose hardness of the part. Samples were irradiated at Low Dose Rate (LDR) under bias and with all pins grounded, and at High Dose Rate (HDR) under bias only.

The ISL70227SEH is available in two versions differing in total ionizing dose acceptance testing. The ISL70227SEH is acceptance tested on a wafer-by-wafer basis to 100krad(Si) at HDR (50-300rad(Si)/s) and to 50krad(Si) at LDR (0.01rad(Si)/s). The ISL70227SRH is acceptance tested on a wafer-by-wafer basis to 100krad(Si) at HDR (50-300rad(Si)/s) only. The ‘EH’ and ‘RH’ versions are of the same design and silicon.

Product Description

The ISL70227SEH is a precision dual operational amplifier featuring very low noise, low offset voltage, low input bias current, and low temperature drift. These features plus its radiation tolerance, make the ISL70227SEH suitable for applications requiring both high DC accuracy and AC performance. Applications for the part include precision instrumentation, active filters, and power supply controls. The ISL70227SEH is available in a 10 Ld hermetic ceramic flatpack and operates across the extended temperature range of -55°C to +125°C. Constructed using the Renesas dielectrically isolated PR40 process, the part is immune to single-event latchup. The ISL70227SEH offers ensured performance across the full -55°C to +125°C military temperature range.

Related Literature

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

- ISL70227SEH, ISL70227SRH device pages
- MIL-STD-883 test method 1019

1. Test Description

1.1 Irradiation Facilities

HDR testing was performed at 65rad(Si)/s using a Gammacell 220 gamma ray irradiator located in the Palm Bay, Florida Renesas facility. LDR testing was performed at 0.01rad(Si)/s using the Renesas Palm Bay panoramic LDR irradiator.

1.2 Test Fixturing

Figure 1 shows the configuration used for biased irradiation.

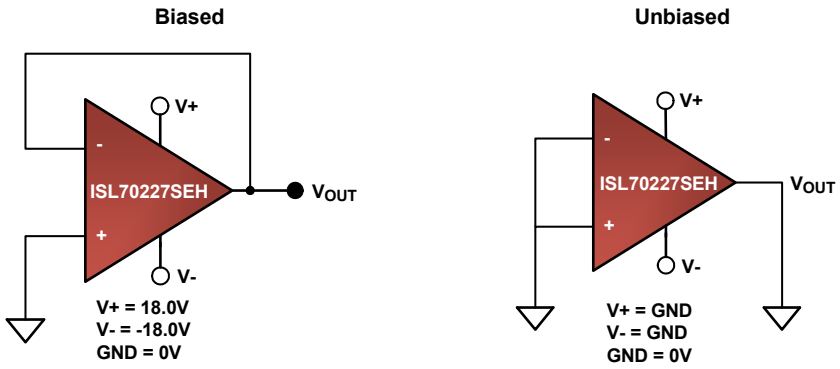

Figure 1. ISL70227SEH Irradiation Bias Configuration per SMD 5962-12223

1.3 Characterization Equipment and Procedures

All electrical testing was performed outside the irradiator using the production Automated Test Equipment (ATE) with data logging at each downpoint. Downpoint electrical testing was performed at room temperature.

1.4 Experimental Matrix

Total dose irradiation proceeded in accordance with the guidelines of MIL-STD-883 Test Method 1019. The experimental matrix consisted of four samples irradiated at LDR under bias, four samples irradiated at LDR with all pins grounded and sixteen samples irradiated at HDR under bias.

Samples of the ISL70227SEH were drawn from production inventory; the HDR data is taken from wafer-by-wafer acceptance testing results. Samples were taken from production lots WLH4XAAAA and WLH4XEH (LDR) and WTM3XCAEH (HDR), which were packaged in the 10 Ld hermetic solder-sealed flatpack (CDFP4-F10) package. Samples were processed through the standard burn-in cycle before irradiation and were screened to the ATE limits at room temperature prior to the test.

1.5 Downpoints

Downpoints for the two LDR tests were 0, 50, 100, and 150krad(Si). Downpoints for the HDR test were 0 and 100krad(Si). Two samples each from the LDR tests were subjected to a 168-hour biased high temperature anneal at 100°C using the same bias configuration as the biased irradiations.

2. Results

2.1 Attributes Data

Table 1. ISL70227SEH Total Dose Testing Attributes Data

Part	Dose Rate (Note 1)	Bias	Sample Size	Downpoint	Pass (Note 2)	Rejects
ISL70227SEH	LDR	Biased	4	Pre-irradiation	4	0
				50krad(Si)	4	0
				100krad(Si)	0	4
				150krad(Si)	0	4
				Anneal	2	0
ISL70227SEH	LDR	Grounded	4	Pre-irradiation	4	0
				50krad(Si)	4	0
				100krad(Si)	4	0
				150krad(Si)	0	4
				Anneal	2	0
ISL70227SEH	HDR	Biased	16	Pre-irradiation	16	0
				100krad(Si)	16	0

Notes:
1. 'HDR' indicates high dose rate while 'LDR' indicates low dose rate.
2. 'Pass' indicates a sample that passes all post-irradiation SMD limits.

2.2 Variables Data

Figures 2 through 20 show data at all downpoints. The plots show the median of key parameters as a function of low and high dose rate total dose for each of the two irradiation conditions. The plots show the median for these parameters due to the relatively small sample sizes of four per LDR cell. Also shown are the minimum/maximum error bars at all data points.

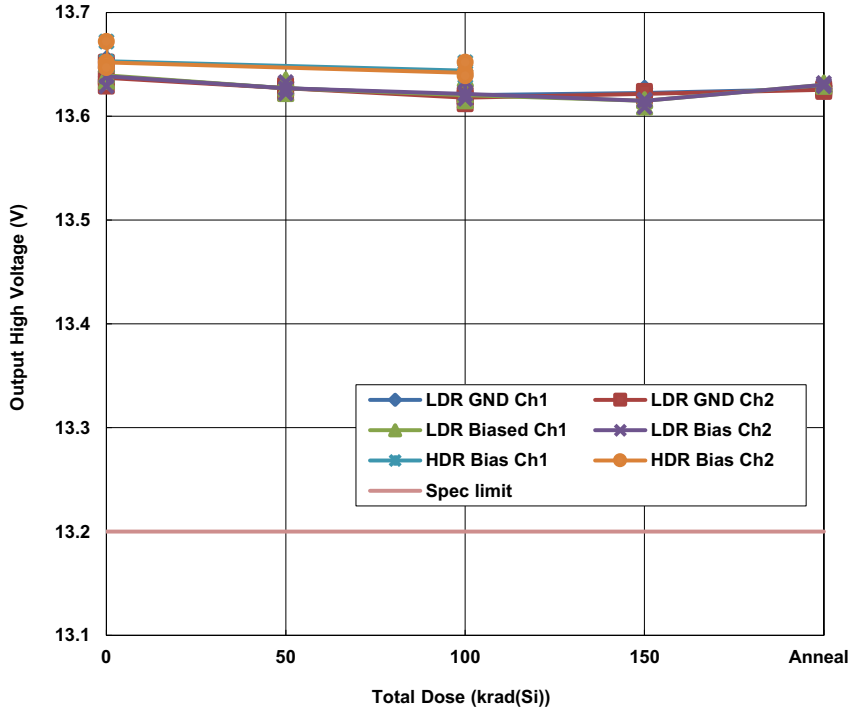

Figure 2. ISL70227SEH median output high voltage as a function of total dose irradiation at LDR (biased and unbiased) and at HDR (biased only). The dose rate was 0.01rad(Si)/s for LDR irradiation and 65rad(Si)/s for HDR irradiation. Sample size for the two LDR cells was 4 while the HDR cell sample size was 16. The post-irradiation SMD limit is 13.2V minimum.

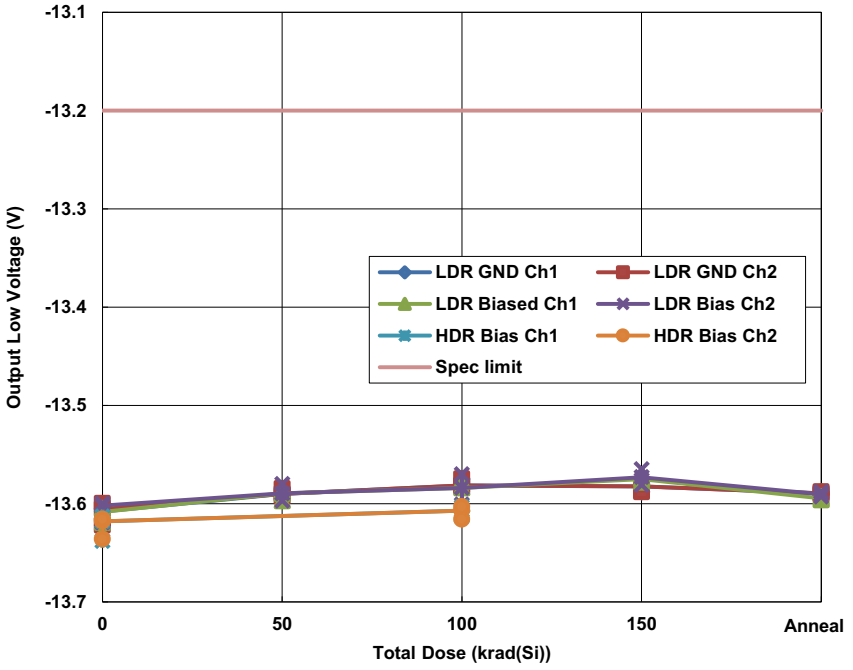

Figure 3. ISL70227SEH median output low voltage as a function of total dose irradiation at LDR (biased and unbiased) and at HDR (biased only). The dose rate was 0.01rad(Si)/s for LDR irradiation and 65rad(Si)/s for HDR irradiation. Sample size for the two LDR cells was 4 while the HDR cell sample size was 16. The post-irradiation SMD limit is -13.2V maximum.

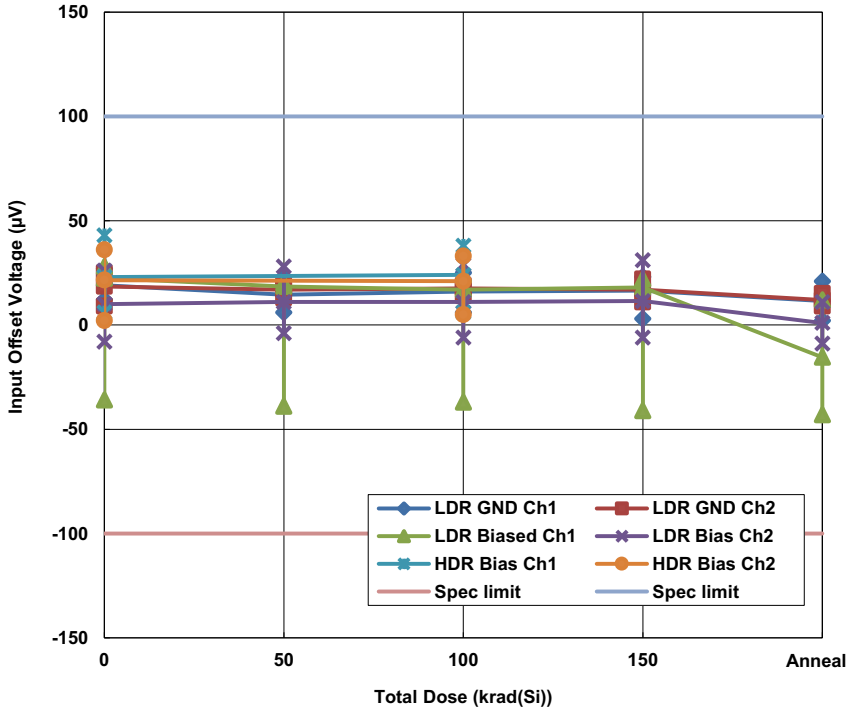

Figure 4. ISL70227SEH median input offset voltage, Channels 1 and 2, as a function of total dose irradiation at LDR (biased and unbiased) and at HDR (biased only). The dose rate was 0.01rad(Si)/s for LDR irradiation and 65rad(Si)/s for HDR irradiation. Sample size for the two LDR cells was 4 while the HDR cell sample size was 16. The post-irradiation SMD limits are -100µV to 100µV.

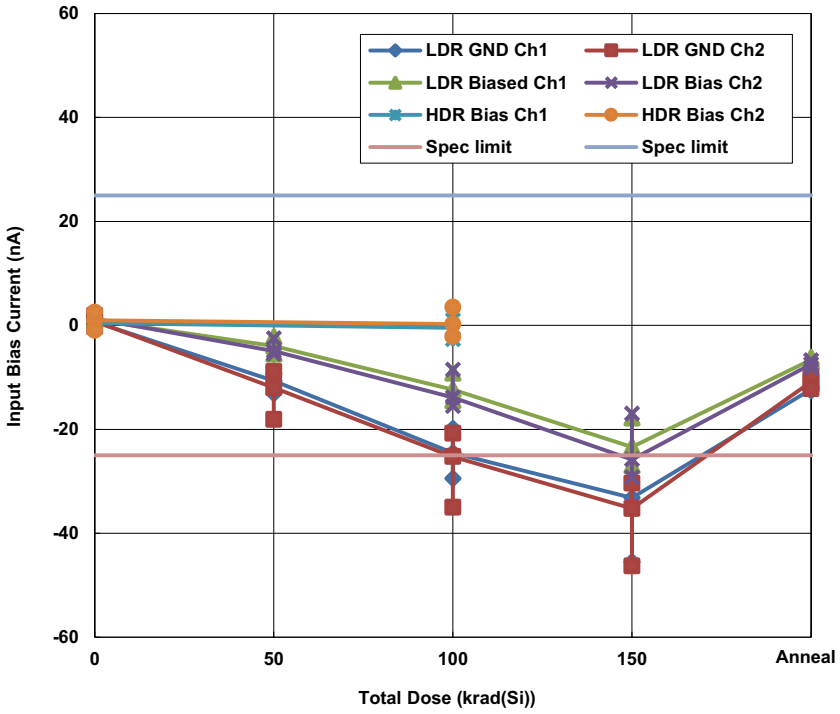

Figure 5. ISL70227SEH median positive input bias current, Channels 1 and 2, as a function of total dose irradiation at LDR (biased and unbiased) and at HDR (biased only). The dose rate was 0.01rad(Si)/s for LDR irradiation and 65rad(Si)/s for HDR irradiation. Sample size for the two LDR cells was 4 while the HDR cell sample size was 16. The post-irradiation SMD limits are -25nA to 25nA.

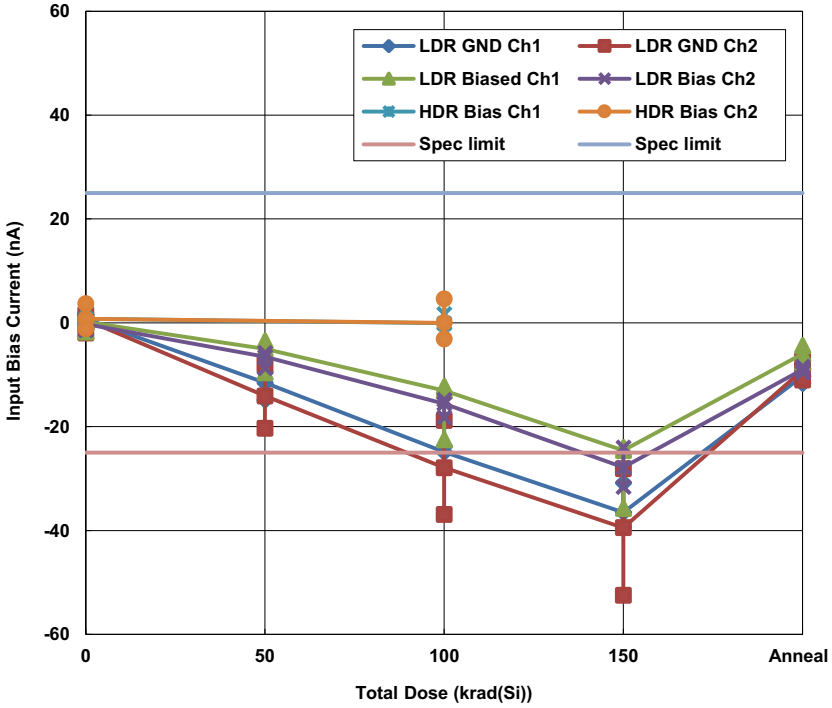

Figure 6. ISL70227SEH median negative input bias current, Channels 1 and 2, as a function of total dose irradiation at LDR (biased and unbiased) and at HDR (biased only). The dose rate was 0.01rad(Si)/s for LDR irradiation and 65rad(Si)/s for HDR irradiation. Sample size for the two LDR cells was 4 while the HDR cell sample size was 16. The post-irradiation SMD limits are -25nA to 25nA.

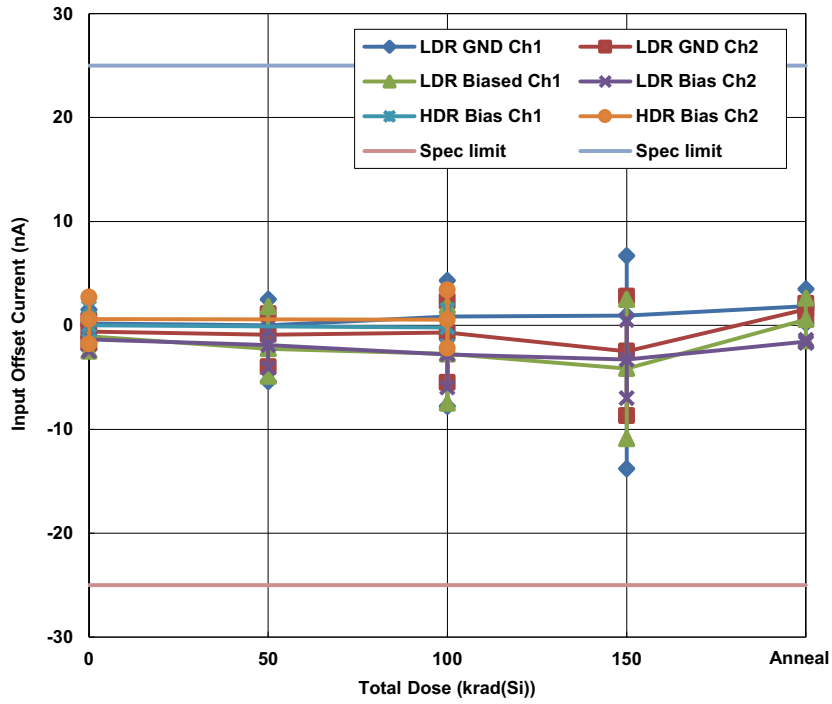

Figure 7. ISL70227SEH median input offset current, Channels 1 and 2, as a function of total dose irradiation at LDR (biased and unbiased) and at HDR (biased only). The dose rate was 0.01rad(Si)/s for LDR irradiation and 65rad(Si)/s for HDR irradiation. Sample size for the two LDR cells was 4 while the HDR cell sample size was 16. The post-irradiation SMD limits are -25nA to 25nA.

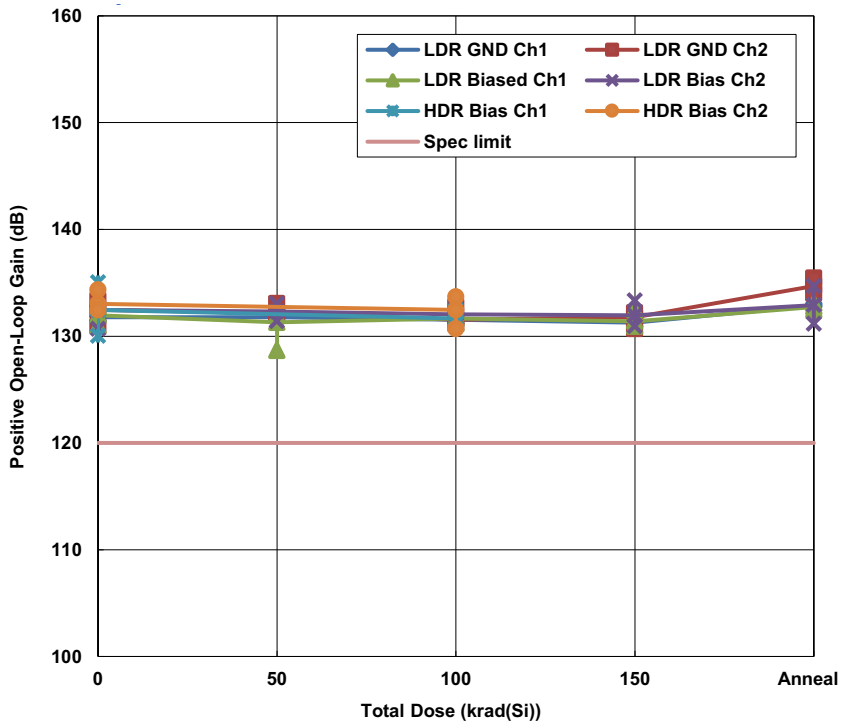

Figure 8. ISL70227SEH median positive open-loop gain, Channels 1 and 2, as a function of total dose irradiation at LDR (biased and unbiased) and at HDR (biased only). The dose rate was 0.01rad(Si)/s for LDR irradiation and 65rad(Si)/s for HDR irradiation. Sample size for the two LDR cells was 4 while the HDR cell sample size was 16. The post-irradiation SMD limit is 120dB minimum.

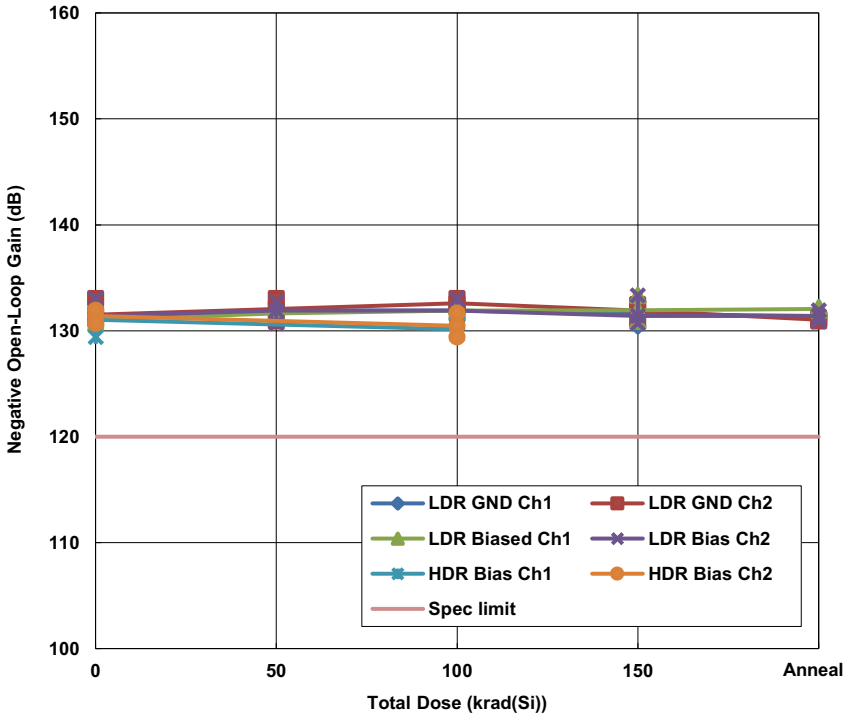

Figure 9. ISL70227SEH median negative open-loop gain, Channels 1 and 2, as a function of total dose irradiation at LDR (biased and unbiased) and at HDR (biased only). The dose rate was 0.01rad(Si)/s for LDR irradiation and 65rad(Si)/s for HDR irradiation. Sample size for the two LDR cells was 4 while the HDR cell sample size was 16. The post-irradiation SMD limit is 120dB minimum.

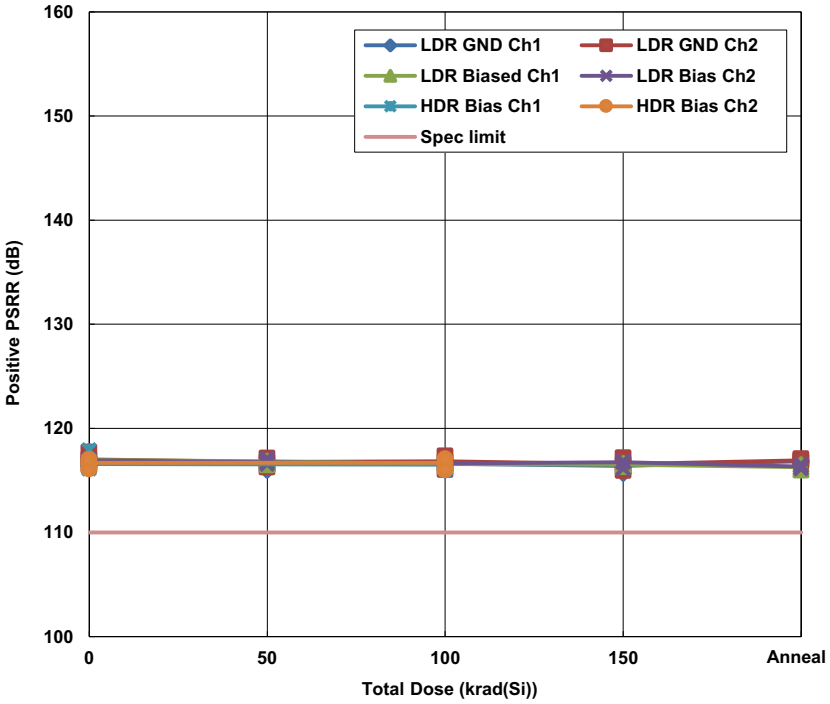

Figure 10. ISL70227SEH median positive power supply rejection ratio, Channels 1 and 2, as a function of total dose irradiation at LDR (biased and unbiased) and at HDR (biased only). The dose rate was 0.01rad(Si)/s for LDR irradiation and 65rad(Si)/s for HDR irradiation. Sample size for the two LDR cells was 4 while the HDR cell sample size was 16. The post-irradiation SMD limit is 110dB minimum.

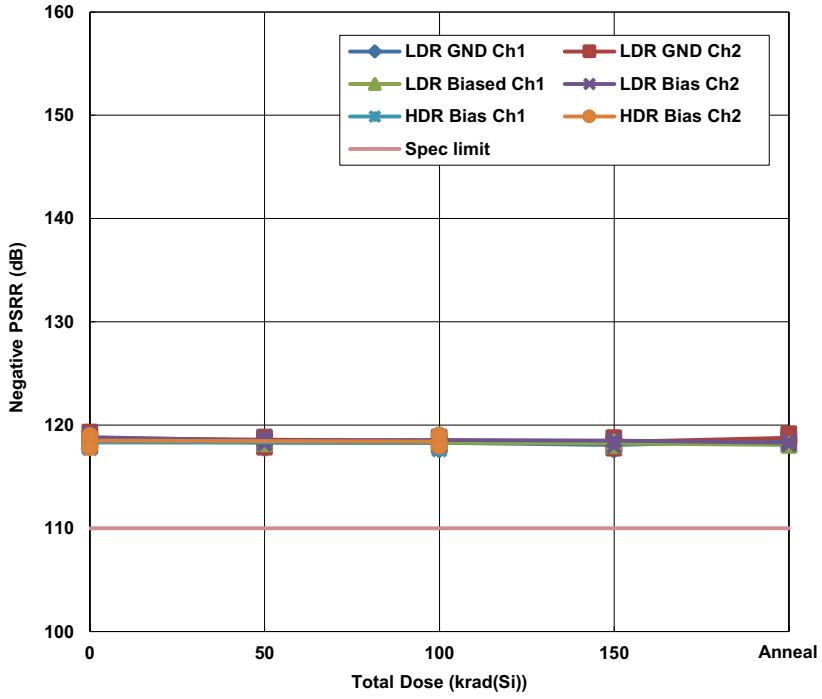

Figure 11. ISL70227SEH median negative power supply rejection ratio, Channels 1 and 2, as a function of total dose irradiation at LDR (biased and unbiased) and at HDR (biased only). The dose rate was 0.01rad(Si)/s for LDR irradiation and 65rad(Si)/s for HDR irradiation. Sample size for the two LDR cells was 4 while the HDR cell sample size was 16. The post-irradiation SMD limit is 110dB minimum.

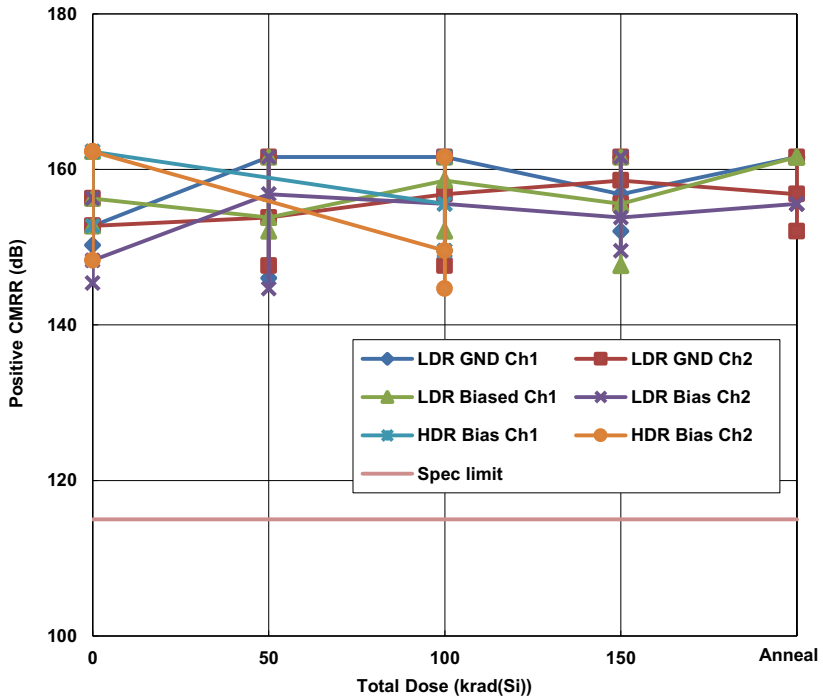

Figure 12. ISL70227SEH median positive common-mode rejection ratio, Channels 1 and 2, as a function of total dose irradiation at LDR (biased and unbiased) and at HDR (biased only). The dose rate was 0.01rad(Si)/s for LDR irradiation and 65rad(Si)/s for HDR irradiation. Sample size for the two LDR cells was 4 while the HDR cell sample size was 16. The post-irradiation SMD limit is 115dB minimum.

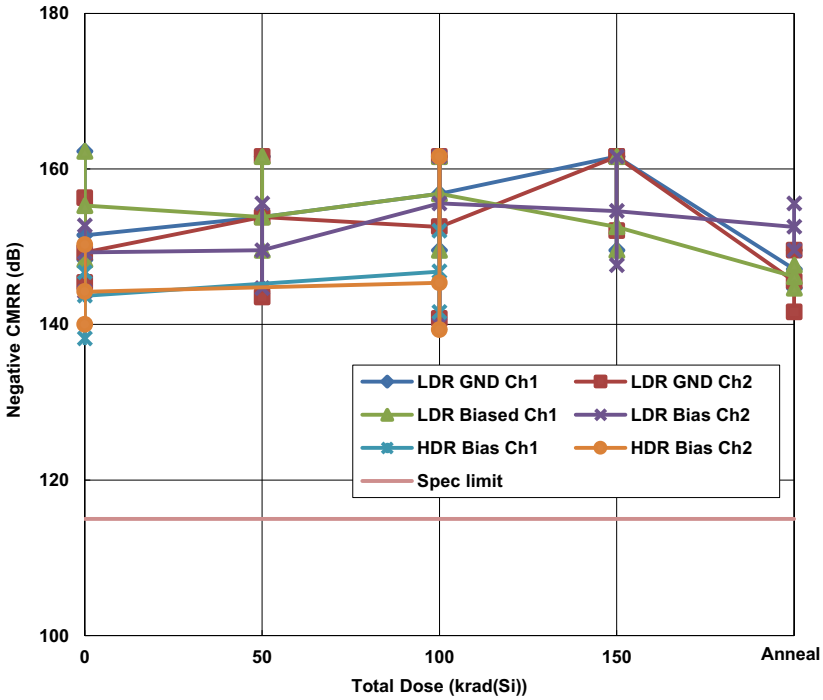

Figure 13. ISL70227SEH median negative common-mode rejection ratio, Channels 1 and 2, as a function of total dose irradiation at LDR (biased and unbiased) and at HDR (biased only). The dose rate was 0.01rad(Si)/s for LDR irradiation and 65rad(Si)/s for HDR irradiation. Sample size for the two LDR cells was 4 while the HDR cell sample size was 16. The post-irradiation SMD limit is 115dB minimum.

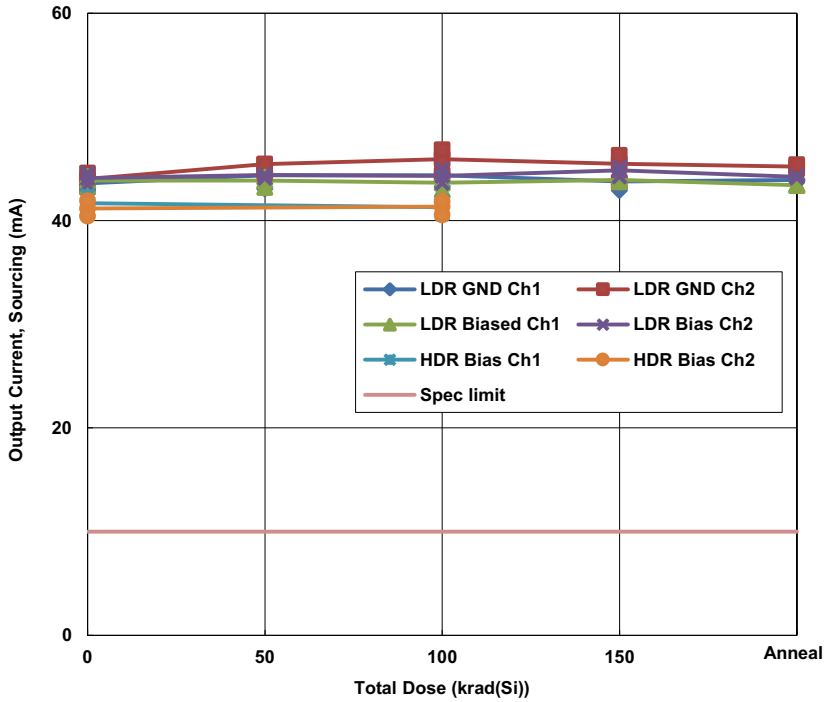

Figure 14. ISL70227SEH median output current (sourcing) Channels 1 and 2, as a function of total dose irradiation at LDR (biased and unbiased) and at HDR (biased only). The dose rate was 0.01rad(Si)/s for LDR irradiation and 65rad(Si)/s for HDR irradiation. Sample size for the two LDR cells was 4 while the HDR cell sample size was 16. The post-irradiation ATE limit is 10mA minimum.

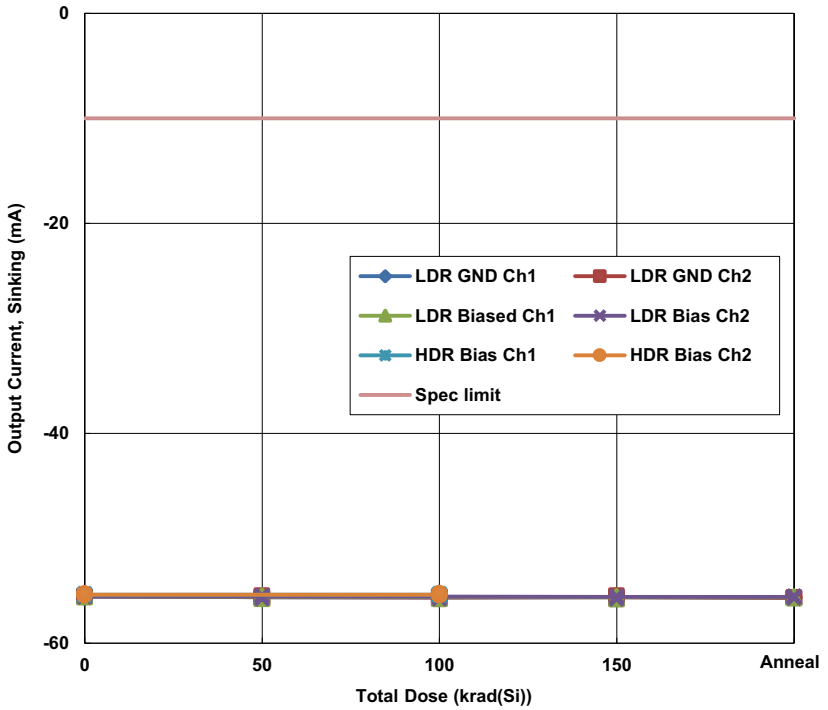

Figure 15. ISL70227SEH median output current (sinking) Channels 1 and 2, as a function of total dose irradiation at LDR (biased and unbiased) and at HDR (biased only). The dose rate was 0.01rad(Si)/s for LDR irradiation and 65rad(Si)/s for HDR irradiation. Sample size for the two LDR cells was 4 while the HDR cell sample size was 16. The post-irradiation ATE limit is -10mA maximum.

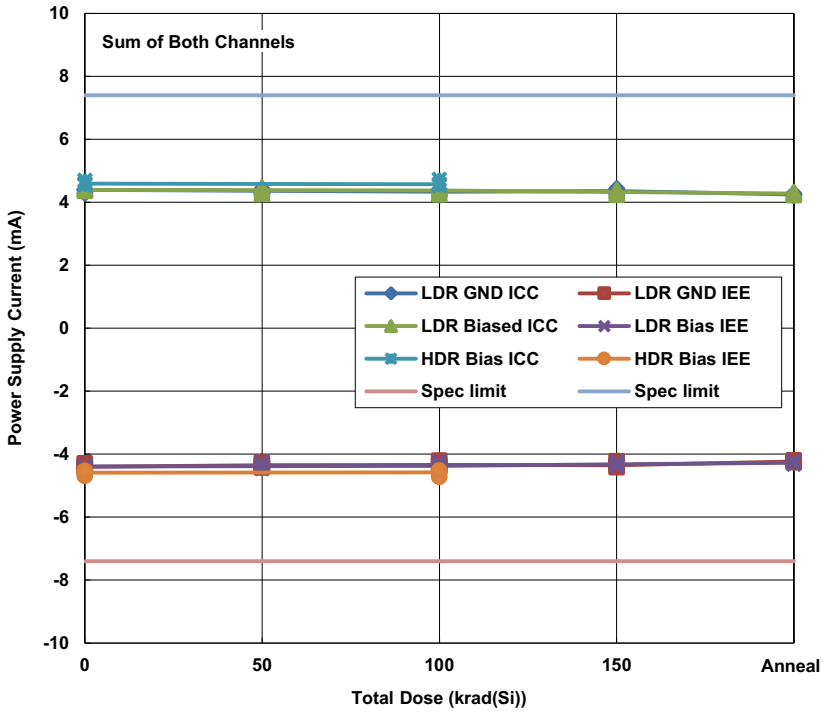

Figure 16. ISL70227SEH median positive and negative power supply current, as a function of total dose irradiation at LDR (biased and unbiased) and at HDR (biased only). The dose rate was 0.01rad(Si)/s for LDR irradiation and 65rad(Si)/s for HDR irradiation. Sample size for the two LDR cells was 4 while the HDR cell sample size was 16. The post-irradiation SMD limits are 7.4mA maximum (I_{CC}) and -7.4mA minimum (I_{EE}).

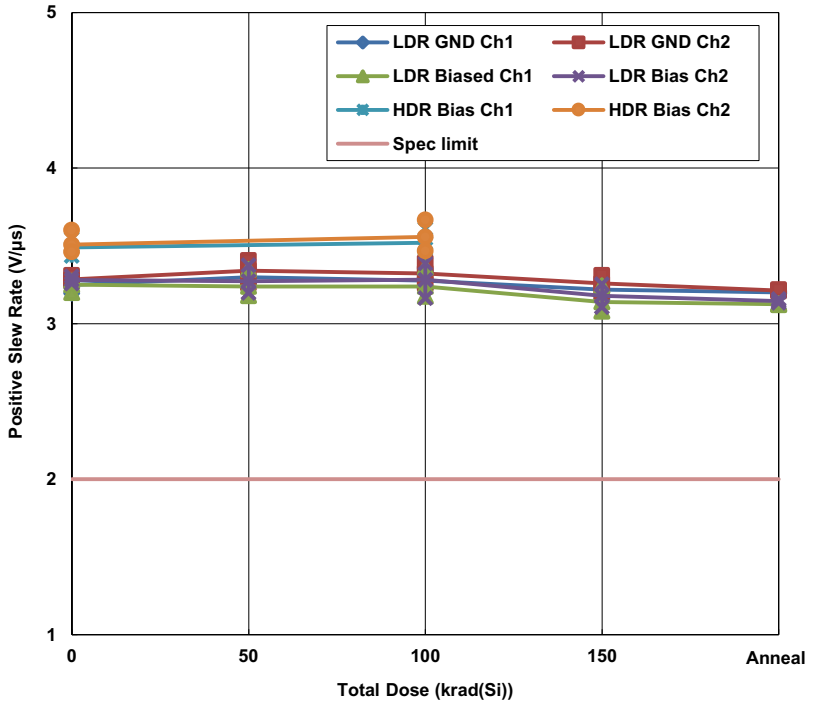

Figure 17. ISL70227SEH median positive slew rate, Channels 1 and 2, as a function of total dose irradiation at LDR (biased and unbiased) and at HDR (biased only). The dose rate was 0.01rad(Si)/s for LDR irradiation and 65rad(Si)/s for HDR irradiation. Sample size for the two LDR cells was 4 while the HDR cell sample size was 16. The post-irradiation SMD limit is 2V/µs minimum.

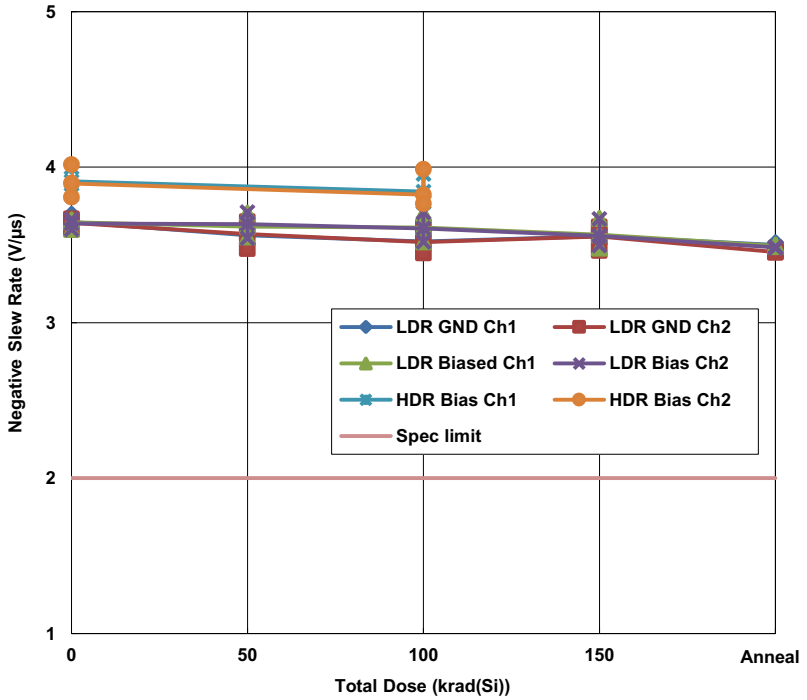

Figure 18. ISL70227SEH median negative slew rate, Channels 1 and 2, as a function of total dose irradiation at LDR (biased and unbiased) and at HDR (biased only). The dose rate was 0.01rad(Si)/s for LDR irradiation and 65rad(Si)/s for HDR irradiation. Sample size for the two LDR cells was 4 while the HDR cell sample size was 16. The post-irradiation SMD limit is 2V/µs minimum.

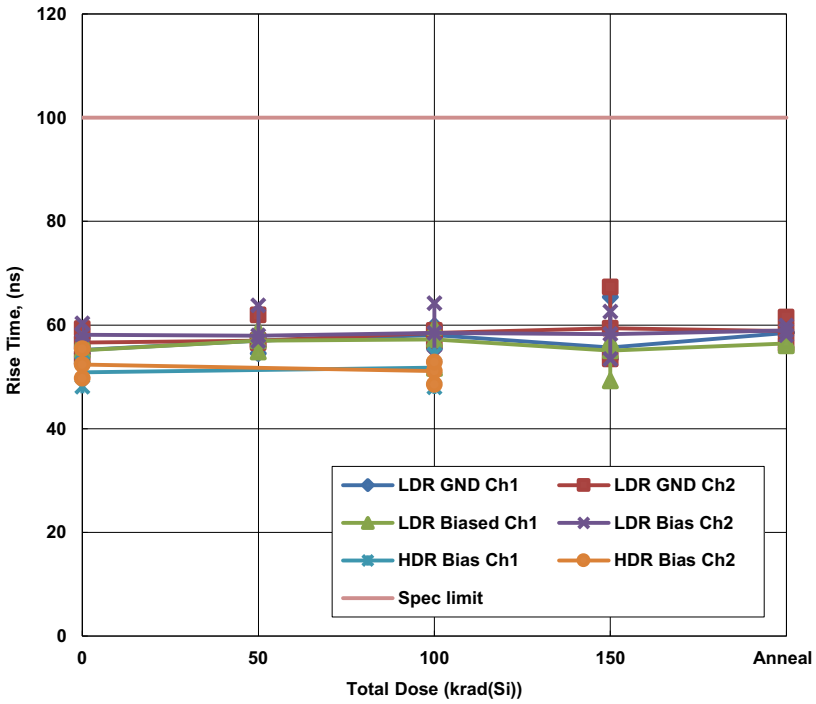

Figure 19. ISL70227SEH median rise time, Channels 1 and 2, as a function of total dose irradiation at LDR (biased and unbiased) and at HDR (biased only). The dose rate was 0.01rad(Si)/s for LDR irradiation and 65rad(Si)/s for HDR irradiation. Sample size for the two LDR cells was 4 while the HDR cell sample size was 16. The post-irradiation SMD limit is 100ns maximum.

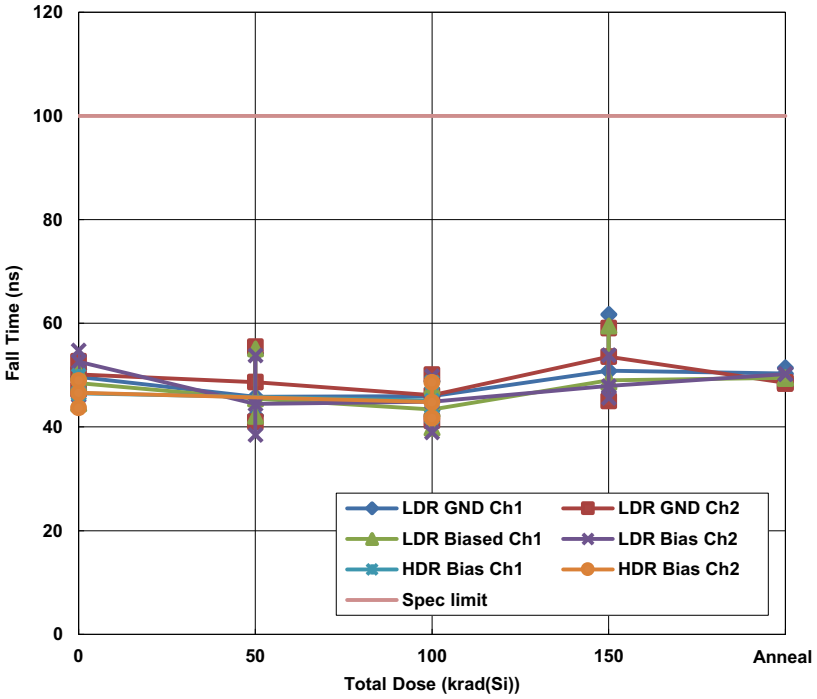

Figure 20. ISL70227SEH median fall time, Channels 1 and 2, as a function of total dose irradiation at LDR (biased and unbiased) and at HDR (biased only). The dose rate was 0.01rad(Si)/s for LDR irradiation and 65rad(Si)/s for HDR irradiation. Sample size for the two LDR cells was 4 while the HDR cell sample size was 16. The post-irradiation SMD limit is 100ns maximum.

3. Conclusion

This document reports the ISL70227SEH dual operational amplifier's low and high dose rate total dose testing results. Parts were tested at low and high dose rates under biased and unbiased conditions as outlined in MIL-STD-883 Test Method 1019, at 0.01rad(Si)/s and 50rad(Si)/s, respectively. The LDR tests were run to 150krad(Si) and the HDR tests were run to 100krad(Si).

The positive and negative input bias currents (Figures 5 and 6) were stable over HDR irradiation but showed considerable increase over both biased and grounded LDR irradiation. We observed failures at 100krad(Si) under bias (all four samples) and after 150krad(Si) grounded (also all four samples). This parameter increased well beyond the pre-irradiation Group A specification limits and the part must be considered LDR sensitive (see MIL-STD-883, TM1019, section 3.13.1.1). We also note that the post LDR high-temperature anneal returned the input bias current parameters to well within the SMD post-irradiation limits.

All other parameters were stable over irradiation, with some presumably ATE-induced variations in the positive and negative common-mode rejection ratio (Figures 12 and 13). No significant differences in total dose response for these parameters were noted between biased and grounded irradiation. Additionally, no channel-to-channel differences were noted, either in the pre-irradiation data or in the total dose response of the parts.

4. Appendices

Table 2. Reported Parameters

Figure	Parameter	Limit (Low)	Limit (High)	Units	Notes
2	Output high voltage	13.2	-	V	Channels 1 and 2
3	Output low voltage	-	-13.2	V	Channels 1 and 2
4	Input offset voltage	-100	+100	µV	Channels 1 and 2
5	Positive input bias current	-25	+25	nA	Channels 1 and 2
6	Negative input bias current	-25	+25	nA	Channels 1 and 2
7	Input offset current	-25	+25	nA	Channels 1 and 2
8	Positive open-loop gain, biased	120	-	dB	Channels 1 and 2
9	Negative open-loop gain, biased	120	-	dB	Channels 1 and 2
10	Positive power-supply rejection ratio	110	-	dB	Channels 1 and 2
11	Negative power-supply rejection ratio	110	-	dB	Channels 1 and 2
12	Positive common-mode rejection ratio	115	-	dB	Channels 1 and 2
13	Positive common-mode rejection ratio	115	-	dB	Channels 1 and 2
14	Output short-circuit current, sourcing	10	-	mA	Channels 1 and 2
15	Output short-circuit current, sinking	-	-10	mA	Channels 1 and 2
16	Positive supply current	-	7.4	mA	Sum of both channels
	Negative supply current	-7.4	-	mA	Sum of both channels
17	Positive slew rate	2	-	V/µs	Channels 1 and 2
18	Negative slew rate	2	-	V/µs	Channels 1 and 2
19	Positive rise time	-	100	ns	Channels 1 and 2
20	Negative rise time	-	100	ns	Channels 1 and 2

5. Revision History

Rev.	Date	Description
1.00	Jun.24.19	Applied new formatting. Higher LDR dose results on new wafer lot. Added Revision History.
0.00	Oct.20.17	Initial release

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