ISL7119EH

Total Dose Testing

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Introduction

This report summarizes the results of a low and high dose rate total dose test of the ISL7119EH dual voltage comparator. The test was conducted in order to determine the sensitivity of the part to the total dose environment and to low dose rate irradiation in particular.

The base ISL7119 is available in two versions. The ISL7119RH is acceptance tested on a wafer by wafer basis at high dose rate (50–300rad(Si)/s) to a total dose of 300krad(Si). The ISL7119EH is acceptance tested on a wafer by wafer basis at low dose rate (<0.01rad(Si)/s) to a total dose of 50krad(Si) and at high dose rate (50–300rad(Si)/s) to a total dose of 300krad(Si). Both parts use the same die and package and differ only in their total dose acceptance testing.

Reference Documents

- MIL-STD-883G test method 1019.7
- MIL-PRF-38535 (QML)
- ISL7119EH data sheet
- DLA Standard Microcircuit Drawing (SMD) 5962-07215

Part Description

The ISL7119RH and ISL7119EH are dual radiation hardened high speed voltage comparators fabricated on a single monolithic chip. The part is designed to operate over a wide dual supply voltage range as well as a single 5V logic supply and ground. The open collector output stage facilitates interfacing with a variety of logic devices and has the added ability to drive loads at output currents up to 25mA. The ISL7119RH and ISL7119EH are fabricated on the Intersil dielectrically isolated Radiation Hardened Silicon Gate (RSG) process, which provides immunity to single event latchup (SEL) and highly reliable performance in the natural space environment. Specifications for radiation hardened MIL-PRF-38535 (QML) devices are controlled by the Defense Logistics Agency Land and Maritime (DLA). Detailed electrical specifications for the ISL7119RH and ISL7119EH are contained in SMD 5962-07215, which must be quoted when ordering. A listing of key specifications follows.

- Electrically screened to DLA SMD 5962-07215
- QML qualified per MIL-PRF-38535 requirements
- Radiation environment
  - Maximum high dose rate total dose . . . . . 300krad(Si)
  - Latch-up free under any conditions
- Input offset voltage (V_{IO}). . . . . 8mV (max)
- Input bias current (I_{BIAS}). . . . . 1000nA (max)
- Input offset current (I_{IO}) . . . . . 150nA (max)
- Saturation voltage @ I_{SINK} = 3.2mA (V_{SAT}) . . . . 0.65V (max)
- Saturation voltage @ I_{SINK} = 25mA (V_{SAT}). . . . . 1.8V (max)
- Response time (t_{PD}) . . . . . .160ns (max)
- ICC (both channels) . . . . . 12mA (max)
- IEE (both channels) . . . . . 5mA (max)

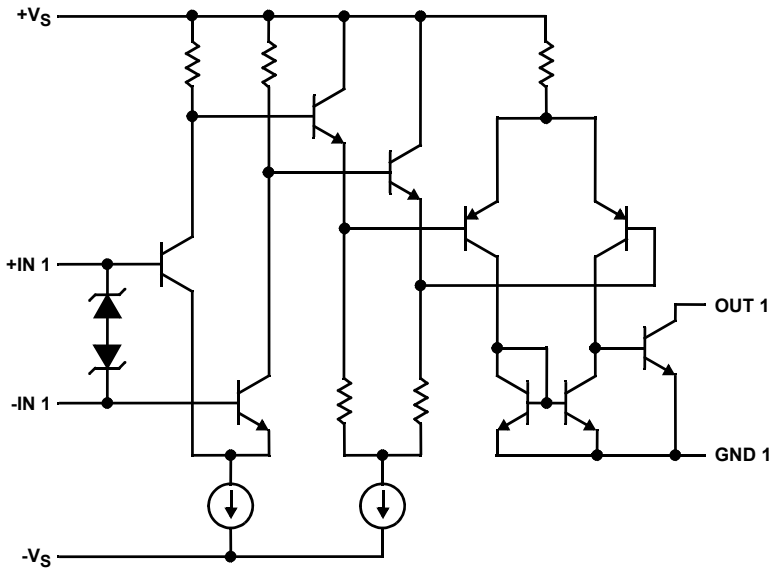

FIGURE 1. ISL7119EH SCHEMATIC DIAGRAM (ONE CHANNEL)

The ISL7119EH is implemented in Intersil's dielectrically isolated radiation hardened silicon gate BiCMOS technology (RSG). Active devices include 30V CMOS and complementary bipolar transistors. The process in production is under MIL PRF 38535 certification and is used for a range of space qualified products. Figure 1 shows a simplified schematic diagram of one channel of the device.

Test Description

Irradiation Facilities

Low dose rate testing was done at Intersil's low dose rate irradiation facility located in Palm Bay, FL. This facility was built expressly for supporting production (LDR assurance testing) of Intersil products. A description of the Intersil LDR facility can be found on the Intersil web site. The facility uses a ^{60}Co source and maintains a 10mrad(Si)/s flux by device positioning relative to the source. Devices are packaged in PbAl boxes to shield them against low energy secondary gamma radiation, as required by MIL STD 883. High dose rate testing was performed using a Gammacell 220 ^{60}Co irradiator located in the Palm Bay, Florida Intersil facility. The high dose rate irradiations were done at 55 rad(Si)/s per MIL-STD-883 Method 1019.7.

Test Fixturing

Figure 2 shows the configuration used for biased irradiation in conformance with Standard Microcircuit Drawing (SMD) 5962-07215. This configuration was used for both low and high dose rate biased irradiation. The unbiased low dose rate irradiation was carried out with all pins grounded.

Characterization Equipment and Procedures

All electrical testing was performed outside the irradiator using the production automated test equipment (ATE) with datalogging of all parameters at each downpoint. All electrical testing was performed at room temperature.

Experimental Matrix

The experimental matrix consisted of three cells: ten samples irradiated at low dose rate with all pins grounded, ten samples irradiated at low dose rate under bias and twenty samples irradiated at high dose rate under bias. All data was obtained from routine wafer acceptance testing, which is performed on a wafer by wafer basis at low and high dose rate for the –EH part, and the sample sizes were representative of five production wafers of the ISL7119EH.

Samples of the ISL7119EH were drawn from production run DMJ8HEH, mask series 53584B01, and were packaged in the standard hermetic 10-pin ceramic flatpack (CFP) production package, code KCB. The date code was X1113ABBC. Samples were processed through the standard burn-in cycle before irradiation and were screened to the SMD 5962-07215 limits at room, low and high temperature before the test. No post-irradiation anneals were performed.

Down Points

Downpoints were zero and 300krad(Si) for the high dose rate test and zero, 50, 100 and 150krad(Si) for the low dose rate test.

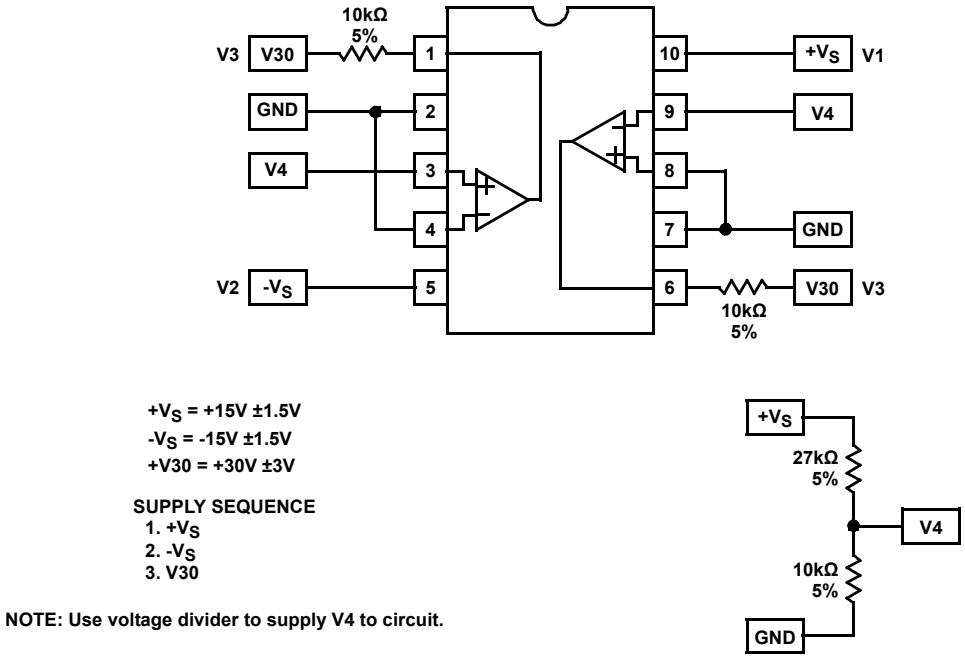

FIGURE 2. IRRADIATION BIAS CONFIGURATION FOR THE ISL7119EH PER STANDARD MICROCIRCUIT DRAWING (SMD) 5962-07215, AS USED FOR BOTH LOW AND HIGH DOSE RATE IRRADIATION REPORTED IN THIS DOCUMENT

Results

Test Results

The low and high dose rate tests of the ISL7119EH are complete and showed no reject devices after irradiation to 150krad(Si) at low dose rate and 300krad(Si) at high dose rate, screening to the SMD post-irradiation limits.

Variable Data

The plots in Figures 3 through 16 show data at all downpoints. The plots show the median of key parameters as a function of total dose for each of the three irradiation conditions. We chose to plot the median (as opposed to for example mean and standard deviation) because of the relatively small sample sizes involved. All parts showed good stability over irradiation, with no observed low dose rate sensitivity. Table 1, below, summarizes the key parameters plotted in Figures 3 through 16. Most of the plots explore possible channel sensitivity by showing data for both channels on the same set of axes. No systemic channel sensitivity was noted.

TABLE 1. SMD PARAMETERS, LIMITS AND FIGURE NUMBER

SMD ELECTRICAL PARAMETER	SYMBOL	PRE/POST RADIATION LIMITS +25°C			FIGURE NUMBER
		MIN	MAX	UNIT	
Positive Supply Current	I_{CC}		12	mA	3
Negative Supply Current	I_{EE}		-5	mA	4
Output Saturation Voltage	V_{SAT}		0.65	V	5
Output Leakage Current	I_{CEX}		20	µA	6
Input Offset Voltage	V_{IO}		8	mV	7
Common Mode Rejection Ration	CMRR	74		dB	8
Positive Input Bias Current	I_{BIAS+}		1	µA	9
Negative Input Bias Current	I_{BIAS-}		1	µA	10
Input Offset Current	I_{IO}		150	nA	11
Open Loop Voltage Gain	A_{VOL}	74		dB	12
Response Time, Low to High (30V Supply)	t_{PLH}		185	ns	13
Response Time, High to Low (30V Supply)	t_{PHL}		185	ns	14
Response Time, Low to High (5V Supply)	t_{PLH}		160	ns	15
Response Time, High to Low (5V Supply)	t_{PHL}		160	ns	16

Parameter Results

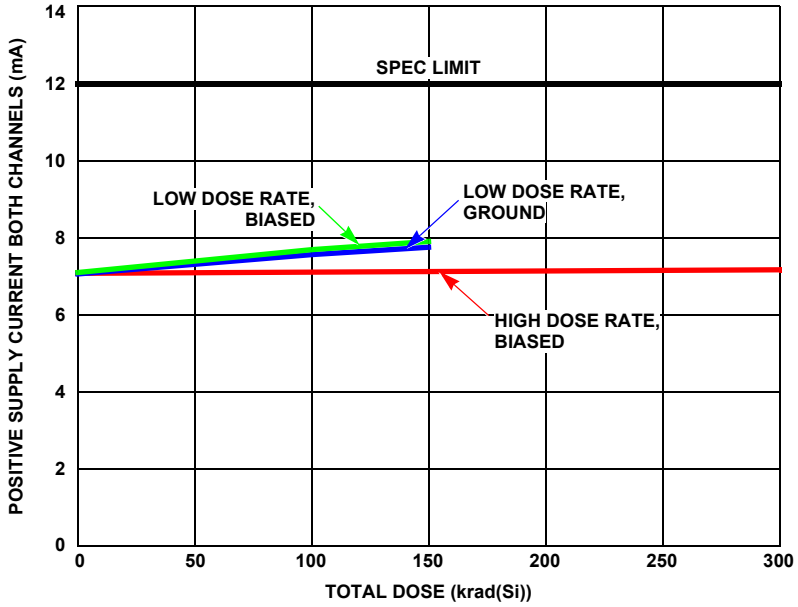

FIGURE 3. ISL7119EH positive power supply current, both channels, ±15V supply, as a function of total dose irradiation at low (biased and grounded) and high (biased only) dose rate. The low dose rate was 0.01rad(Si)/s and the high dose rate was 55rad(Si)/s. Sample size for the high dose rate cell was 20; sample size for the biased and unbiased low dose rate cells was 10. The SMD limit for this parameter is 12.0mA maximum post-irradiation.

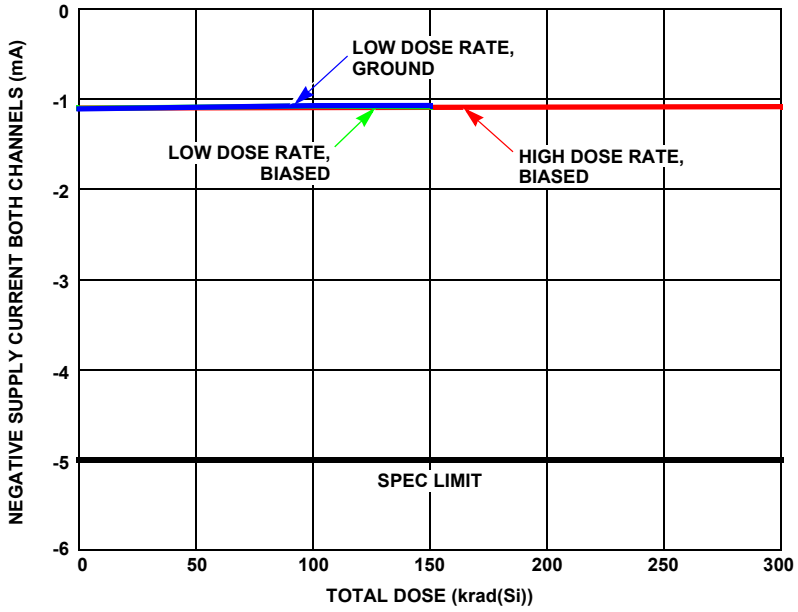

FIGURE 4. ISL7119EH negative power supply current, both channels, ±15V supply, as a function of total dose irradiation at low (biased and grounded) and high (biased only) dose rate. The low dose rate was 0.01rad(Si)/s and the high dose rate was 55rad(Si)/s. Sample size for the high dose rate cell was 20; sample size for the biased and unbiased low dose rate cells was 10. The SMD limit for this parameter is -5.0mA maximum post-irradiation.

Parameter Results (Continued)

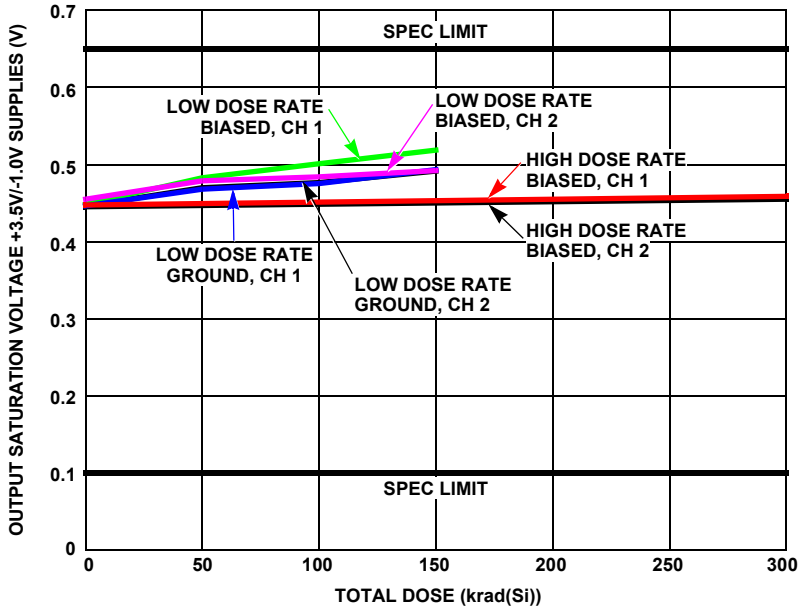

FIGURE 5. ISL7119EH output saturation voltage, +3.5V and -1.0V supplies, channels 1 and 2, as a function of total dose irradiation at low (biased and grounded) and high (biased only) dose rate. The low dose rate was 0.01rad(Si)/s and the high dose rate was 55rad(Si)/s. Sample size for the high dose rate cell was 20; sample size for the biased and unbiased low dose rate cells was 10. The SMD limit for this parameter is 0.65V maximum post-irradiation.

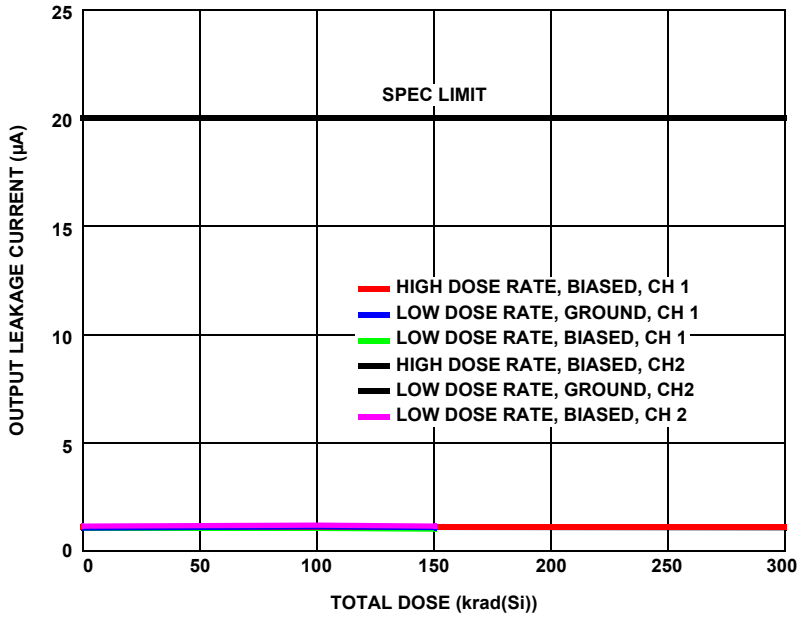

FIGURE 6. ISL7119EH output leakage current, channels 1 and 2, as a function of total dose irradiation at low and high dose rate. The low dose rate was 0.01rad(Si)/s and the high dose rate was 55rad(Si)/s. Sample size for the high dose rate cell was 20; sample size for the biased and unbiased low dose rate cells was 10. The SMD limit for this parameter is 20.0µA post-irradiation.

Parameter Results (Continued)

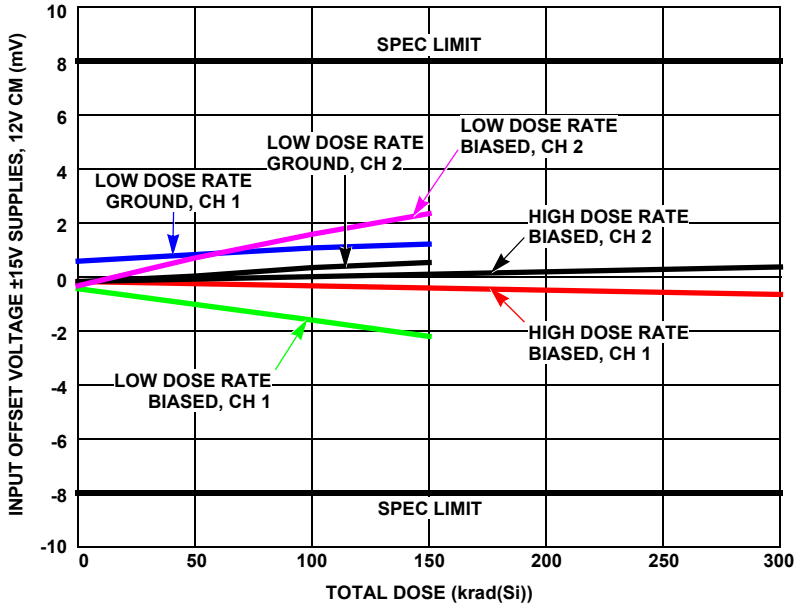

FIGURE 7. ISL7119EH input offset voltage at 12V common mode voltage and 30V supply, channels 1 and 2, as a function of total dose irradiation at low and high dose rate. The low dose rate was 0.01rad(Si)/s and the high dose rate was 55rad(Si)/s. Sample size for the high dose rate cell was 20; sample size for the biased and unbiased low dose rate cells was 10. The post-irradiation SMD limit for this parameter is +/- 8.0mV post-irradiation.

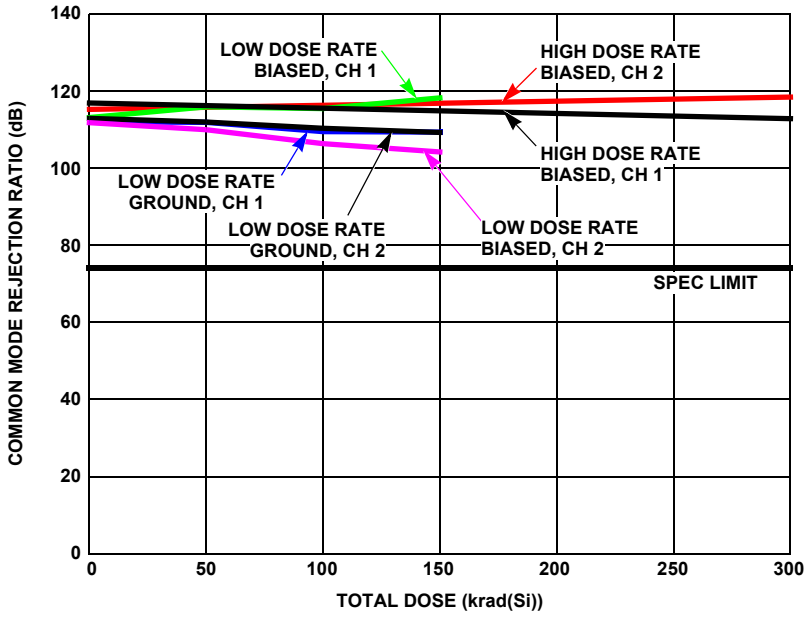

FIGURE 8. ISL7119EH common mode rejection ratio, channels 1 and 2, as a function of total dose irradiation at low and high dose rate. The low dose rate was 0.01rad(Si)/s and the high dose rate was 55rad(Si)/s. Sample size for the high dose rate cell was 20; sample size for the biased and unbiased low dose rate cells was 10. The post-irradiation SMD limit for this parameter is 74.0dB minimum.

Parameter Results (Continued)

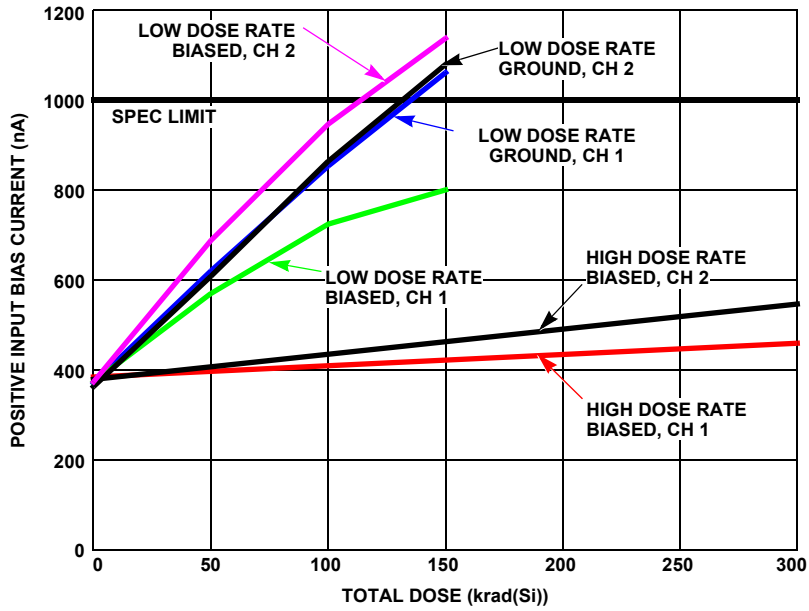

FIGURE 9. ISL7119EH positive input bias current, channels 1 and 2, as a function of total dose irradiation at low and high dose rate. The low dose rate was 0.01rad(Si)/s and the high dose rate was 55rad(Si)/s. Sample size for the high dose rate cell was 20; sample size for the biased and unbiased low dose rate cells was 10. The post-irradiation SMD limit for this parameter is 1000.0nA maximum.

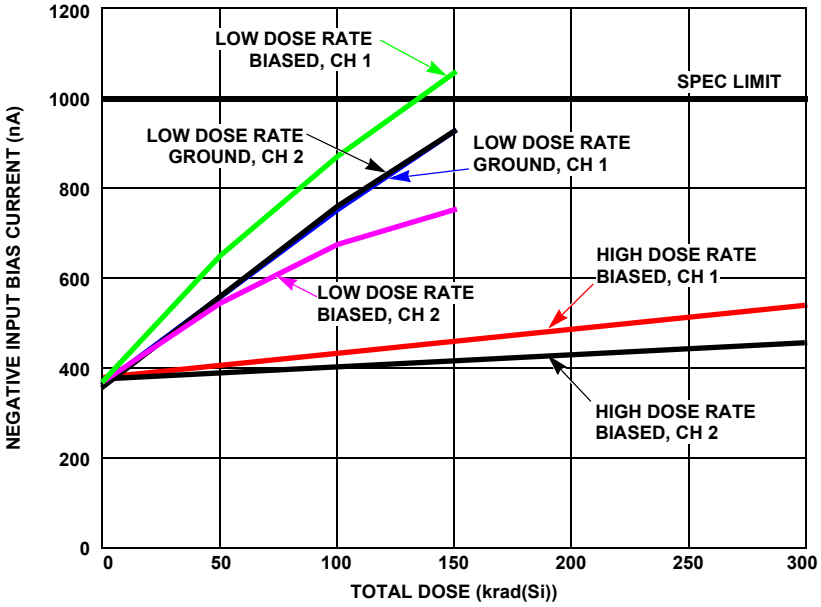

FIGURE 10. ISL7119EH negative input bias current, channels 1 and 2, as a function of total dose irradiation at low and high dose rate. The low dose rate was 0.01rad(Si)/s and the high dose rate was 55rad(Si)/s. Sample size for the high dose rate cell was 20; sample size for the biased and unbiased low dose rate cells was 10. The post-irradiation SMD limit for this parameter is 1000.0nA maximum.

Parameter Results (Continued)

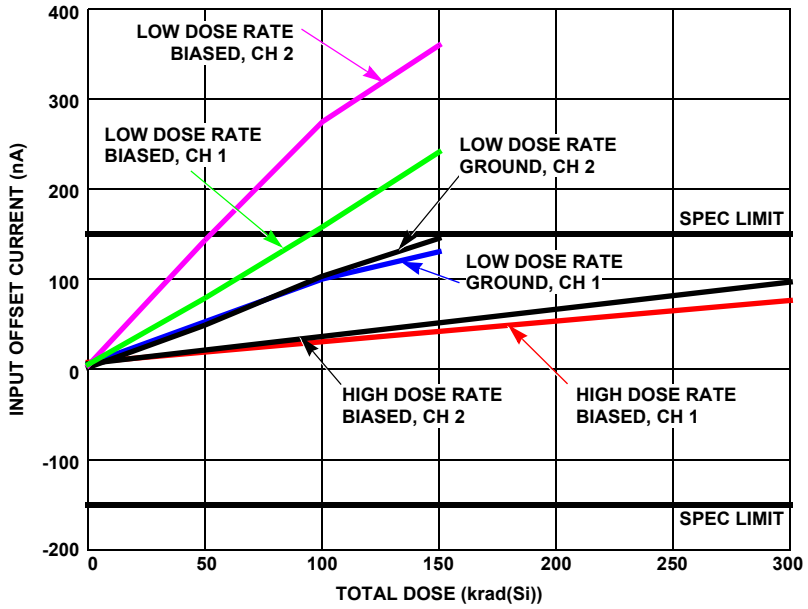

FIGURE 11. ISL7119EH input offset current, channels 1 and 2, as a function of total dose irradiation at low and high dose rate. The low dose rate was 0.01rad(Si)/s and the high dose rate was 55rad(Si)/s. Sample size for the high dose rate cell was 20; sample size for the biased and unbiased low dose rate cells was 10. The post-irradiation SMD limits for this parameter are -150.0nA to 150.0nA.

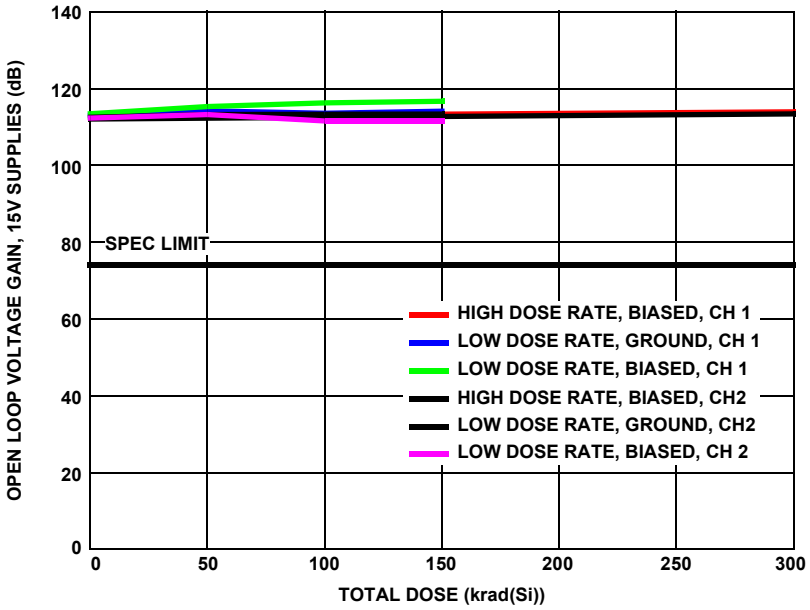

FIGURE 12. ISL7119EH open loop voltage gain, channels 1 and 2, as a function of total dose irradiation at low and high dose rate. The low dose rate was 0.01rad(Si)/s and the high dose rate was 55rad(Si)/s. Sample size for the high dose rate cell was 20; sample size for the biased and unbiased low dose rate cells was 10. The post-irradiation SMD limit for this parameter is 74.0dB minimum.

Parameter Results (Continued)

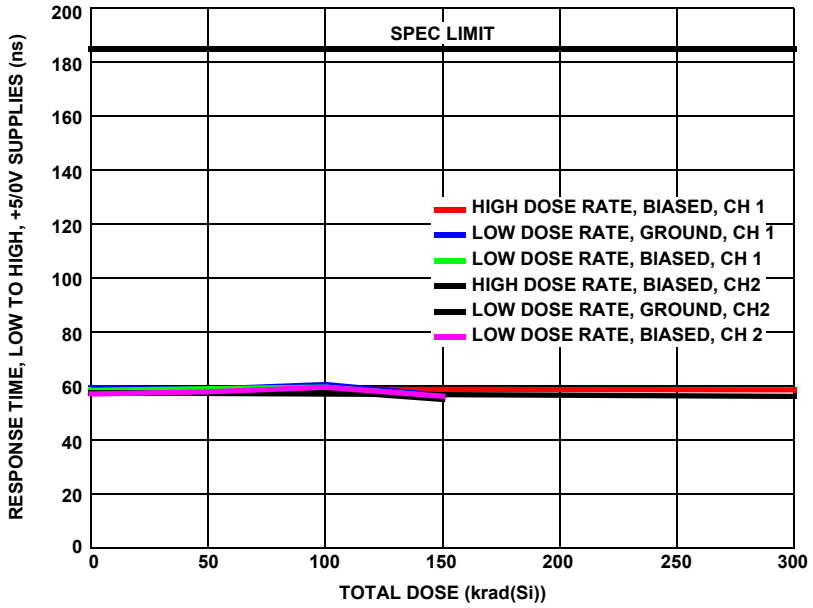

FIGURE 13. ISL7119EH response time, low to high at +5.0V/0V supplies, channels 1 and 2, as a function of total dose irradiation at low and high dose rate. The low dose rate was 0.01rad(Si)/s and the high dose rate was 55rad(Si)/s. Sample size for the high dose rate cell was 20; sample size for the biased and unbiased low dose rate cells was 10. The post-irradiation SMD limit for this parameter is 185.0ns maximum.

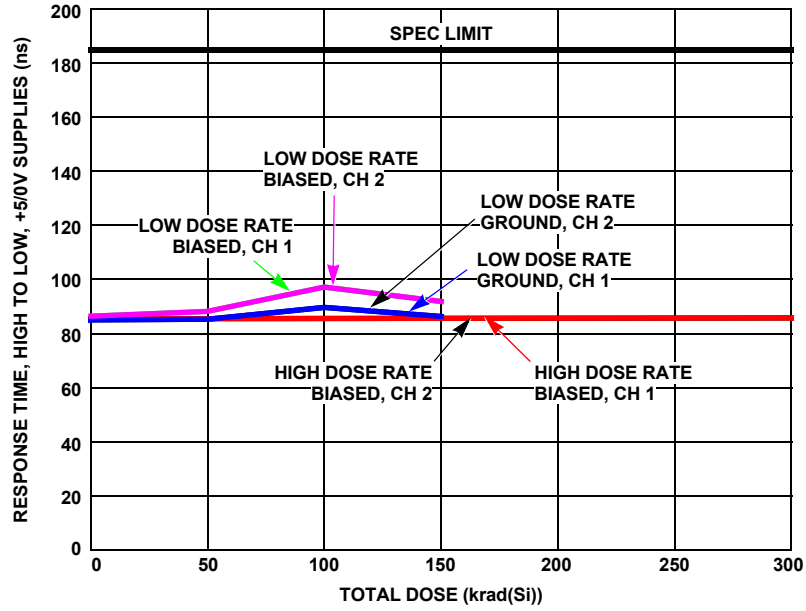

FIGURE 14. ISL7119EH response time, high to low at +5.0V/0V supplies, channels 1 and 2, as a function of total dose irradiation at low and high dose rate. The low dose rate was 0.01rad(Si)/s and the high dose rate was 55rad(Si)/s. Sample size for the high dose rate cell was 20; sample size for the biased and unbiased low dose rate cells was 10. The post-irradiation SMD limit for this parameter is 185.0ns maximum.

Parameter Results (Continued)

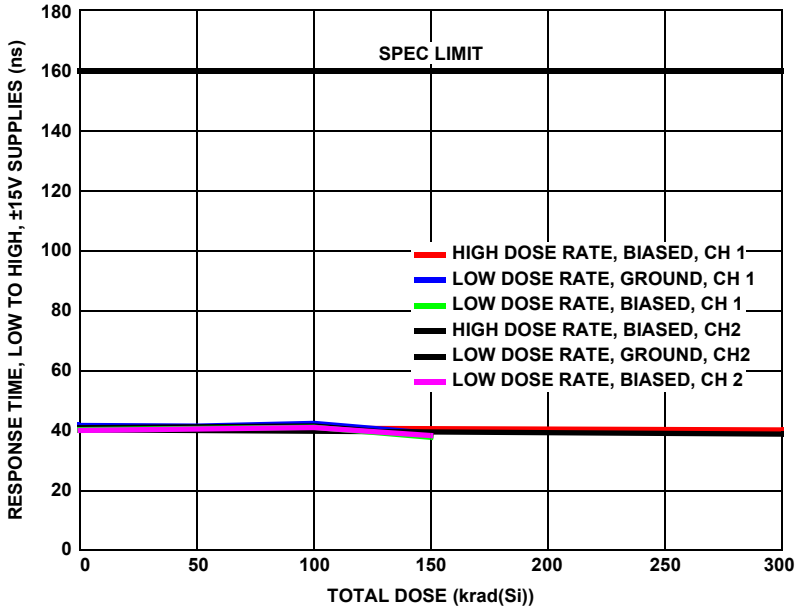

FIGURE 15. ISL7119EH response time, low to high at +15.0V/-15.0V supplies, channels 1 and 2, as a function of total dose irradiation at low and high dose rate. The low dose rate was 0.01rad(Si)/s and the high dose rate was 55rad(Si)/s. Sample size for the high dose rate cell was 20; sample size for the biased and unbiased low dose rate cells was 10. The post-irradiation SMD limit for this parameter is 160.0ns maximum.

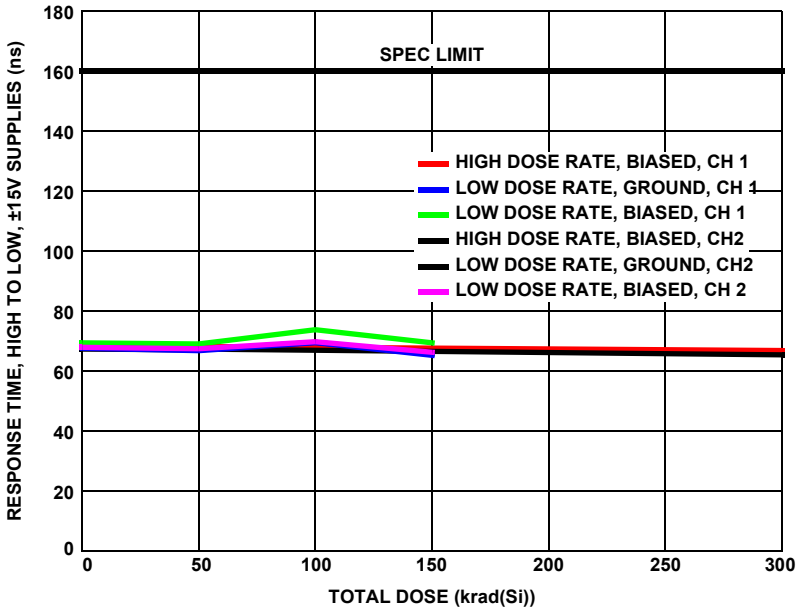

FIGURE 16. ISL7119EH response time, high to low at +15.0V/-15.0V supplies, channels 1 and 2, as a function of total dose irradiation at low and high dose rate. The low dose rate was 0.01rad(Si)/s and the high dose rate was 55rad(Si)/s. Sample size for the high dose rate cell was 20; sample size for the biased and unbiased low dose rate cells was 10. The post-irradiation SMD limit for this parameter is 160.0ns maximum.

Discussion

ATE characterization of the samples at all downpoints is plotted in Figures 3 through 16 and generally showed good stability over total dose irradiation.

Positive and negative power supply current (Figures 3 and 4) showed good stability, with some change in the positive supply current but with post-irradiation values well within the SMD limits. The output saturation voltage (Figure 5) also showed good stability and remained well within the SMD limits. The output leakage current (Figure 6) showed no significant change.

The input offset voltage (Figure 7) showed moderate change for low dose rate (biased) irradiation, but remained well within the SMD limits. The common mode rejection ratio (Figure 8) showed no significant change.

The part displayed low dose rate sensitivity in both the positive and negative input bias current (Figures 9 and 10) parameters. This response is consistent with gain degradation in the NPN input differential pair and has been previously reported in the literature. The input bias current increase was monotonic as a function of dose, with the grounded low dose irradiation worst-case as expected. The input bias current was still within the SMD specification of 1.0µA after 100krad(Si) at low dose rate but was out of specification after 150krad(Si). Accordingly, the part is considered low dose rate sensitive.

The input offset current (Figure 11) is linked to the input bias current and accordingly showed low dose rate sensitivity as well. It was still within the SMD specification of 150nA after 50krad(Si) at low dose rate but was out of specification after 100krad(Si).

The open-loop gain (Figure 12) and the low to high/high to low transition times (Figures 13 through 16) are large signal parameters and remained very stable at all downpoints.

The ISL7119EH is a dual comparator. Like most IC implementations of multiple channel devices, the individual layout design of each channel is very nearly identical, and great care is taken to eliminate channel to channel variations due to interconnect parasitics. Accordingly the data showed little variation between channels, as expected.

Conclusion

This document reports the results of a total dose test of the ISL7119EH dual voltage comparator. Samples were tested under biased and unbiased conditions to a maximum total dose of 150krad(Si) at high and low dose rate.

The part displayed low dose rate sensitivity in both the positive and negative input bias current (Figures 9 and 10) parameters and in the input offset current parameter (Figure 11). This response is consistent with gain degradation in the NPN input differential pair. Accordingly, the part is considered low dose rate sensitive. All samples passed the 1000nA and 150nA (respectively) SMD limits after 50krad(Si) at low dose rate, which is the standard low dose acceptance test used at Intersil and is also the SMD low dose rate specification for the part.

We did not observe any differences between the response to biased and unbiased irradiation, and the part is not considered bias sensitive. Similarly no channel sensitivity was noted.

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