ISL71590SEH

Total Dose Testing

AN1895
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Introduction

This report documents the results of low and high dose rate total dose testing and subsequent anneals of the ISL71590SEH radiation hardened temperature sensor. The tests were conducted to provide an assessment of the total dose hardness of the part, and to provide an estimate of dose rate sensitivity. Parts were irradiated under bias and with all pins grounded at low and high dose rate. The ISL71590SEH is acceptance tested on a wafer-by-wafer basis to 300krad(Si) at high dose rate (50–300rad(Si)/s) and to 50krad(Si) at low dose rate (0.01rad(Si)/s).

Downpoints for the low dose rate tests were 0, 10, 30, 50, 114, and 150krad(Si). Downpoints for the high dose rate tests were 0, 30, 50, 100, 300, and 450krad(Si). All irradiations and anneals are complete.

Key Features

- Minimal accuracy shift over total dose rate irradiation. . . . .-2.0K to +0.5K
- Linear output current 1.0µA/K
- Wide operating power supply range . . . . 4V to 31V
- Low power consumption . . . . .1.5mW at 5V supply
- Operating temperature range . . . . -55°C to +125°C
- SEL/SEB threshold LET. . . . . 86.4MeV•cm^2/mg
- Total dose tolerance, high dose rate. . . . . 300krad(Si)
- Total dose tolerance, low dose rate . . . . 50krad(Si)
- QML qualified per MIL-PRF-38535
- Produced in conformance with Standard Microcircuit Drawing (SMD) 5962-13215

Part Description

The ISL71590SEH is a radiation-hardened two-terminal temperature transducer. It has a high impedance current output that allows it to be insensitive to voltage drops across long lines. With a supply voltage of between 4V and 36V applied to the input pin, the device acts as a constant current generator with a scale factor of 1µA/K. The ISL71590SEH is specified across the -55°C to +125°C temperature range and can operate across the -55°C to +150°C temperature range without the need of additional circuitry.

With power requirements as low as 1.5mW (5V at +25°C), the part is an ideal choice for payload and booster temperature sensing as any well-insulated twisted pair cable can be used for proper operation. The ISL71590SEH can be used in a wide range of applications including temperature compensation networks, laser diode temperature compensation, sensor bias and linearization functions, and Proportional To Absolute Temperature (PTAT) biasing. The high output impedance (>10MΩ) leaves plenty of room for variations in the power supply voltage. The part is electrically durable as it can withstand an absolute maximum forward voltage of 40V outside of the heavy ion environment (with a 37V absolute maximum in-beam rating) and a reverse voltage of -40V. The ISL71590SEH is available in a 2 Ld hermetically sealed flatpack.

Related Literature

- For a full list of related documents, visit our website
  - ISL71590SEH product page
- MIL-STD-883 test method 1019

Test Description

Irradiation Facilities

High dose rate testing was performed at 69.7rad(Si)/s using a Gammacell 220 ^{60}Co irradiator located in the Palm Bay, Florida Intersil facility. Low dose rate testing was performed at 0.01rad(Si)/s using the Intersil Palm Bay Hopewell Designs N40 panoramic ^{60}Co irradiator. Annealing was performed under the Figure 1 bias configuration at +100°C for 168 hours using a small temperature chamber.

Test Fixturing

Figure 1 shows the configuration used for biased irradiation at both high and low dose rate.

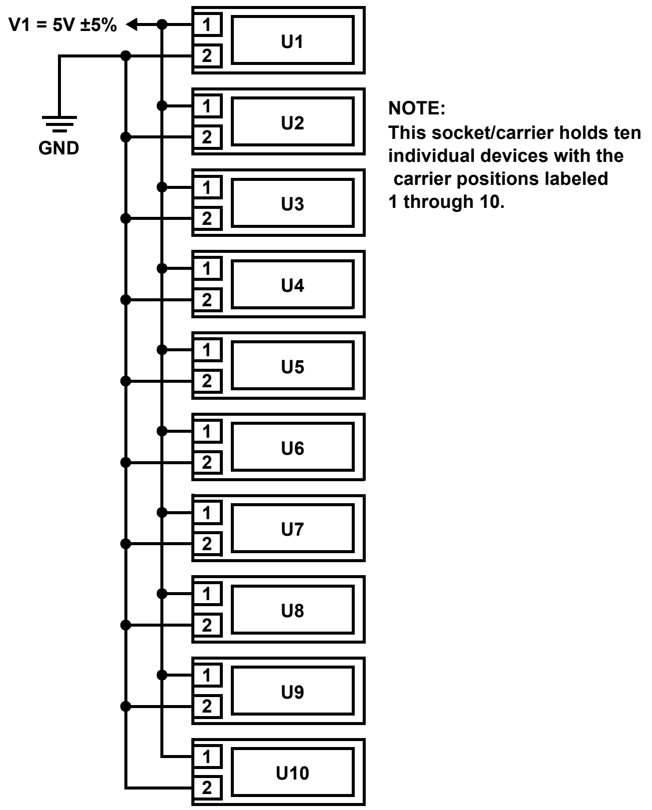

FIGURE 1. IRRADIATION BIAS CONFIGURATION FOR THE ISL71590SEH

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. Due to the precision nature of the part all electrical characterization is performed using production ATE and an advanced constant-temperature liquid bath facility.

Experimental Matrix

Total dose irradiation proceeded in accordance with the guidelines of MIL-STD-883 Test Method 1019.7. The experimental matrix consisted of five samples irradiated at low dose rate under bias, five samples irradiated at low dose rate with all pins grounded, five samples irradiated at high dose rate under bias, and five samples irradiated at high dose rate with all pins grounded.

Samples of the ISL71590SEH were drawn from preproduction wafer lot X0A8P and were packaged in the hermetic 2 Ld solder-sealed production flatpack (K2.A) package. Samples were processed through the standard burnin cycle before irradiation, as required by MIL-STD-883.

Downpoints

Downpoints for the low dose rate tests were 0, 10, 30, 50, 114, and 150krad(Si). Downpoints for the high dose rate tests were 0, 30, 50, 100, 300, and 450krad(Si). All irradiations were followed by a high temperature anneal at +100°C under bias.

Test Results

Attributes Data

TABLE 1. ISL71590SEH TOTAL DOSE TEST ATTRIBUTES DATA

PART	DOSE RATE Rad(Si)/s	BIAS	SAMPLE SIZE	DOWNPOINT	PASS (Note 1)	FAIL
ISL71590SEH	0.01	Figure 1	5	Pre-irradiation	5	-
				10krad(Si)	5	0
				30krad(Si)	5	0
				50krad(Si)	5	0
				114krad(Si)	3	2
				150krad(Si)	1	4
				Anneal	5	0
ISL71590SEH	0.01	Grounded	5	Pre-irradiation	5	-
				10krad(Si)	5	0
				30krad(Si)	5	0
				50krad(Si)	5	0
				114krad(Si)	3	2
				150krad(Si)	0	5
				Anneal	5	0
ISL71590SEH	69.7	Figure 1	5	Pre-irradiation	5	-
				30krad(Si)	5	0
				50krad(Si)	5	0
				100krad(Si)	5	0
				300krad(Si)	5	0
				450krad(Si)	5	0
				Anneal	5	0
ISL71590SEH	69.7	Grounded	5	Pre-irradiation	5	-
				30krad(Si)	5	0
				50krad(Si)	5	0
				100krad(Si)	5	0
				300krad(Si)	5	0
				450krad(Si)	5	0
				Anneal	5	0

NOTE:
1. 'Pass' indicates a sample that passes all post-irradiation SMD limits.

Variables Data

The plots in Figures 2 through 7 show data at all downpoints. We plotted the average, minimum, and maximum of the total dose response for each parameter at low and high dose rate. For clarity in interpreting the temperature error data, Figure 2 shows the combined low and high dose rate response, Figure 3 shows the low dose rate response only, and Figure 4 shows the high dose rate response only.

Variables Data Plots

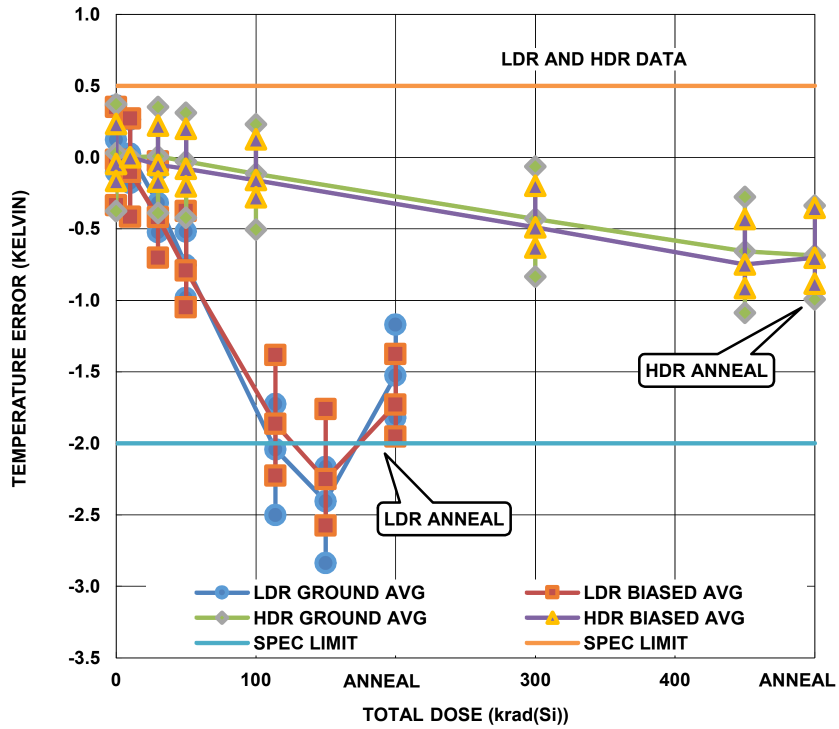

FIGURE 2. ISL71590SEH temperature error in Kelvin as a function of total dose irradiation at low and at high dose rate for the biased (per Figure 1) and unbiased (all pins grounded) cases, plotting the average, minimum, and maximum. The low dose rate was 0.01rad(Si)/s and the high dose rate was 69.7rad(Si)/s. The irradiations were followed by a +100°C 168-hour biased anneal; the LDR anneal was performed after 150krad(Si) at low dose rate, while the HDR anneal was performed after 450krad(Si) at high dose rate. The sample size for all cells was five. The post-irradiation SMD specification limits are -2.0K to +0.5K.

Variables Data Plots (Continued)

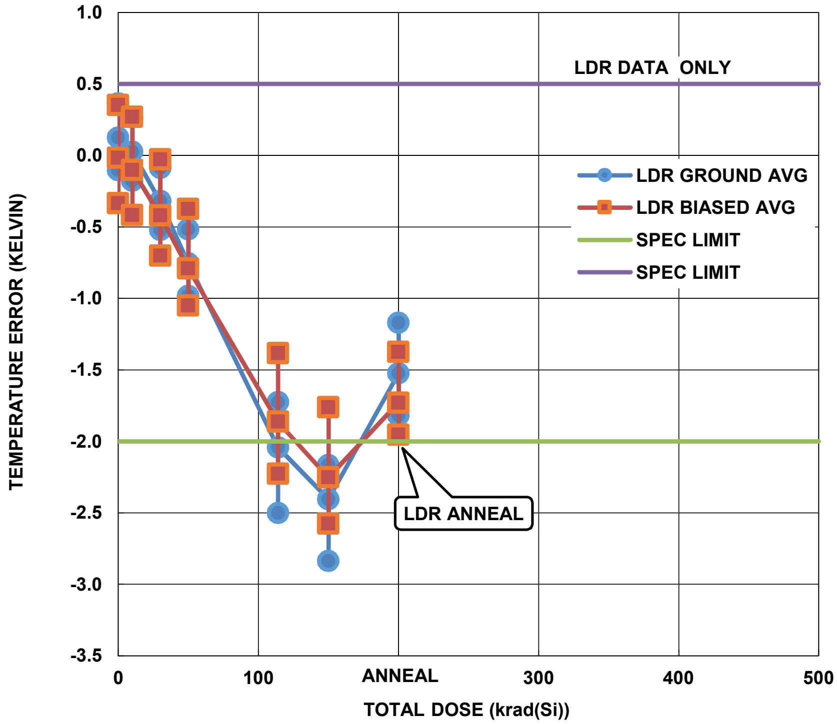

FIGURE 3. ISL71590SEH temperature error in Kelvin as a function of total dose irradiation at low dose rate for the biased (per Figure 1) and unbiased (all pins grounded) cases, plotting the average, minimum, and maximum. The dose rate was 0.01rad(Si)/s. The irradiations were followed by a +100°C 168-hour biased anneal; the LDR anneal was performed after 150krad(Si) at low dose rate. The sample size for all cells was five. The post-irradiation SMD specification limits are -2.0K to +0.5K.

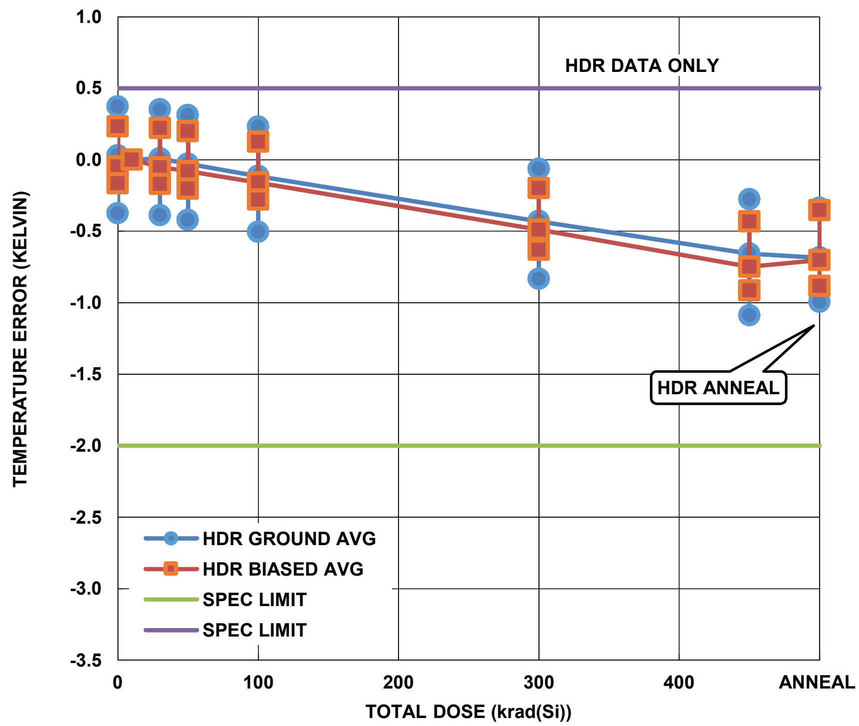

FIGURE 4. ISL71590SEH temperature error in Kelvin as a function of total dose irradiation at high dose rate for the biased (per Figure 1) and unbiased (all pins grounded) cases, plotting the average, minimum, and maximum. The dose rate was 69.7rad(Si)/s. The irradiations were followed by a +100°C 168-hour biased anneal; the HDR anneal was performed after 450krad(Si) at high dose rate. The sample size for all cells was five. The post-irradiation SMD specification limits are -2.0K to +0.5K.

Variables Data Plots (Continued)

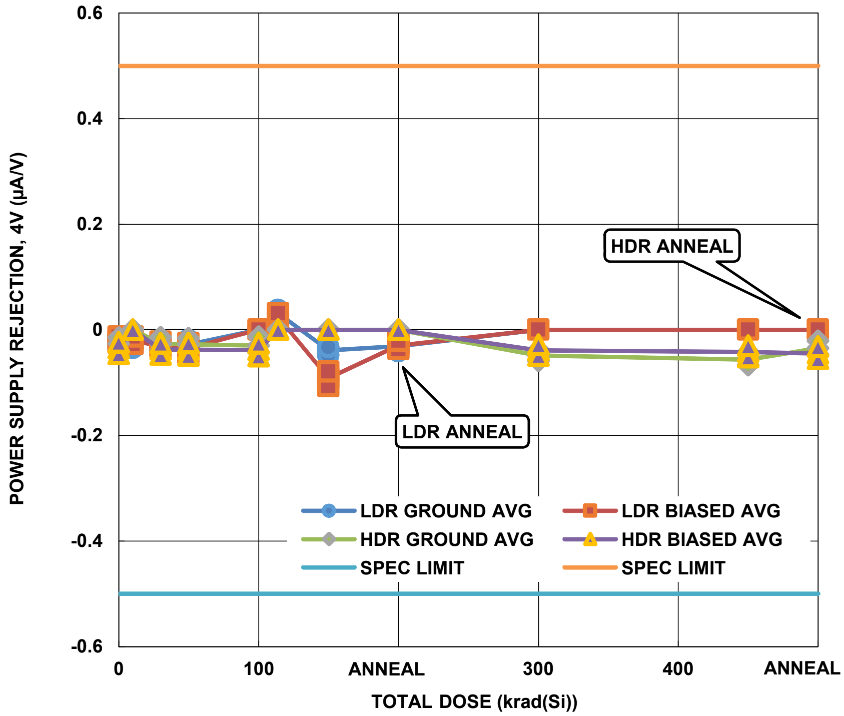

FIGURE 5. ISL71590SEH power supply rejection at 4V supply, in µA/V, as a function of total dose irradiation at low and at high dose rate for the biased (per Figure 1) and unbiased (all pins grounded) cases, plotting the average, minimum, and maximum. The low dose rate was 0.01rad(Si)/s and the high dose rate was 69.7rad(Si)/s. The irradiations were followed by a +100°C 168-hour biased anneal; the LDR anneal was performed after 150krad(Si) at low dose rate, while the HDR anneal was performed after 450krad(Si) at high dose rate. The sample size for all cells was five. The post-irradiation SMD specification limits are -0.5µA/V to +0.5µA/V.

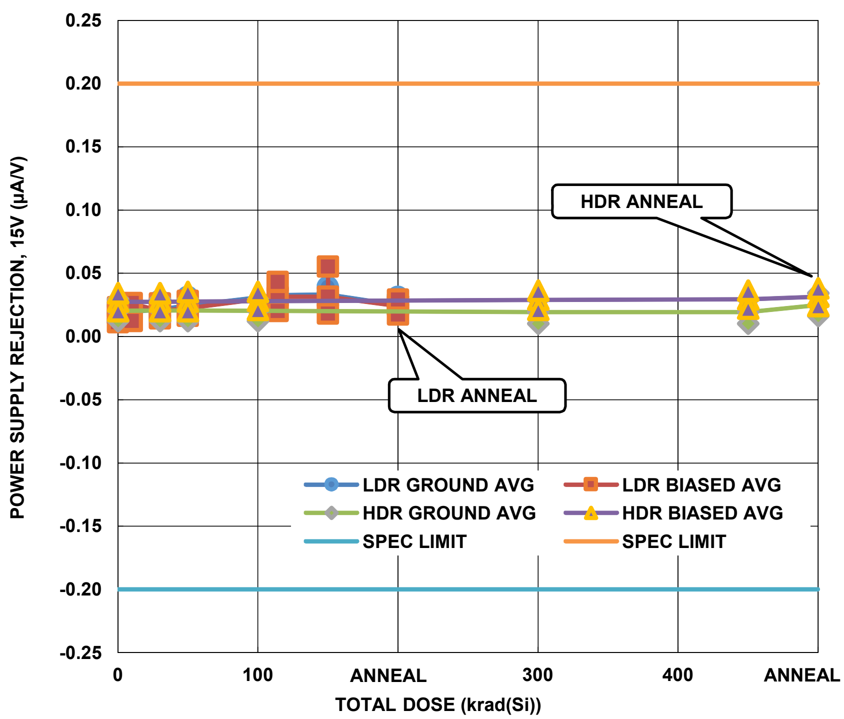

FIGURE 6. ISL71590SEH power supply rejection at 15V supply, in µA/V, as a function of total dose irradiation at low and at high dose rate for the biased (per Figure 1) and unbiased (all pins grounded) cases, plotting the average, minimum, and maximum. The low dose rate was 0.01rad(Si)/s and the high dose rate was 69.7rad(Si)/s. The irradiations were followed by a +100°C 168-hour biased anneal; the LDR anneal was performed after 150krad(Si) at low dose rate, while the HDR anneal was performed after 450krad(Si) at high dose rate. Sample size for all cells was five. The post-irradiation SMD specification limits are -0.2µA/V to +0.2µA/V.

Variables Data Plots (Continued)

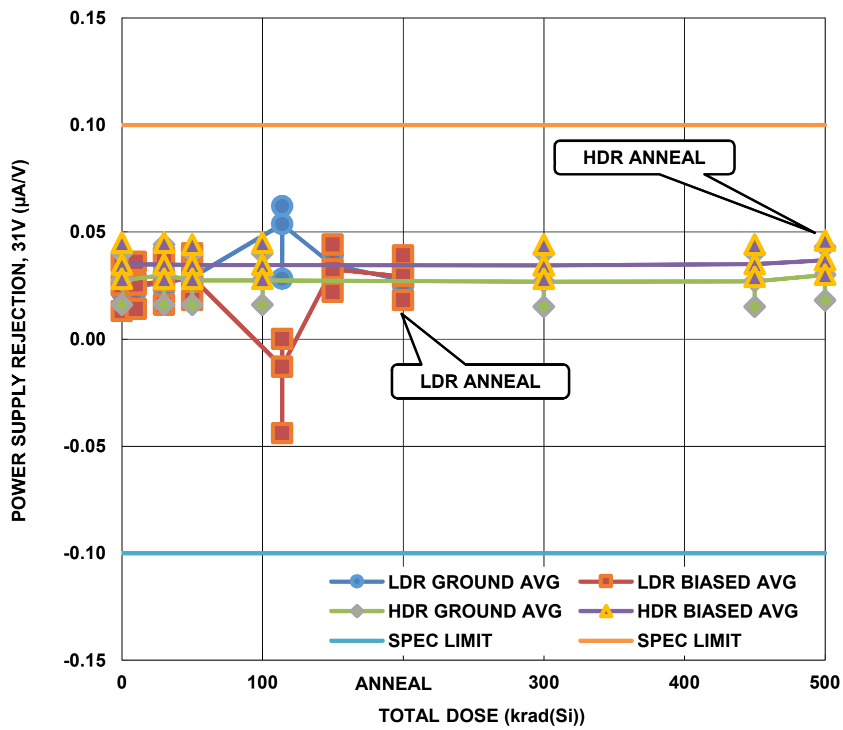

FIGURE 7. ISL71590SEH power supply rejection at 31V supply, in µA/V, as a function of total dose irradiation at low and at high dose rate for the biased (per Figure 1) and unbiased (all pins grounded) cases, plotting the average, minimum, and maximum. The low dose rate was 0.01rad(Si)/s and the high dose rate was 69.7rad(Si)/s. The irradiations were followed by a +100°C 168-hour biased anneal; the LDR anneal was performed after 150krad(Si) at low dose rate, while the HDR anneal was performed after 450krad(Si) at high dose rate. Sample size for all cells was five. The post-irradiation SMD specification limits are -0.1µA/V to +0.1µA/V.

Discussion and Conclusion

We report the results of a characterization low and high dose rate total dose test of the ISL71590SEH integrated temperature sensor. All irradiations were followed by a high temperature anneal at +100°C under bias. All electrical measurements were performed at room temperature and were performed before irradiation, after each irradiation step, and after each annealing period. This is a simple part with one key performance parameter, the temperature error, but that simplicity does not necessarily translate into easy electrical testing. Careful liquid-bath testing using Fluorocarbon fluid is required for repeatable and accurate data (and for adequate production testing as well, incidentally) and we used four control units at each test operation to insure repeatable data.

Figures 2 through 7 show the total dose and anneal response of the part's parameters. In Figure 2 we plot both the low and high dose rate response on the same set of axes, while Figures 3 and 4 show the low dose rate and high dose rate responses separately for clarity.

The temperature error showed a very gradual change over high dose rate irradiation (Figures 2 and 4) from the pre-irradiation value of near zero to -0.5K after 450krad(Si), with minimal anneal response. The low dose rate irradiation produced more pronounced shifts (Figures 2 and 3), with the samples within the -2.0K to +0.5K SMD limits after 50krad(Si), but with some out of specification on the negative side after the 114krad(Si) and 150krad(Si) downpoints. See attributes data in Table 1. We observed a strong anneal response back to approximately -1.5K, see Figures 2 and 3, resulting in all samples being within the -2.0K SMD limit after anneal. Interestingly, we observed no bias sensitivity at all for either dose rate. The power supply rejection is the only other measured parameter and was found to be stable at 4V, 15V, and 31V supply voltage, although the data for the 114krad(Si) low dose rate downpoint is suspect, especially for the 31V case; see Figure 7. The parameter remained well within the respective SMD limits at all downpoints.

We conclude that the temperature error remained within the -2.0K to +0.5K SMD post-irradiation specification limits after 50krad(Si) at low dose rate or 300krad(Si) at high dose rate, but the part must be considered low dose rate sensitive based on the 'delta parameter' diagnostic algorithm outlined in MIL-STD-883 test method 1019 or based simply on inspection of Figure 2. As noted before, the ISL71590SEH is acceptance tested on a wafer-by-wafer basis at both low and high dose rate. No differences in total dose response between biased and grounded irradiation were noted at either dose rate, and the part is hence not considered bias sensitive. Interestingly, high temperature biased annealing following low dose rate irradiation produced a strong anneal signature, while performing the same step on high dose rate samples produced no response at all.

Appendices

TABLE 2. REPORTED PARAMETERS AND THEIR POST-IRRADIATION LIMITS

FIGURE	PARAMETER	LIMIT, LOW	LIMIT, HIGH	UNITS	NOTES
2	Temperature error, high and low dose rate	-2.0	+0.5	K	
3	Temperature error, low dose rate	-2.0	+0.5	K	
4	Temperature error, high dose rate	-2.0	+0.5	K	
5	Power supply rejection ratio	-0.5	+0.5	µA/V	4V supply
6	Power supply rejection ratio	-0.2	+0.2	µA/V	15V supply
7	Power supply rejection ratio	-0.1	+0.1	µA/V	31V supply

Revision History

The revision history provided is for informational purposes only and is believed to be accurate, but not warranted. Please visit our website to make sure you have the latest revision.

DATE	REVISION	CHANGE
December 15, 2016	AN1895.2	Updated temperature error limits.
September 2, 2015	AN1895.1	Final report - all irradiations and anneals are complete.
November 1, 2013	AN1895.0	Initial report.

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