ISL70219ASEH

Total Dose Testing

TR046
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Introduction

This document reports the results of low and high dose rate total dose testing of the ISL70219ASEH dual operational amplifier. The tests were conducted to assess the total dose hardness of the part and to provide an estimate of dose rate, bias, or anneal sensitivity. Parts were irradiated under bias and with all pins grounded at low and high dose rate.The ISL70219ASEH is acceptance tested on a wafer-by-wafer basis to 300krad(Si) at high dose rate (50rad(Si)/s–300rad(Si)/s) and to 50krad(Si) at low dose rate (0.01rad(Si)/s).

Related Literature

For a full list of related documents, visit our website

- ISL70219ASEH product page
- MIL-STD-883 Test Method 1019

Part Description

The ISL70219ASEH is a precision dual operational amplifier featuring competitive low noise vs power consumption characteristics, low offset voltage, low input bias current, and low temperature drift, making this device an excellent choice for hardened applications requiring high DC accuracy and moderate AC performance. The ISL70219ASEH is offered in a 10 Ld hermetic package and is specified across the -55°C to +125°C temperature range. Constructed with the Renesas dielectrically isolated PR40 process, this device is immune to single event latchup and features improved Single Event Transient (SET) performance. The ISL70219ASEH offers ensured performance across the full -55°C to +125°C military temperature range.

The following list shows key pre- and post-radiation specifications.

- Input offset voltage . . . . . ±85µV pre, ±110µV post, max
- Input bias current . . . . . ±2.5nA pre, ±15.0nA post, max
- Input offset current . . . . . ±2.5nA pre, ±10.0nA post, max
- Supply current, each amplifier . . . . . 725µA pre, 850µA post, max
- Voltage noise 8nV/Hz
- Common-mode rejection ratio 120dB
- Power supply rejection ratio 120dB
- Open-loop gain 129.5dB
- Supply voltage range . . . . . .4.5V to 36V in beam (86.4MeV•cm^2/mg)
- Operating temperature range . . . . . -55°C to +125°C
- Standard Microcircuit Drawing (SMD) 5962-14226

1. Test Description

1.1 Irradiation Facilities

High dose rate testing was performed at 60rad(Si)/s using a Gammacell 220 irradiator located at the Renesas facility in Palm Bay, FL. Low dose rate testing was performed at 0.01rad(Si)/s using the Renesas Palm Bay N40 panoramic low dose rate irradiator.

1.2 Test Fixturing

Figure 1 shows the configurations used for biased and unbiased irradiation.

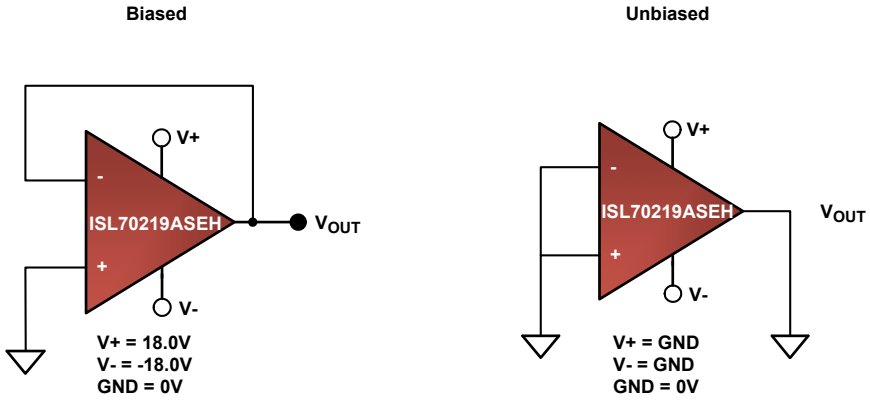

Figure 1. Irradiation Bias Configuration For The ISL70219ASEH Per SMD 5962-14226

1.3 Characterization Equipment and Procedures

All electrical testing was performed outside the irradiator using the production Automated Test Equipment (ATE) with datalogging at each downpoint. Downpoint electrical testing was performed at room temperature. Post-irradiation anneals were performed using a small temperature chamber.

1.4 Experimental Matrix

Total dose irradiation proceeded in accordance with the guidelines of MIL-STD-883 Test Method 1019.7. The experimental matrix consisted of 16 samples irradiated at low dose rate under bias, 16 samples irradiated at low dose rate with all pins grounded, 12 samples irradiated at high dose rate under bias, and 12 samples irradiated at high dose rate with all pins grounded. Two control units were used to ensure repeatable data.

Samples of the ISL70219ASEH were drawn from PR40 fabrication lot X0M0J and were packaged in a hermetic 10 Ld solder-sealed flatpack package (CDFP4-F10, code KCP, seal date 26 March 2014). Samples were processed through the standard burn-in cycle before irradiation, as required by MIL-STD-883, and were screened to the ATE limits at room temperature before the test.

1.5 Downpoints

Downpoints for the low dose rate tests were zero, 10krad(Si), 30krad(Si), and 50krad(Si).A post low dose rate biased anneal was performed after 50krad(Si). Downpoints for the high dose rate tests were zero, 30krad(Si), 50krad(Si), 100krad(Si), 300krad(Si), and 450krad(Si); the 450krad(Si) level represents the 50% overtest over the part's rated 300krad(Si), as per MIL-STD-883 Method 1019. Post high dose rate biased anneals were performed after 300krad(Si) and 450krad(Si).

2. Results

2.1 Attributes Data

High dose rate irradiation and subsequent anneals of the ISL70219ASEH are complete. The low dose anneal was performed on half the LDR samples after the 50krad(Si) downpoint. The other half were going to be irradiated further but technical issues prevented that.

All parts met the SMD post-radiation specifications at all downpoints. No differences in total dose response were noted between biased and grounded irradiation for any parameters. Additionally, no channel-to-channel differences

were noted, either in the pre-irradiation data or in the total dose response of the parts. We did note clear dose rate sensitivity in the input bias current, and the part is considered dose rate sensitive.

The ISL70219ASEH is acceptance tested on a wafer-by-wafer basis to 300krad(Si) at the high dose rate (50rad(Si)/s–300rad(Si)/s) and to 50krad(Si) at the low dose rate (0.01rad(Si)/s, providing hardness assurance at both dose rates. Table 1 summarizes the results.

Table 1. ISL71091ASEH Total Dose Test Attributes Data

Dose Rate (Note 1)	Bias	Sample Size	Downpoint	Pass (Note 2)	Rejects
LDR	Biased	16	Pre-irradiation	16	0
			10krad(Si)	16	0
			30krad(Si)	16	0
			50krad(Si)	16	0
			Sample anneal	8	0
LDR	Grounded	16	Pre-irradiation	16	0
			10krad(Si)	16	0
			30krad(Si)	16	0
			50krad(Si)	16	0
			Sample anneal	8	0
HDR	Biased	12	Pre-irradiation	12	0
			30krad(Si)	12	0
			50krad(Si)	12	0
			100krad(Si)	12	0
			300krad(Si)	12	0
			Sample anneal	6	0
			450krad(Si)	12	0
			Sample anneal	12	0
HDR	Grounded	12	Pre-irradiation	12	
			30krad(Si)	12	0
			50krad(Si)	12	0
			100krad(Si)	12	0
			300krad(Si)	12	0
			Sample anneal	6	0
			450krad(Si)	12	0
			Sample anneal	12	0

Notes:

1. “HDR” indicates high dose rate (50rad(Si)s-300rad(Si)/s) as specified in MIL-STD-883 TM1019; the actual dose rate for these tests was 65rad(Si)/s. “LDR” indicates low dose rate (0.01rad(Si)/s), also as specified in TM1019.
2. “Pass” indicates a sample that passes all post-irradiation SMD limits.

2.2 Variables Data

The plots in Figures 2 through 31 show data for key parameters at all downpoints to date. We have plotted representative results for the ±18V and ±5V supply voltage cases, with some CMRR and PSRR data shown for ±2.75V. 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. All samples passed the SMD post-irradiation limits at all downpoints.

3. Variables Data Plots

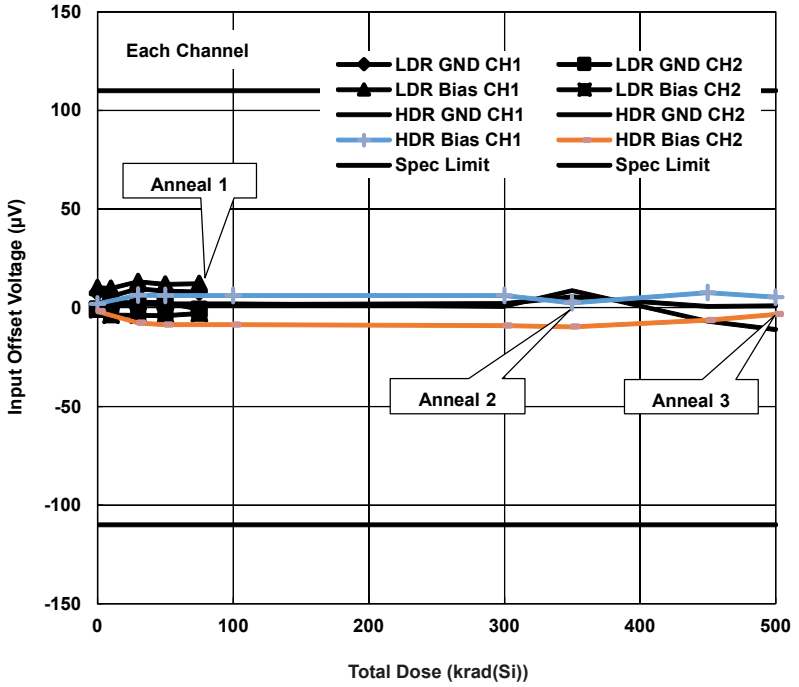

Figure 2. ISL70219ASEH input offset voltage, ±18V supplies, Channels 1 and 2, as a function of total dose irradiation at low and high dose rate for the biased and unbiased cases. The dose rate was 0.01rad(Si)/s for low dose rate irradiation and 60rad(Si)/s for high dose rate irradiation. Sample size for the LDR cells was 16 and sample size for the HDR cells was 12. Anneals were performed after 50krad(Si) at low dose rate and after 300krad(Si) and 450krad(Si) at high dose rate. See "Attributes Data" on page 2. The post-irradiation SMD limits are -110µV and +110µV.

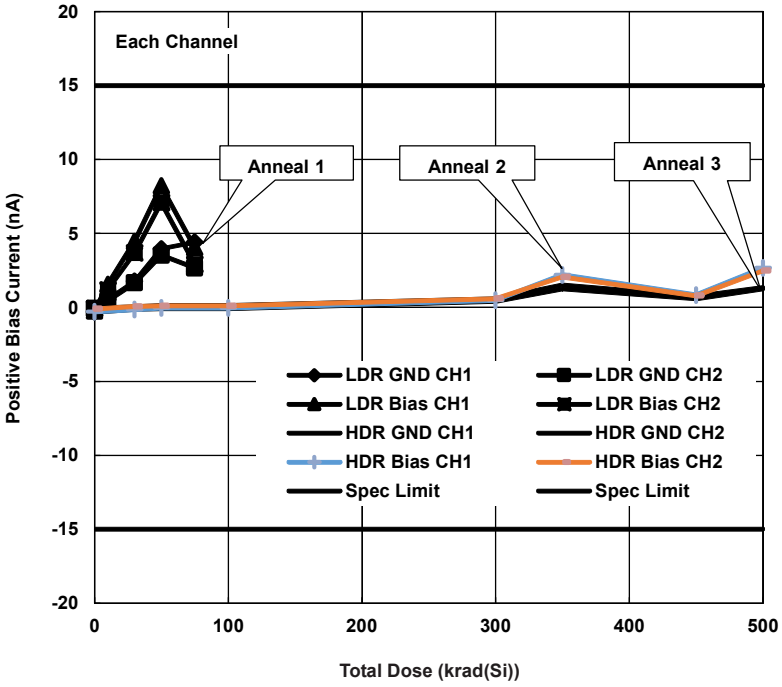

Figure 3. ISL70219ASEH positive input bias current, ±18V supplies, Channels 1 and 2, as a function of total dose irradiation at low and high dose rate for the biased and unbiased cases. The dose rate was 0.01rad(Si)/s for low dose rate irradiation and 60rad(Si)/s for high dose rate irradiation. Sample size for the LDR cells was 16 and sample size for the HDR cells was 12. Anneals were performed after 50krad(Si) at low dose rate and after 300krad(Si) and 450krad(Si) at high dose rate. See "Attributes Data" on page 2. The post-irradiation SMD limits are -15nA and +15nA.

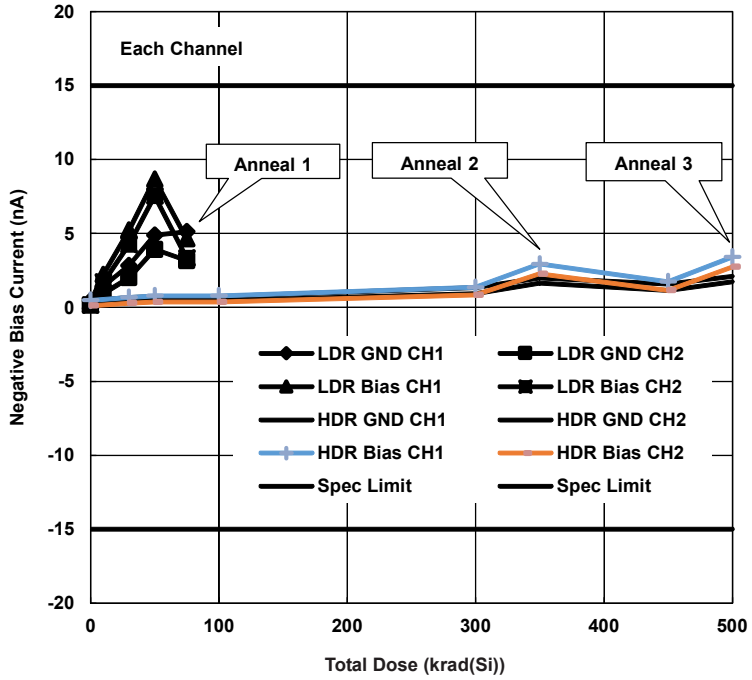

Figure 4. ISL70219ASEH negative input bias current, ±18V supplies, Channels 1 and 2, as a function of total dose irradiation at low and high dose rate for the biased and unbiased cases. The dose rate was 0.01rad(Si)/s for low dose rate irradiation and 60rad(Si)/s for high dose rate irradiation. Sample size for the LDR cells was 16 and sample size for the HDR cells was 12. Anneals were performed after 50krad(Si) at low dose rate and after 300krad(Si) and 450krad(Si) at high dose rate. See "Attributes Data" on page 2. The post-irradiation SMD limits are -15nA and +15nA.

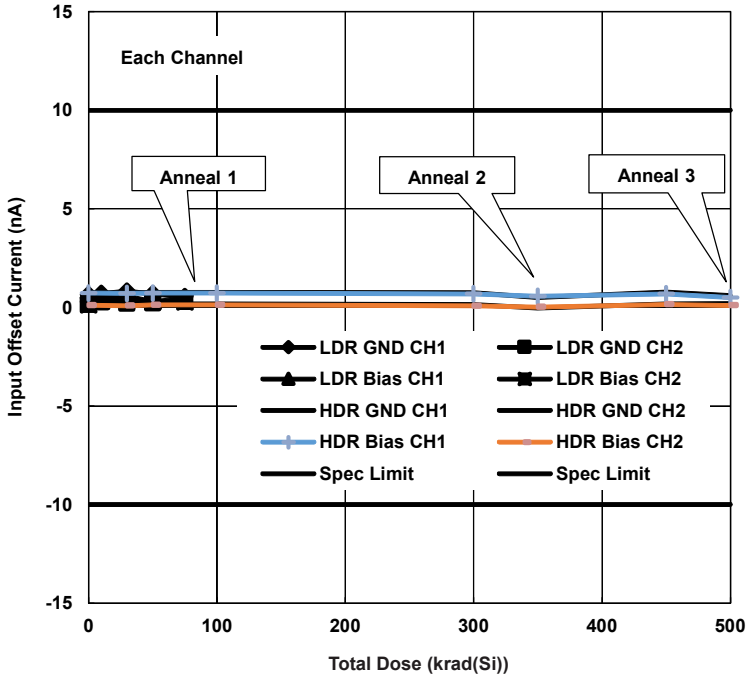

Figure 5. ISL70219ASEH input offset current, ±18V supplies, Channels 1 and 2, as a function of total dose irradiation at low and high dose rate for the biased and unbiased cases. The dose rate was 0.01rad(Si)/s for low dose rate irradiation and 60rad(Si)/s for high dose rate irradiation. Sample size for the LDR cells was 16 and sample size for the HDR cells was 12. Anneals were performed after 50krad(Si) at low dose rate and after 300krad(Si) and 450krad(Si) at high dose rate. See "Attributes Data" on page 2. The post-irradiation SMD limits are -10nA and +10nA.

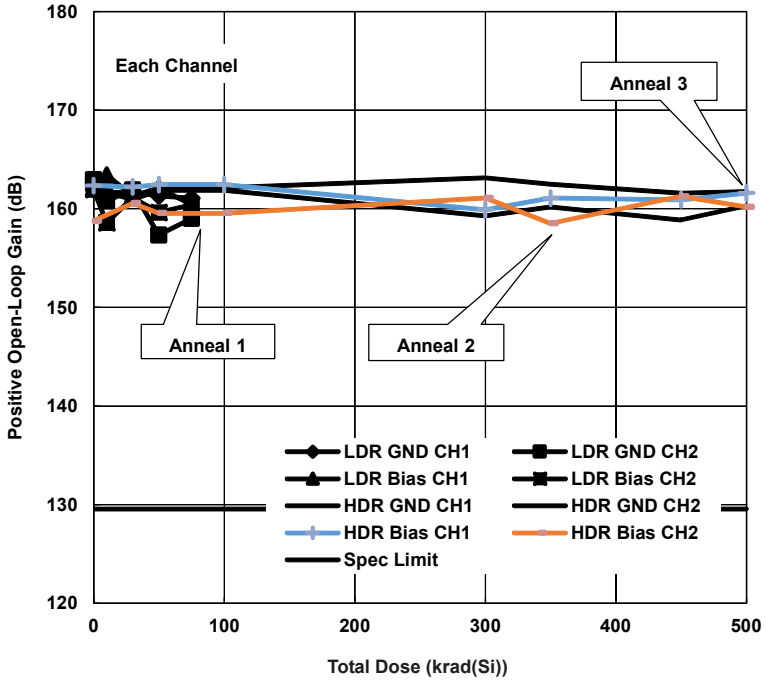

Figure 6. ISL70219ASEH positive open-loop gain, ±18V supplies, Channels 1 and 2, as a function of total dose irradiation at low and high dose rate for the biased and unbiased cases. The dose rate was 0.01rad(Si)/s for low dose rate irradiation and 60rad(Si)/s for high dose rate irradiation. Sample size for the LDR cells was 16 and sample size for the HDR cells was 12. Anneals were performed after 50krad(Si) at low dose rate and after 300krad(Si) and 450krad(Si) at high dose rate. See "Attributes Data" on page 2. The post-irradiation SMD limit is 129.5dB minimum.

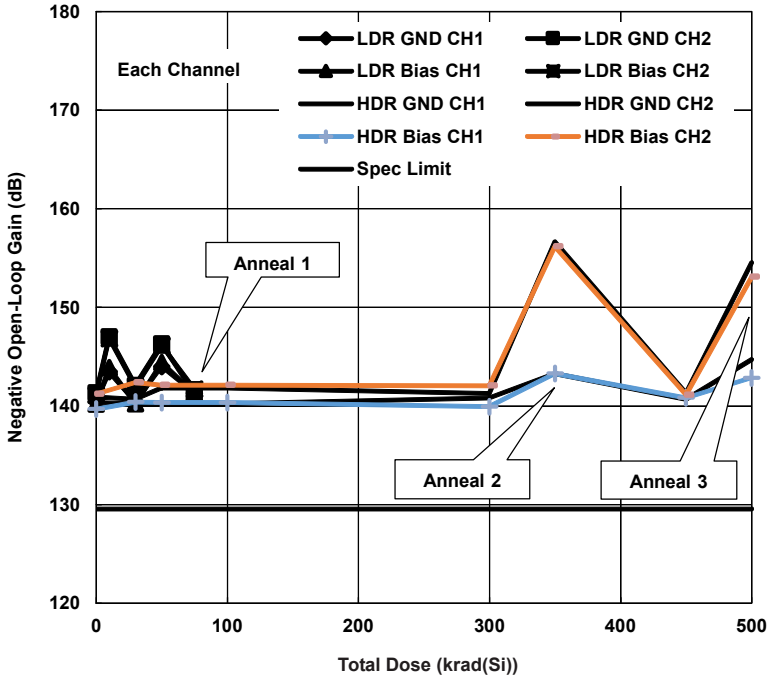

Figure 7. ISL70219ASEH negative open-loop gain, ±18V supplies, Channels 1 and 2, as a function of total dose irradiation at low and high dose rate for the biased and unbiased cases. The dose rate was 0.01rad(Si)/s for low dose rate irradiation and 60rad(Si)/s for high dose rate irradiation. Sample size for the LDR cells was 16 and sample size for the HDR cells was 12. Anneals were performed after 50krad(Si) at low dose rate and after 300krad(Si) and 450krad(Si) at high dose rate. See "Attributes Data" on page 2. The post-irradiation SMD limit is 129.5dB minimum.

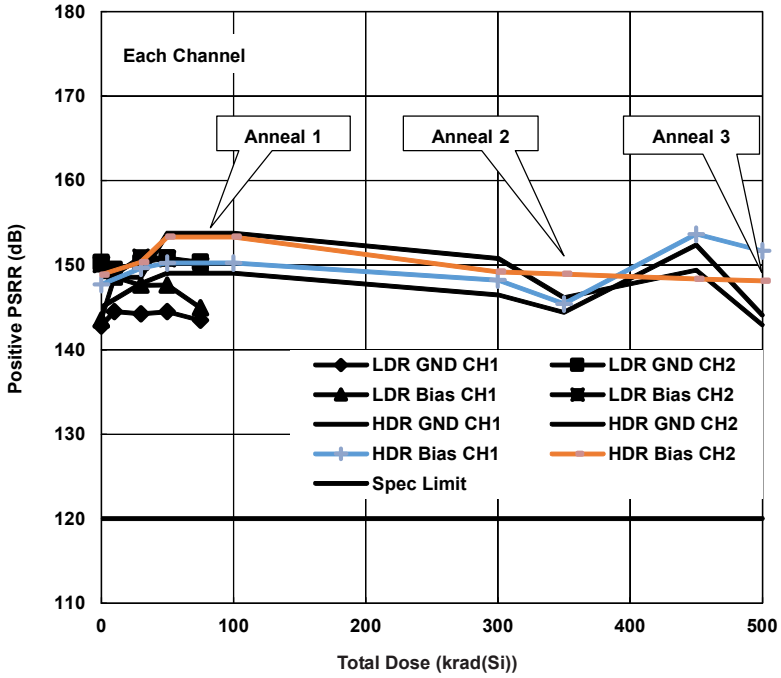

Figure 8. ISL70219ASEH positive Power Supply Rejection Ratio (PSRR), ±18V supplies, Channels 1 and 2, as a function of total dose irradiation at low and high dose rate for the biased and unbiased cases. The dose rate was 0.01rad(Si)/s for low dose rate irradiation and 60rad(Si)/s for high dose rate irradiation. Sample size for the LDR cells was 16 and sample size for the HDR cells was 12. Anneals were performed after 50krad(Si) at low dose rate and after 300krad(Si) and 450krad(Si) at high dose rate. See "Attributes Data" on page 2. The post-irradiation SMD limit is 120dB minimum.

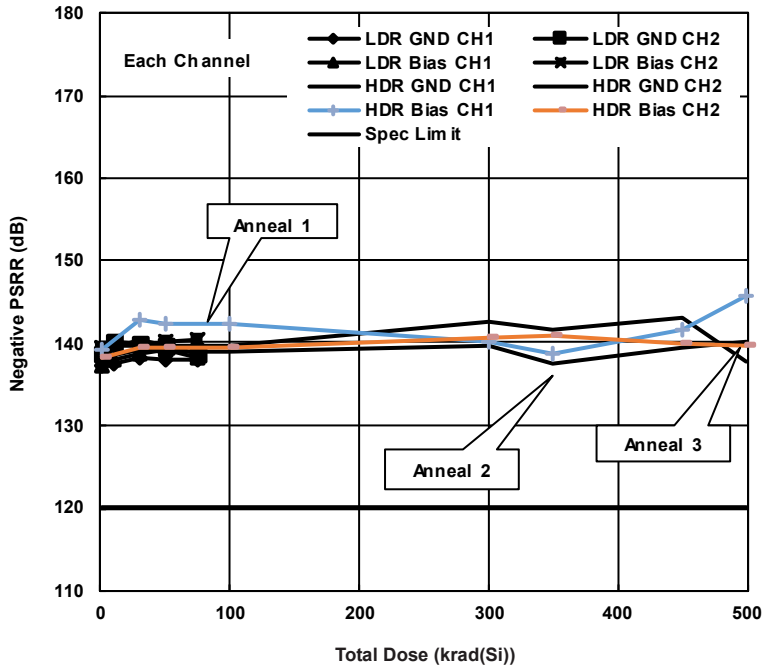

Figure 9. ISL70219ASEH negative Power Supply Rejection Ratio (PSRR), ±18V supplies, Channels 1 and 2, as a function of total dose irradiation at low and high dose rate for the biased and unbiased cases. The dose rate was 0.01rad(Si)/s for low dose rate irradiation and 60rad(Si)/s for high dose rate irradiation. Sample size for the LDR cells was 16 and sample size for the HDR cells was 12. Anneals were performed after 50krad(Si) at low dose rate and after 300krad(Si) and 450krad(Si) at high dose rate. See "Attributes Data" on page 2. The post-irradiation SMD limit is 120dB minimum.

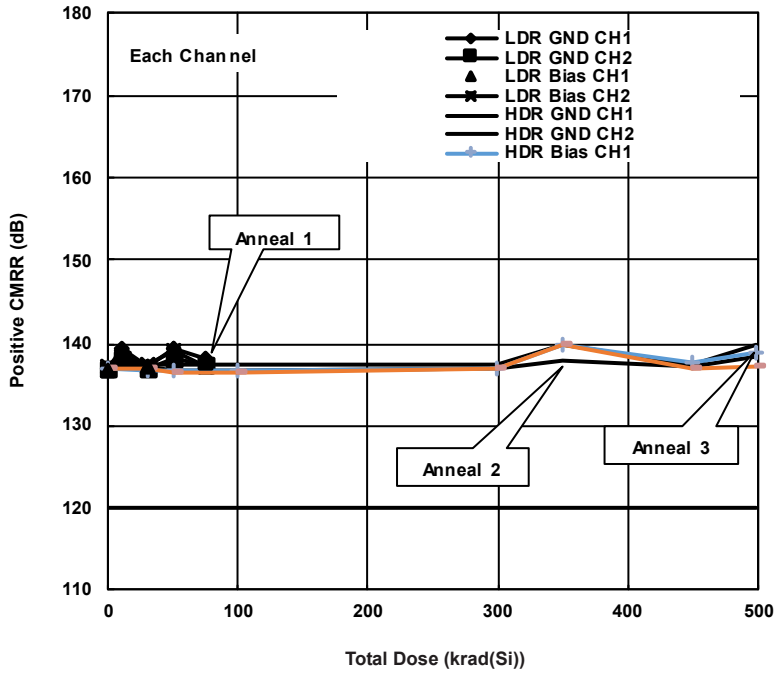

Figure 10. ISL70219ASEH positive Common-Mode Rejection Ratio (CMRR), ±18V supplies, Channels 1 and 2, as a function of total dose irradiation at low and high dose rate for the biased and unbiased cases. The dose rate was 0.01rad(Si)/s for low dose rate irradiation and 60rad(Si)/s for high dose rate irradiation. Sample size for the LDR cells was 16 and sample size for the HDR cells was 12. Anneals were performed after 50krad(Si) at low dose rate and after 300krad(Si) and 450krad(Si) at high dose rate. See "Attributes Data" on page 2. The post-irradiation SMD limit is 120dB minimum.

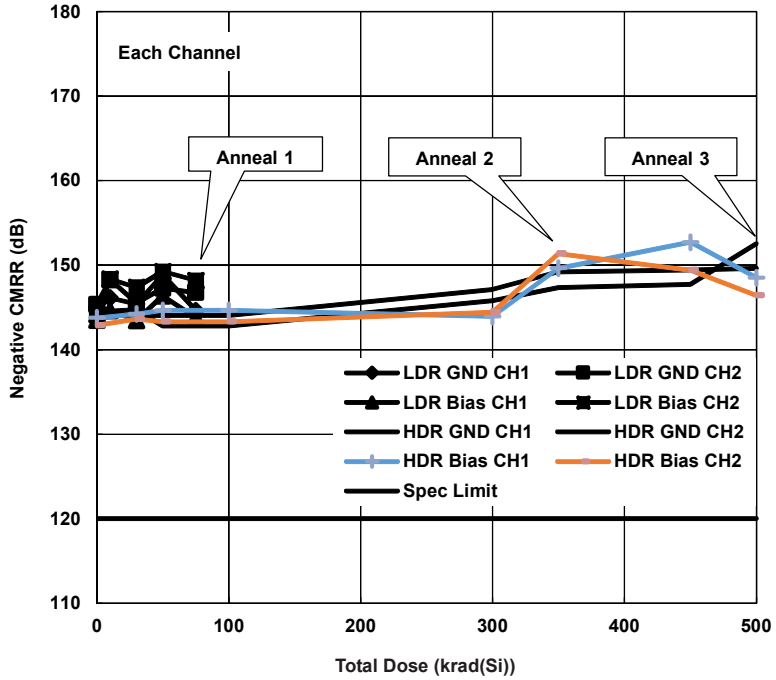

Figure 11. ISL70219ASEH negative Common-Mode Rejection Ratio (CMRR), ±18V supplies, Channels 1 and 2, as a function of total dose irradiation at low and high dose rate for the biased and unbiased cases. The dose rate was 0.01rad(Si)/s for low dose rate irradiation and 60rad(Si)/s for high dose rate irradiation. Sample size for the LDR cells was 16 and sample size for the HDR cells was 12. Anneals were performed after 50krad(Si) at low dose rate and after 300krad(Si) and 450krad(Si) at high dose rate. See "Attributes Data" on page 2. The post-irradiation SMD limit is 120dB minimum.

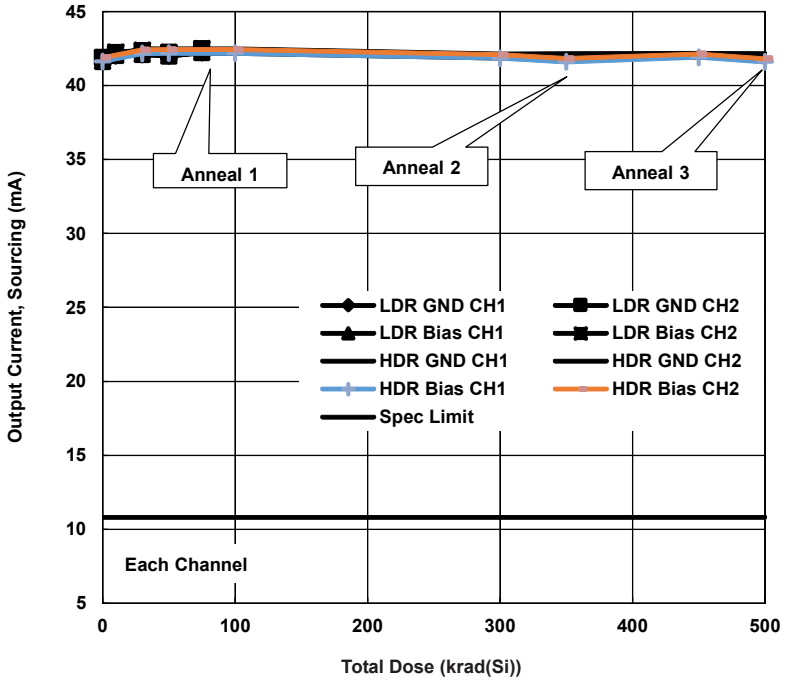

Figure 12. ISL70219ASEH output short-circuit current, sourcing, ±18V supplies, Channels 1 and 2, as a function of total dose irradiation at low and high dose rate for the biased and unbiased cases. The dose rate was 0.01rad(Si)/s for low dose rate irradiation and 60rad(Si)/s for high dose rate irradiation. Sample size for the LDR cells was 16 and sample size for the HDR cells was 12. Anneals were performed after 50krad(Si) at low dose rate and after 300krad(Si) and 450krad(Si) at high dose rate. See "Attributes Data" on page 2. The post-irradiation SMD limit is 10.8mA (typical) minimum.

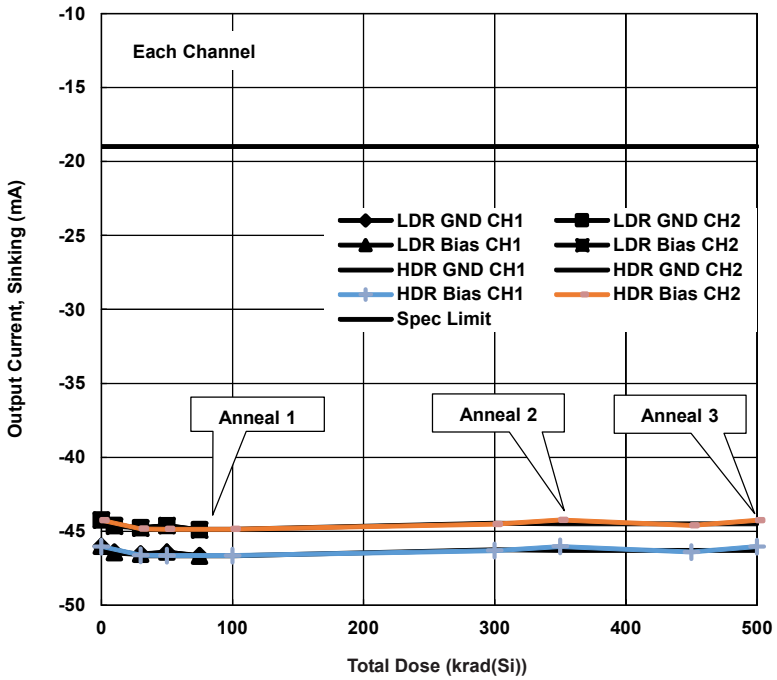

Figure 13. ISL70219ASEH output short-circuit current, sinking, ±18V supplies, Channels 1 and 2, as a function of total dose irradiation at low and high dose rate for the biased and unbiased cases. The dose rate was 0.01rad(Si)/s for low dose rate irradiation and 60rad(Si)/s for high dose rate irradiation. Sample size for the LDR cells was 16 and sample size for the HDR cells was 12. Anneals were performed after 50krad(Si) at low dose rate and after 300krad(Si) and 450krad(Si) at high dose rate. See "Attributes Data" on page 2. The post-irradiation SMD limit is -19mA (typical) minimum.

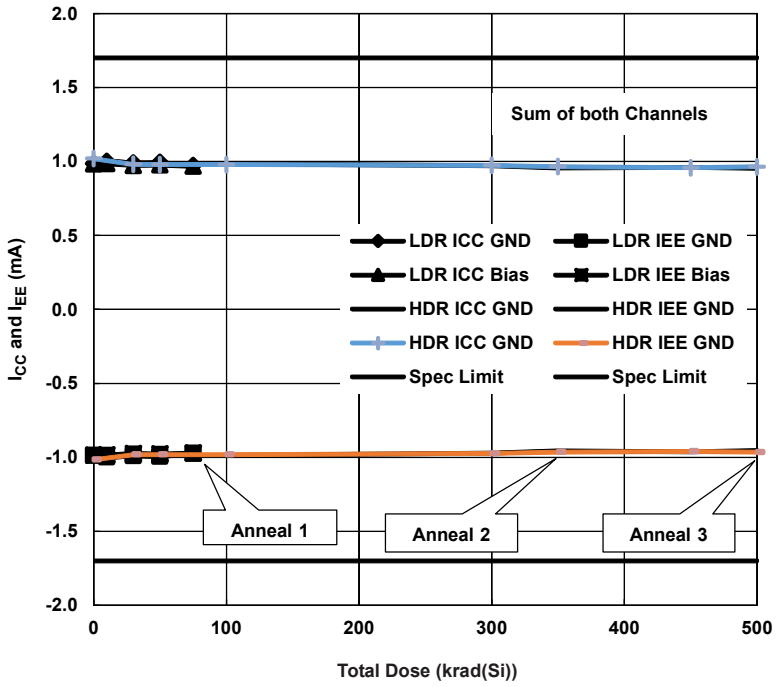

Figure 14. ISL70219ASEH positive and negative supply current, ±18V supplies, Channels 1 and 2, as a function of total dose irradiation at low and high dose rate for the biased and unbiased cases. The dose rate was 0.01rad(Si)/s for low dose rate irradiation and 60rad(Si)/s for high dose rate irradiation. Sample size for the LDR cells was 16 and sample size for the HDR cells was 12. Anneals were performed after 50krad(Si) at low dose rate and after 300krad(Si) and 450krad(Si) at high dose rate. See "Attributes Data" on page 2. The post-irradiation SMD limits are -1.7mA (I_{CC}) and +1.7mA (I_{EE}).

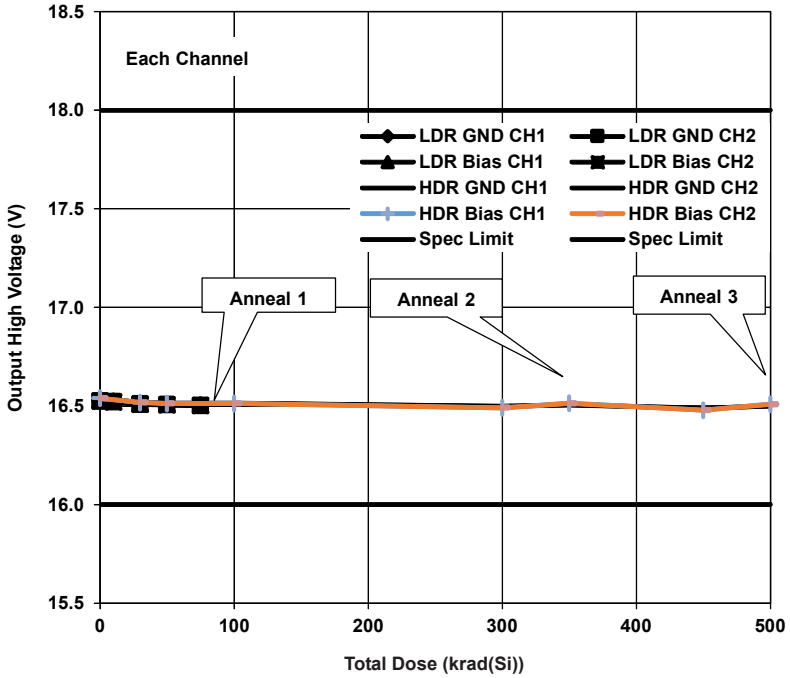

Figure 15. ISL70219ASEH output high voltage, Channels 1 and 2, ±18V supplies, as a function of total dose irradiation at low and high dose rate for the biased and unbiased cases. The dose rate was 0.01rad(Si)/s for low dose rate irradiation and 60rad(Si)/s for high dose rate irradiation. Sample size for the LDR cells was 16 and sample size for the HDR cells was 12. Anneals were performed after 50krad(Si) at low dose rate and after 300krad(Si) and 450krad(Si) at high dose rate. See "Attributes Data" on page 2. The post-irradiation SMD limits are 16.0V and 18.0V.

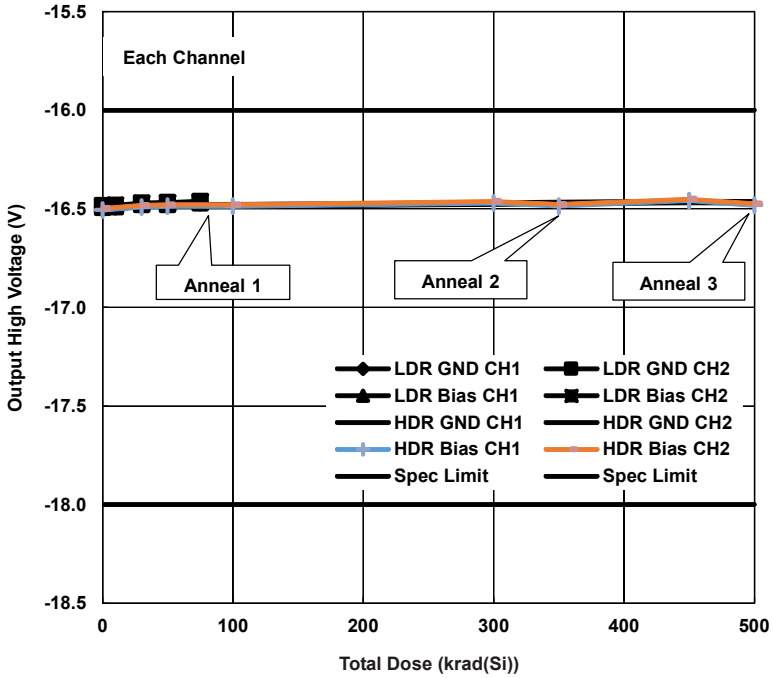

Figure 16. ISL70219ASEH output low voltage, Channels 1 and 2, ±18V supplies, as a function of total dose irradiation at low and high dose rate for the biased and unbiased cases. The dose rate was 0.01rad(Si)/s for low dose rate irradiation and 60rad(Si)/s for high dose rate irradiation. Sample size for the LDR cells was 16 and sample size for the HDR cells was 12. Anneals were performed after 50krad(Si) at low dose rate and after 300krad(Si) and 450krad(Si) at high dose rate. See "Attributes Data" on page 2. The post-irradiation SMD limits are -16V and -18V.

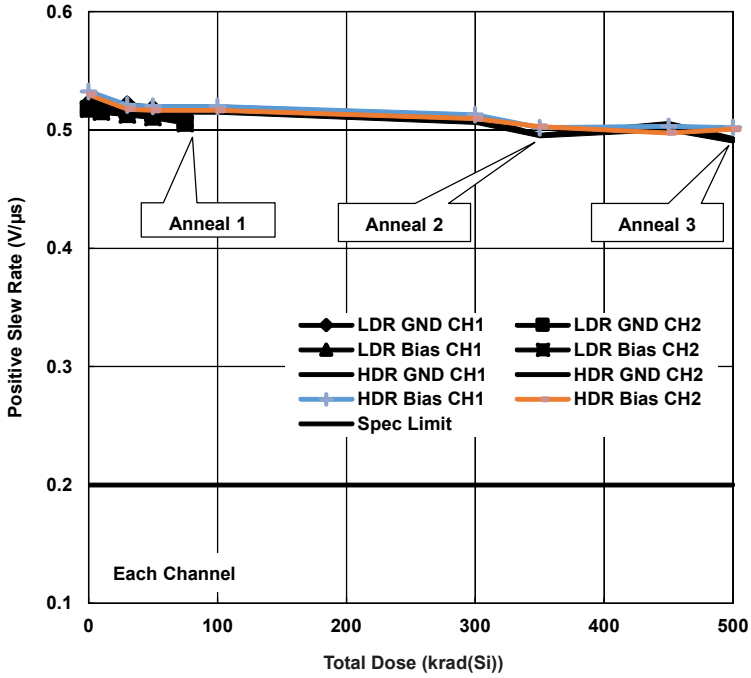

Figure 17. ISL70219ASEH positive slew rate, Channels 1 and 2, ±18V supplies, as a function of total dose irradiation at low and high dose rate for the biased and unbiased cases. The dose rate was 0.01rad(Si)/s for low dose rate irradiation and 60rad(Si)/s for high dose rate irradiation. Sample size for the LDR cells was 16 and sample size for the HDR cells was 12. Anneals were performed after 50krad(Si) at low dose rate and after 300krad(Si) and 450krad(Si) at high dose rate. See "Attributes Data" on page 2. The post-irradiation SMD limit is 0.2V/µs minimum.

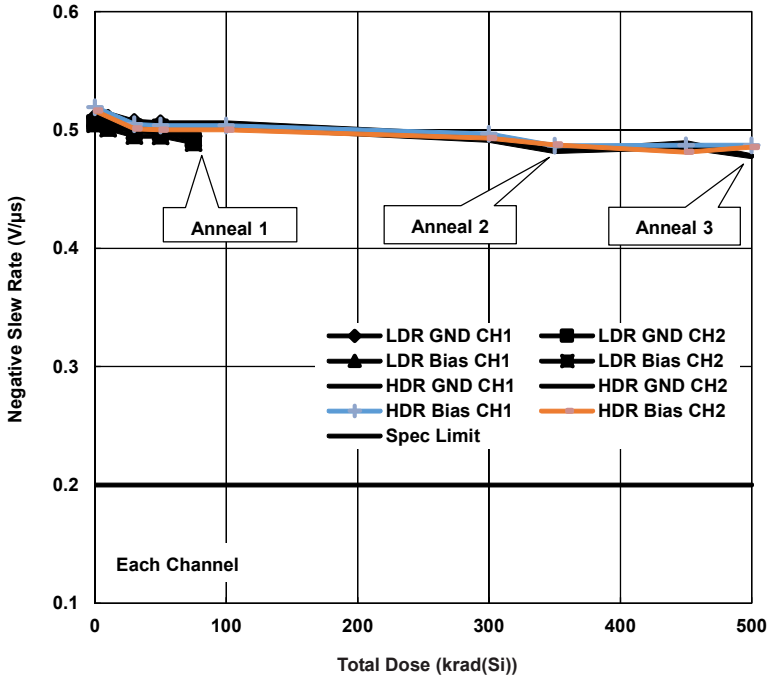

Figure 18. ISL70219ASEH negative slew rate, Channels 1 and 2, ±18V supplies, as a function of total dose irradiation at low and high dose rate for the biased and unbiased cases. The dose rate was 0.01rad(Si)/s for low dose rate irradiation and 60rad(Si)/s for high dose rate irradiation. Sample size for the LDR cells was 16 and sample size for the HDR cells was 12. Anneals were performed after 50krad(Si) at low dose rate and after 300krad(Si) and 450krad(Si) at high dose rate. See "Attributes Data" on page 2. The post-irradiation SMD limit is 0.2V/µs minimum.

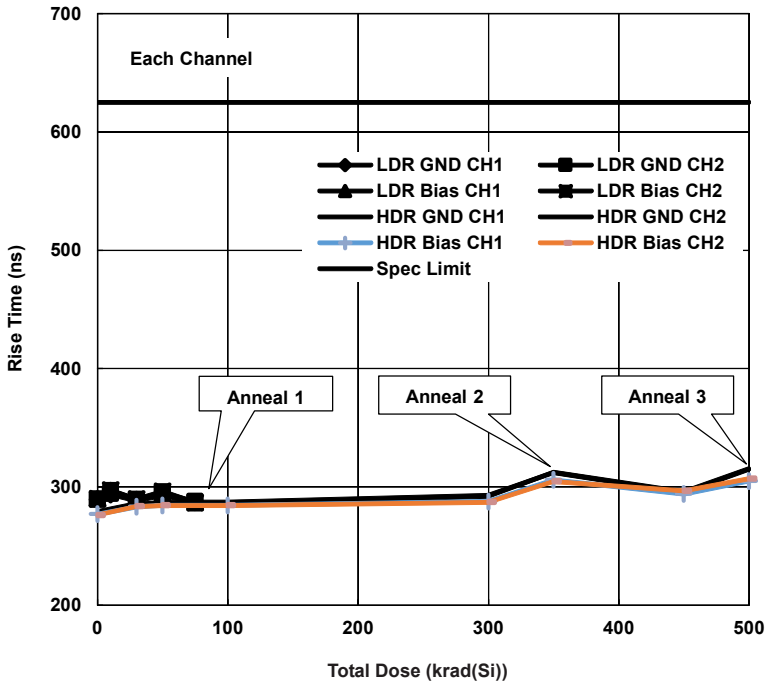

Figure 19. ISL70219ASEH rise time, Channels 1 and 2, ±18V supplies, as a function of total dose irradiation at low and high dose rate for the biased and unbiased cases. The dose rate was 0.01rad(Si)/s for low dose rate irradiation and 60rad(Si)/s for high dose rate irradiation. Sample size for the LDR cells was 16 and sample size for the HDR cells was 12. Anneals were performed after 50krad(Si) at low dose rate and after 300krad(Si) and 450krad(Si) at high dose rate. See "Attributes Data" on page 2. The post-irradiation SMD limit is 625ns minimum.

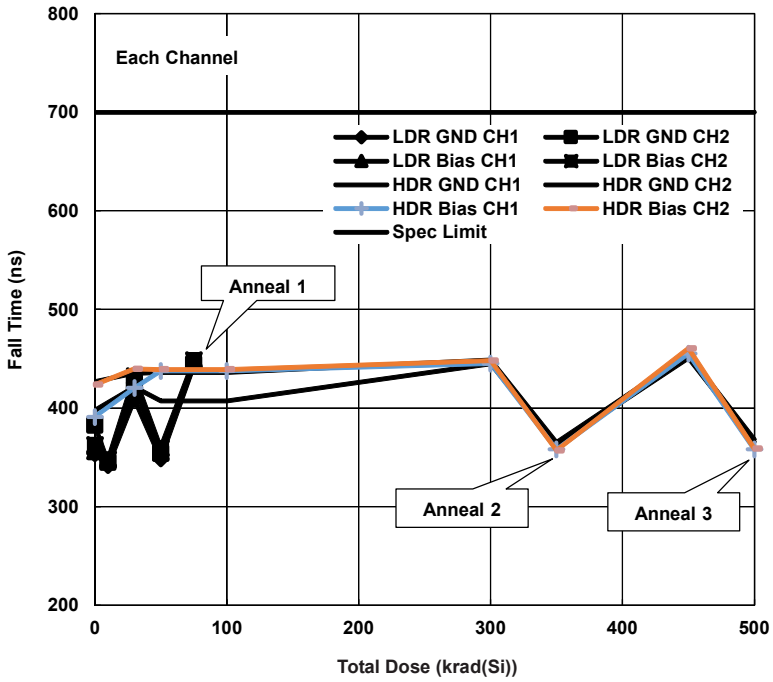

Figure 20. ISL70219ASEH fall time, Channels 1 and 2, ±18V supplies, as a function of total dose irradiation at low and high dose rate for the biased and unbiased cases. The dose rate was 0.01rad(Si)/s for low dose rate irradiation and 60rad(Si)/s for high dose rate irradiation. Sample size for the LDR cells was 16 and sample size for the HDR cells was 12. Anneals were performed after 50krad(Si) at low dose rate and after 300krad(Si) and 450krad(Si) at high dose rate. See "Attributes Data" on page 2. The post-irradiation SMD limit is 700ns minimum.

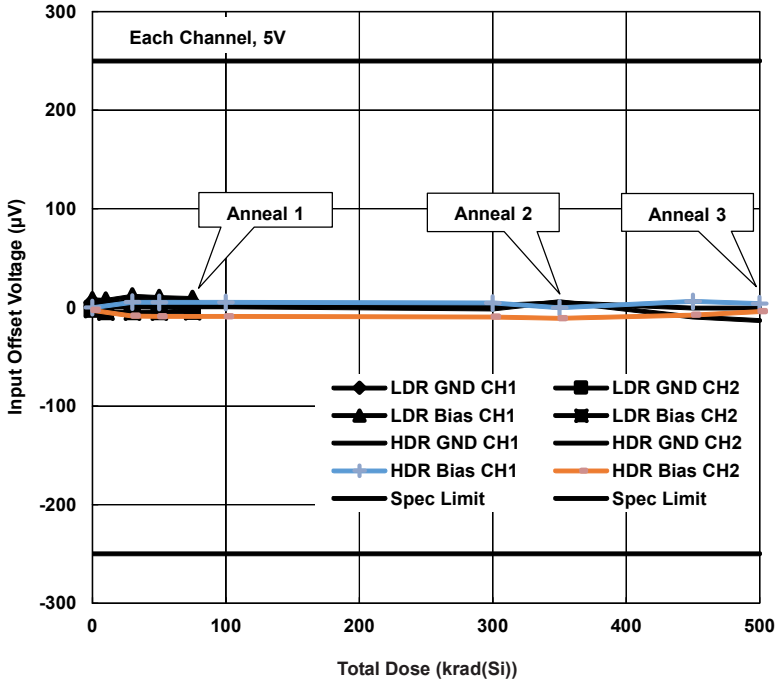

Figure 21. ISL70219ASEH input offset voltage, Channels 1 and 2, ±5V supplies, as a function of total dose irradiation at low and high dose rate for the biased and unbiased cases. The dose rate was 0.01rad(Si)/s for low dose rate irradiation and 60rad(Si)/s for high dose rate irradiation. Sample size for the LDR cells was 16 and sample size for the HDR cells was 12. Anneals were performed after 50krad(Si) at low dose rate and after 300krad(Si) and 450krad(Si) at high dose rate. See "Attributes Data" on page 2. The post-irradiation SMD limits are -250µV and +250µV.

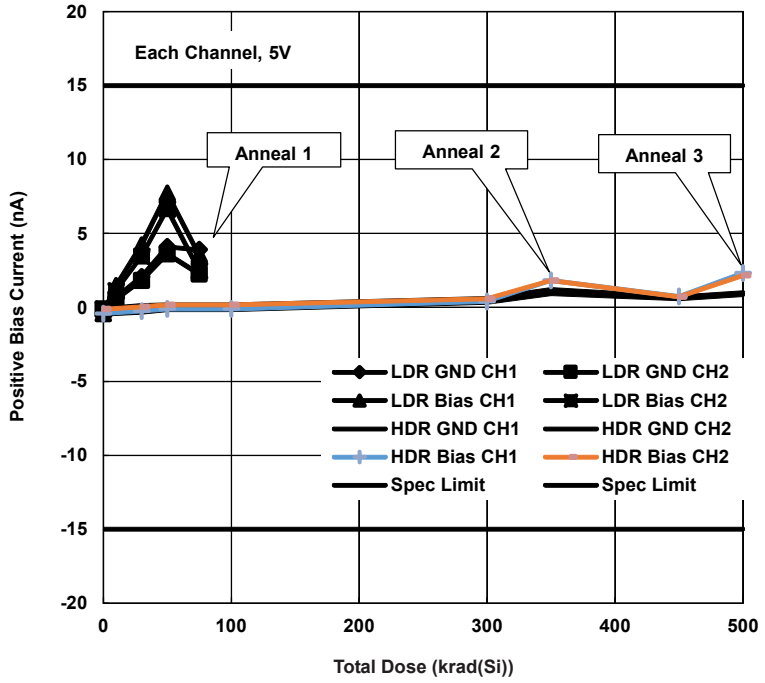

Figure 22. ISL70219ASEH positive bias current, Channels 1 and 2, ±5V supplies, as a function of total dose irradiation at low and high dose rate for the biased and unbiased cases. The dose rate was 0.01rad(Si)/s for low dose rate irradiation and 60rad(Si)/s for high dose rate irradiation. Sample size for the LDR cells was 16 and sample size for the HDR cells was 12. Anneals were performed after 50krad(Si) at low dose rate and after 300krad(Si) and 450krad(Si) at high dose rate. See "Attributes Data" on page 2. The post-irradiation SMD limits are -15nA and +15nA.

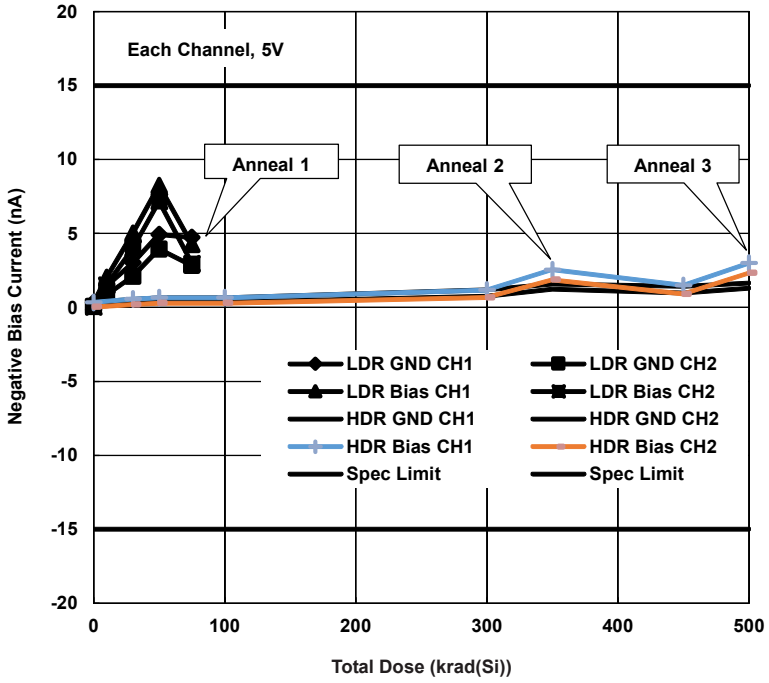

Figure 23. ISL70219ASEH negative bias current, Channels 1 and 2, ±5V supplies, as a function of total dose irradiation at low and high dose rate for the biased and unbiased cases. The dose rate was 0.01rad(Si)/s for low dose rate irradiation and 60rad(Si)/s for high dose rate irradiation. Sample size for the LDR cells was 16 and sample size for the HDR cells was 12. Anneals were performed after 50krad(Si) at low dose rate and after 300krad(Si) and 450krad(Si) at high dose rate. See "Attributes Data" on page 2. The post-irradiation SMD limits are -15nA and +15nA.

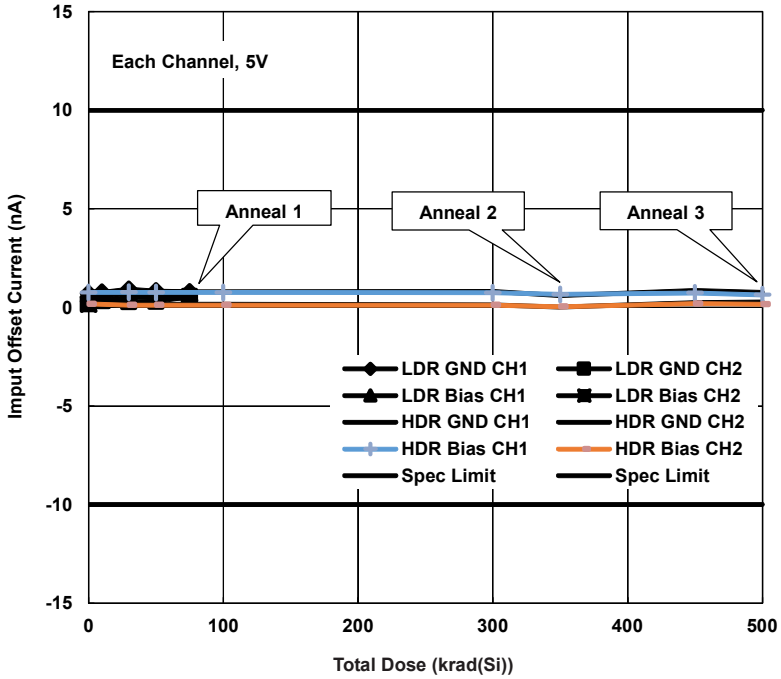

Figure 24. ISL70219ASEH input offset current, Channels 1 and 2, ±5V supplies, as a function of total dose irradiation at low and high dose rate for the biased and unbiased cases. The dose rate was 0.01rad(Si)/s for low dose rate irradiation and 60rad(Si)/s for high dose rate irradiation. Sample size for the LDR cells was 16 and sample size for the HDR cells was 12. Anneals were performed after 50krad(Si) at low dose rate and after 300krad(Si) and 450krad(Si) at high dose rate. See "Attributes Data" on page 2. The post-irradiation SMD limits are -10.0nA and +10.0nA.

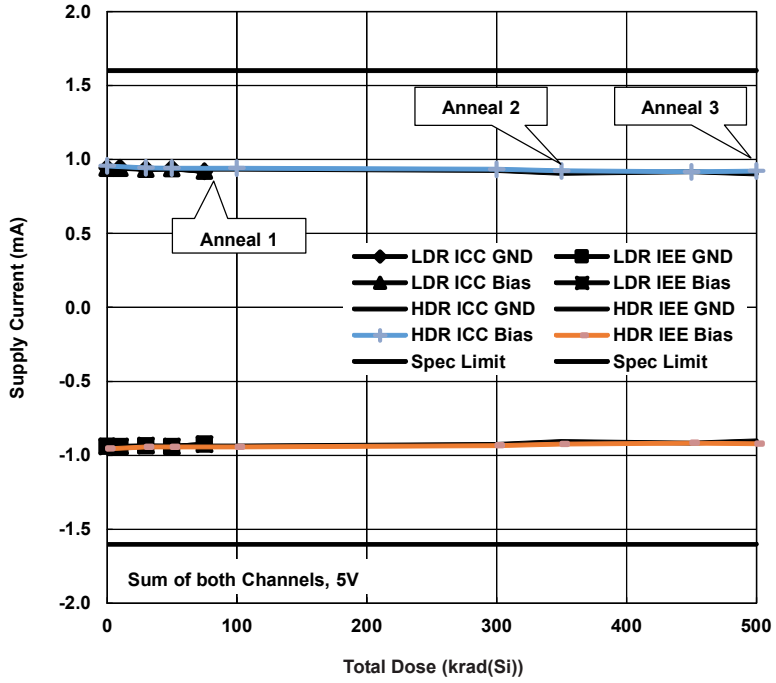

Figure 25. ISL70219ASEH positive and negative supply current, Channels 1 and 2, ±5V supplies, as a function of total dose irradiation at low and high dose rate for the biased and unbiased cases. The dose rate was 0.01rad(Si)/s for low dose rate irradiation and 60rad(Si)/s for high dose rate irradiation. Sample size for the LDR cells was 16 and sample size for the HDR cells was 12. Anneals were performed after 50krad(Si) at low dose rate and after 300krad(Si) and 450krad(Si) at high dose rate. See "Attributes Data" on page 2. The post-irradiation SMD limits are -1.6mA (I_{CC}) and +1.6mA (I_{EE}).

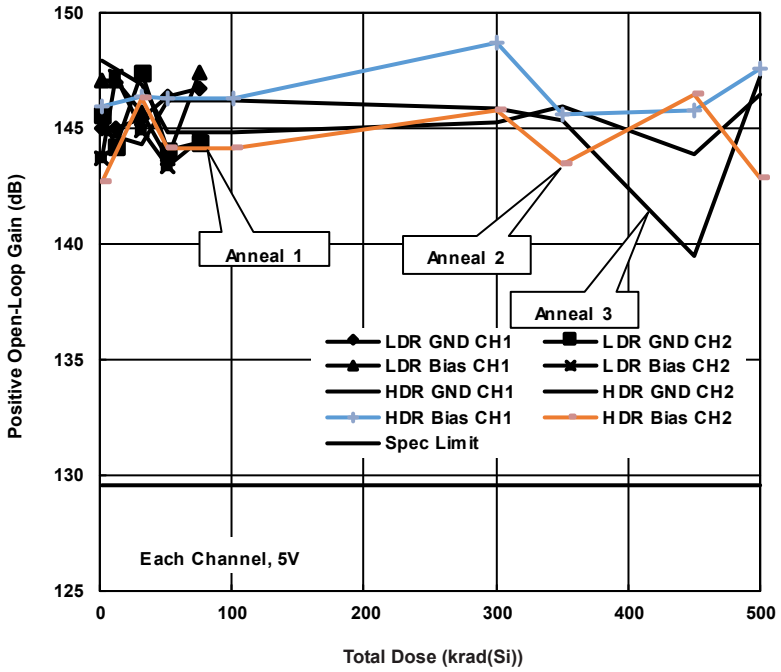

Figure 26. ISL70219ASEH positive open-loop gain, Channels 1 and 2, ±5V supplies, as a function of total dose irradiation at low and high dose rate for the biased and unbiased cases. The dose rate was 0.01rad(Si)/s for low dose rate irradiation and 60rad(Si)/s for high dose rate irradiation. Sample size for the LDR cells was 16 and sample size for the HDR cells was 12. Anneals were performed after 50krad(Si) at low dose rate and after 300krad(Si) and 450krad(Si) at high dose rate. See "Attributes Data" on page 2. The post-irradiation SMD limit is 129dB minimum.

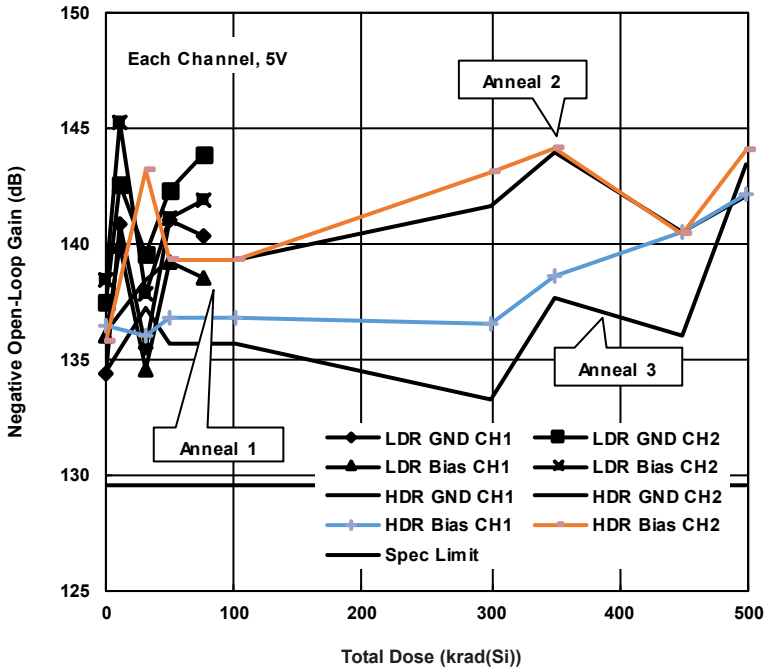

Figure 27. ISL70219ASEH negative open-loop gain, Channels 1 and 2, ±5V supplies, as a function of total dose irradiation at low and high dose rate for the biased and unbiased cases. The dose rate was 0.01rad(Si)/s for low dose rate irradiation and 60rad(Si)/s for high dose rate irradiation. Sample size for the LDR cells was 16 and sample size for the HDR cells was 12. Anneals were performed after 50krad(Si) at low dose rate and after 300krad(Si) and 450krad(Si) at high dose rate. See "Attributes Data" on page 2. The post-irradiation SMD limit is 129dB minimum.

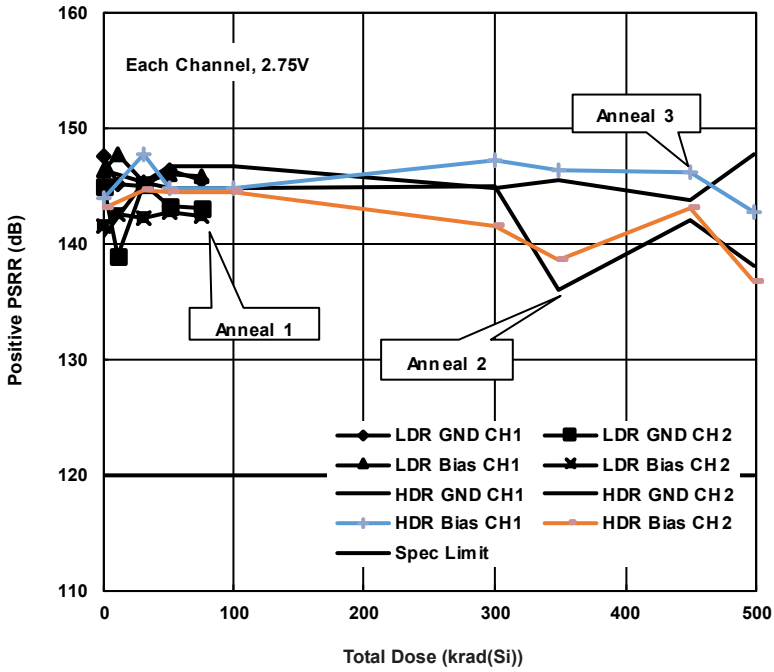

Figure 28. ISL70219ASEH positive Power Supply Rejection Ratio (PSRR), Channels 1 and 2, ±2.75V supplies, as a function of total dose irradiation at low and high dose rate for the biased and unbiased cases. The dose rate was 0.01rad(Si)/s for low dose rate irradiation and 60rad(Si)/s for high dose rate irradiation. Sample size for the LDR cells was 16 and sample size for the HDR cells was 12. Anneals were performed after 50krad(Si) at low dose rate and after 300krad(Si) and 450krad(Si) at high dose rate. See "Attributes Data" on page 2. The post-irradiation SMD limit is 120dB minimum.

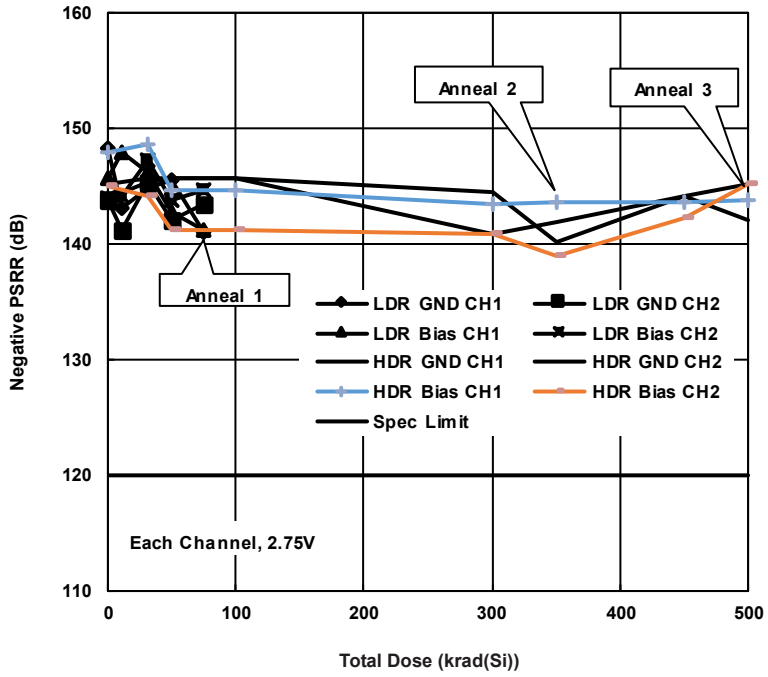

Figure 29. ISL70219ASEH negative Power Supply Rejection Ratio (PSRR), Channels 1 and 2, ±2.75V supplies, as a function of total dose irradiation at low and high dose rate for the biased and unbiased cases. The dose rate was 0.01rad(Si)/s for low dose rate irradiation and 60rad(Si)/s for high dose rate irradiation. Sample size for the LDR cells was 16 and sample size for the HDR cells was 12. Anneals were performed after 50krad(Si) at low dose rate and after 300krad(Si) and 450krad(Si) at high dose rate. See "Attributes Data" on page 2. The post-irradiation SMD limit is 120dB minimum.

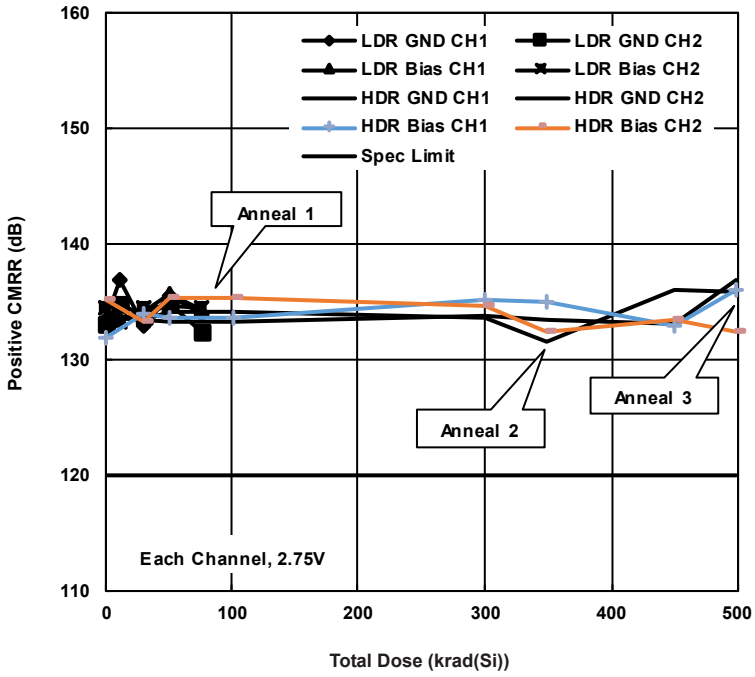

Figure 30. ISL70219ASEH positive Common-Mode Rejection Ratio (CMRR), Channels 1 and 2, ±3.0V supplies, as a function of total dose irradiation at low and high dose rate for the biased and unbiased cases. The dose rate was 0.01rad(Si)/s for low dose rate irradiation and 60rad(Si)/s for high dose rate irradiation. Sample size for the LDR cells was 16 and sample size for the HDR cells was 12. Anneals were performed after 50krad(Si) at low dose rate and after 300krad(Si) and 450krad(Si) at high dose rate. See "Attributes Data" on page 2. The post-irradiation SMD limit is 120dB minimum.

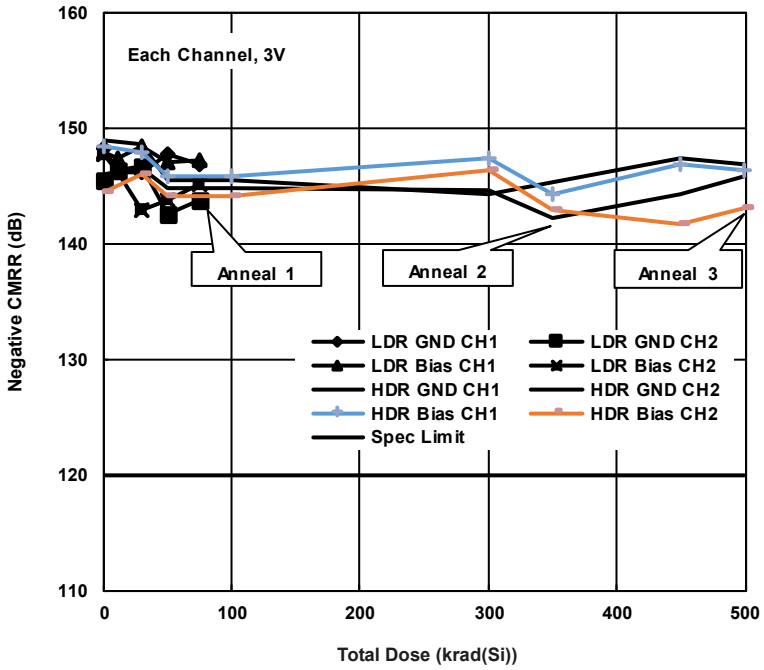

Figure 31. ISL70219ASEH negative Common-Mode Rejection Ratio (CMRR), Channels 1 and 2, ±3.0V supplies, as a function of total dose irradiation at low and high dose rate for the biased and unbiased cases. The dose rate was 0.01rad(Si)/s for low dose rate irradiation and 60rad(Si)/s for high dose rate irradiation. Sample size for the LDR cells was 16 and sample size for the HDR cells was 12. Anneals were performed after 50krad(Si) at low dose rate and after 300krad(Si) and 450krad(Si) at high dose rate. See "Attributes Data" on page 2. The post-irradiation SMD limit is 120dB minimum.

4. Discussion and Conclusion

This document describes the results of low and high dose rate testing of the ISL70219ASEH dual operational amplifier. Parts were tested at low and high dose rate under biased (see Figure 1) and unbiased (grounded) conditions per MIL-STD-883 Test Method 1019.7, at 0.01rad(Si)/s and 50rad(Si)/s respectively. The low dose rate test was run to 50krad(Si); the high dose rate test was run to 450krad(Si), representing a 1.5 times 'overtest' of its 300krad(Si) rating. High temperature biased anneals were performed after 50krad(Si) at low dose rate and after 300krad(Si) and 450krad(Si) at high dose rate.

All samples met the SMD post-radiation specifications at all downpoints. No differences in total dose response 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. We did note dose rate sensitivity in the input bias current (Figures 3, 4, 22, and 23), and the part must hence be considered dose rate sensitive. The ISL70219ASEH is acceptance tested on a wafer-by-wafer basis to 300krad(Si) at high dose rate (50rad(Si)/s-300rad(Si)/s) and to 50krad(Si) at low dose rate (0.01rad(Si)/s, providing hardness assurance at both dose rates. Table 1 on page 3 summarizes the results, and we will discuss these for each parameter.

The input offset voltage at ±18V (Figure 2) was stable over both dose rates and showed little anneal response after the three anneals, while still remaining well within the post-radiation SMD limits of -110µV to 110µV.

The positive and negative input bias currents at ±18V (Figures 3 and 4) were stable over high dose rate irradiation but showed a substantial increase over low dose rate. The parameters remained within the post-irradiation specification limits but the part is considered low dose rate sensitive based on the 'delta parameter' diagnostic algorithm outlined in MIL-STD-883 test method 1019. The post low dose rate anneal response was negative, that is, back to the near-zero

pre-irradiation values, while the post high dose rate anneal response was positive, indicating further degradation. The post-anneal values remained within the SMD post-radiation limits.

The input offset current at ±18V (Figure 5) was very stable over low and high dose rate irradiation and showed little anneal response and no dose rate sensitivity. This is in contrast with the input bias current results and may be interpreted as the absolute value of gain (beta) of the input pair transistors being dose rate sensitive while the beta *match* is not.

The positive open-loop gain at ±18V (Figure 6) was stable at all downpoints. The negative open-loop gain (Figure 7) showed considerable variation including anneal responses in the direction of *higher* gain. The parameters remained well above the 129.5dB SMD limit at all downpoints, and the results may well be indicative of testing issues for this parameter and not of any effects of ^{60}Co irradiation.

The positive and negative power supply rejection ratio at ±18V (Figures 8 and 9) and common-mode rejection ratio at ±18V (Figures 10 and 11) were stable at both dose rates and over anneals and remained well within the SMD limits.

The sourcing and sinking output short-circuit currents at ±18V (Figures 12 and 13) were stable at both dose rates and over all three anneals. These two parameters are not specified in the SMD, and we used the data sheet ‘typical’ specifications of 10.8mA and -19.0mA, respectively.

The positive and negative supply currents at ±18V (Figure 14) were very stable at both dose rates and remained well within the SMD limits. Figure 14 plots the *sum* of both channels.

The high and low output voltages at ±18V (Figures 15 and 16) were very stable at both dose rates and after all three anneals and remained well within the SMD limits.

The positive and negative slew rates at ±18V (Figures 17 and 18) were very stable at both dose rates and after all three anneals and remained well within the SMD limits.

The rise time at ±18V (Figure 19) was very stable at both dose rates and over anneals and remained well within the SMD limits. The fall time at ±18V (Figure 20) showed considerable variation over low dose rate and significant responses to the three anneals. In all cases the values of this parameter were well inside the SMD post-irradiation limit of 700ns.

The input offset voltage at ±5V (Figure 21) was stable over both dose rates and showed little anneal response after the three anneals, while still remaining well within the post-radiation SMD limits of -110µV to 110µV.

The positive and negative input bias currents at ±5V (Figures 22 and 23) were stable over high dose rate irradiation but showed a substantial increase over low dose rate. The parameters remained well within the post-irradiation specification limits but the part is considered low dose rate sensitive based on the ‘delta parameter’ diagnostic algorithm outlined in MIL-STD-883 test method 1019. The post low dose rate anneal response was negative, that is, back to the near-zero pre-irradiation values, while the post high dose rate anneal showed very little response. The post-anneal values remained within the SMD post-radiation limits for all three anneals.

The input offset current at ±5V (Figure 24) was very stable over low and high dose rate irradiation and showed little anneal response.

The positive and negative supply currents at ±5V (Figure 25) were very stable at both dose rates and remained well within the SMD limits. The figure plots the sum of both channels.

The positive open-loop gain at ±18V (Figure 26) was stable at all downpoints but showed some reduction from 300krad(Si) to 450krad(Si) while staying well within the SMD limits. The negative open-loop gain (Figure 27) showed considerable variation including anneal responses in the direction of *higher* gain, as also encountered for the ±18V data. The parameters remained well above the 129.5dB SMD limit at all downpoints, and the results may be indicative of testing issues as discussed earlier.

The positive and negative power supply rejection ratio at ±2.75V (Figures 28 and 29) and common-mode rejection ratio at ±2.75V (Figures 30 and 31) were stable at both dose rates and over anneals and remained well within the SMD limits.

We conclude that the ISL70219ASEH shows good performance over low and high dose rate irradiation and subsequent anneals, with data taken at several supply voltages. No major differences in total dose response were noted between

biased and grounded irradiation for any parameters. Additionally, no channel-to-channel differences were noted, either in the pre-irradiation data or in the total dose response of the parts. We did note clear low dose rate sensitivity in the input bias current results, and the part is considered dose rate sensitive as a result. The ISL70219ASEH is acceptance tested at high and low dose rate on a wafer-by-wafer basis to 300krad(Si) and to 50krad(Si), respectively, providing hardness assurance at both dose rates.

5. Appendix

Table 2. Monitored Parameters and Their Post-Irradiation Limits

Figure	Parameter	Limit, Low	Limit, High	Units	Supplies	Notes
Figure 2	Input Offset Voltage	-110	+110	µV	±18V	Channels 1 and 2
Figure 3	Positive Input Bias Current	-15	+15	nA	±18V	Channels 1 and 2
Figure 4	Negative Input Bias Current	-15	+15	nA	±18V	Channels 1 and 2
Figure 5	Input Offset Current	-10	+10	nA	±18V	Channels 1 and 2
Figure 6	Positive Open-Loop Gain	129.5	-	dB	±18V	Channels 1 and 2
Figure 7	Negative Open-Loop Gain	129.5	-	dB	±18V	Channels 1 and 2
Figure 8	Positive Power Supply Rejection Ratio	120	-	dB	±18V	Channels 1 and 2
Figure 9	Negative Power Supply Rejection Ratio	120	-	dB	±18V	Channels 1 and 2
Figure 10	Positive Common-Mode Rejection Ratio	120	-	dB	±18V	Channels 1 and 2
Figure 11	Positive Common-Mode Rejection Ratio	120	-	dB	±18V	Channels 1 and 2
Figure 12	Output Short-Circuit Current, Sourcing	10.8 typical	-	mA	±18V	Channels 1 and 2
Figure 13	Output Short-Circuit Current, Sinking	-19.0 typical	-	mA	±18V	Channels 1 and 2
Figure 14	Positive and Negative Supply Current	-1.7	1.7	mA	±18V	Sum of both channels
Figure 15	Output High Voltage	16	18	V	±18V	Channels 1 and 2
Figure 16	Output Low Voltage	-18	-16	V	±18V	Channels 1 and 2
Figure 17	Positive Slew Rate	0.2	-	V/µs	±18V	Channels 1 and 2
Figure 18	Negative Slew Rate	0.2	-	V/µs	±18V	Channels 1 and 2
Figure 19	Rise Time	-	625	ns	±18V	Channels 1 and 2
Figure 20	Fall Time	-	700	ns	±18V	Channels 1 and 2
Figure 21	Input Offset Voltage	-250	250	µV	±5V	Channels 1 and 2
Figure 22	Positive Bias Current	-15	15	nA	±5V	Channels 1 and 2
Figure 23	Negative Bias Current	-15	15	nA	±5V	Channels 1 and 2
Figure 24	Input Offset Current	-10	10	nA	±5V	Channels 1 and 2
Figure 25	Positive and Negative Supply Current	-1.6	1.6	mA	±5V	Sum of both channels
Figure 26	Positive Open-Loop Gain	129.5	-	dB	±5V	Channels 1 and 2
Figure 27	Negative Open-Loop Gain	129.5	-	dB	±5V	Channels 1 and 2
Figure 28	Positive Power Supply Rejection Ratio	120	-	dB	±5V	Channels 1 and 2
Figure 29	Negative Power Supply Rejection Ratio	120	-	dB	±5V	Channels 1 and 2
Figure 30	Positive Common-Mode Rejection Ratio	120	-	dB	±5V	Channels 1 and 2
Figure 31	Negative Common-Mode Rejection Ratio	120	-	dB	±5V	Channels 1 and 2

6. Revision History

Date	Rev.	Description
May 23, 2018	0.00	Initial release.

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