Neutron testing of the ISL71590SEH temperature sensor

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Revision 0

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1. Introduction

This report summarizes results of preliminary 1 MeV equivalent neutron testing of the ISL71590SEH temperature sensor. The test was conducted in order to determine the sensitivity of the part to the displacement damage ('DD') caused by the neutron environment. A single neutron fluence of 2×10^{12} n/cm^2 was used. This project was carried out in collaboration with Honeywell Aerospace (Clearwater, FL), and their support is gratefully acknowledged.

2: 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 over the -55°C to 125°C temperature range and can operate over 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-lead hermetically sealed flatpack. Key features of the part follow.

- Minimal accuracy shift over low dose rate irradiation	-1°C maximum
- Linear output current	1.0 μA/K maximum
- 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	86.4 MeV.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	

3: Test Description

3.1 Irradiation Facilities

Neutron irradiation was performed by the Honeywell team at the Fast Burst Reactor facility at White Sands Missile Range (White Sands, NM), which provides a controlled 1MeV equivalent neutron flux. Parts were tested in an unbiased configuration with all leads open. As neutron irradiation activates many of the elements found in a packaged integrated circuit, the samples required (as expected) some 'cooldown time' before being shipped back to Intersil (Palm Bay, FL) for electrical testing.

3.2 Characterization equipment and procedures

Electrical testing was performed before and after irradiation using the Intersil production automated test equipment (ATE). All electrical testing was performed at room temperature.

3.3 Experimental matrix

Testing proceeded in general accordance with the guidelines of MIL-STD-883 Test Method 1017. The experimental matrix consisted of five samples irradiated to 2 x 10^{12} n/cm^2. Three control units were used.

4: Results

4.1 Test results

Neutron testing of the ISL71590SEH is complete and the results are reported in the balance of this report.

4.2 Variables data

The plots in Figs. 1 through 4 show data plots for key parameters before and after irradiation to each level. The plots show the median, minimum and maximum of each parameter as a function of neutron irradiation. We show the post - total dose irradiation electrical limits taken from the SMD for reference only, as the ISL71590SEH is not formally specified for neutron irradiation.

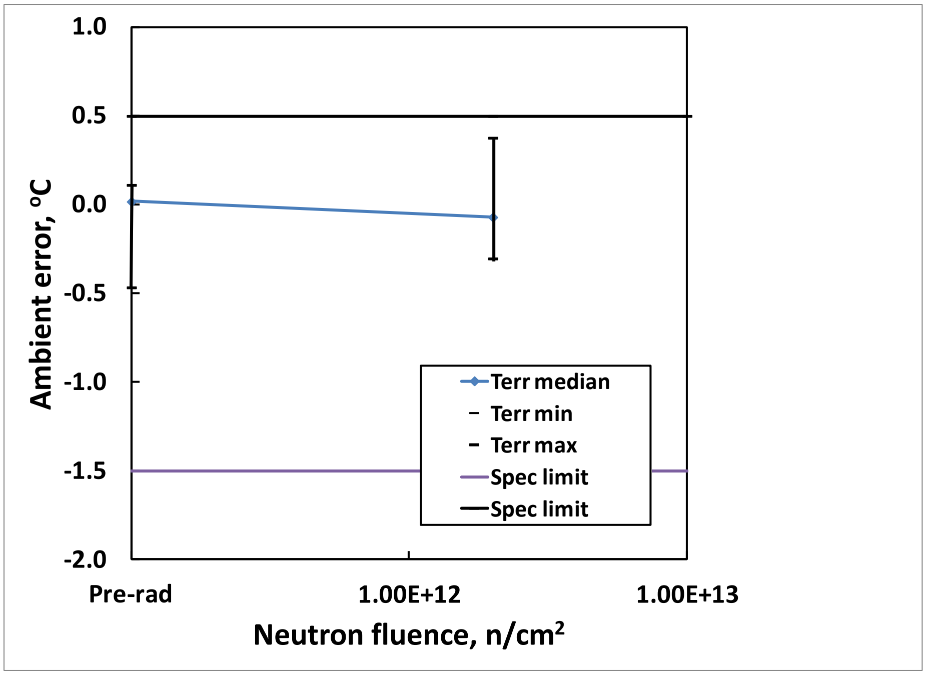

Fig. 1: ISL71590SEH temperature error as a function of neutron irradiation, showing the median, minimum and maximum of the populations at each level. The sample size was 5 and the neutron fluence was 2 x 10^{12} n/cm^2, with three control units. The post-total dose irradiation SMD limits are -1.5^{o}C to +0.5^{o}C.

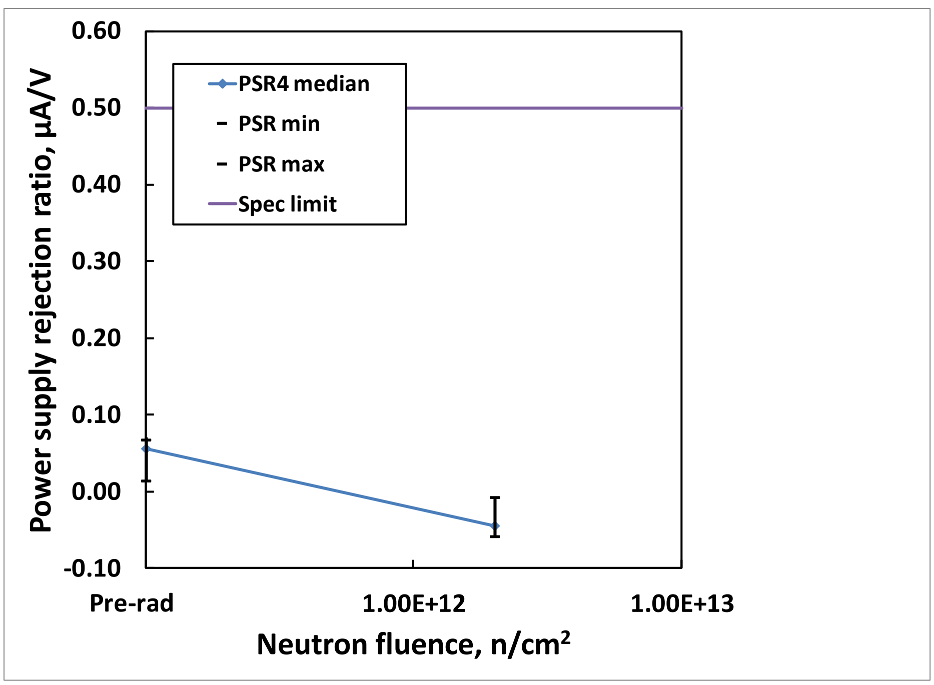

Fig. 2: ISL71590SEH power supply rejection ratio at 4.0V as a function of neutron irradiation, showing the median, minimum and maximum of the populations at each level. The sample size was 5 and the neutron fluence was 2 x 10^{12} n/cm^2, with three control units. The post-total dose irradiation SMD limit is 0.50 µA/V maximum.

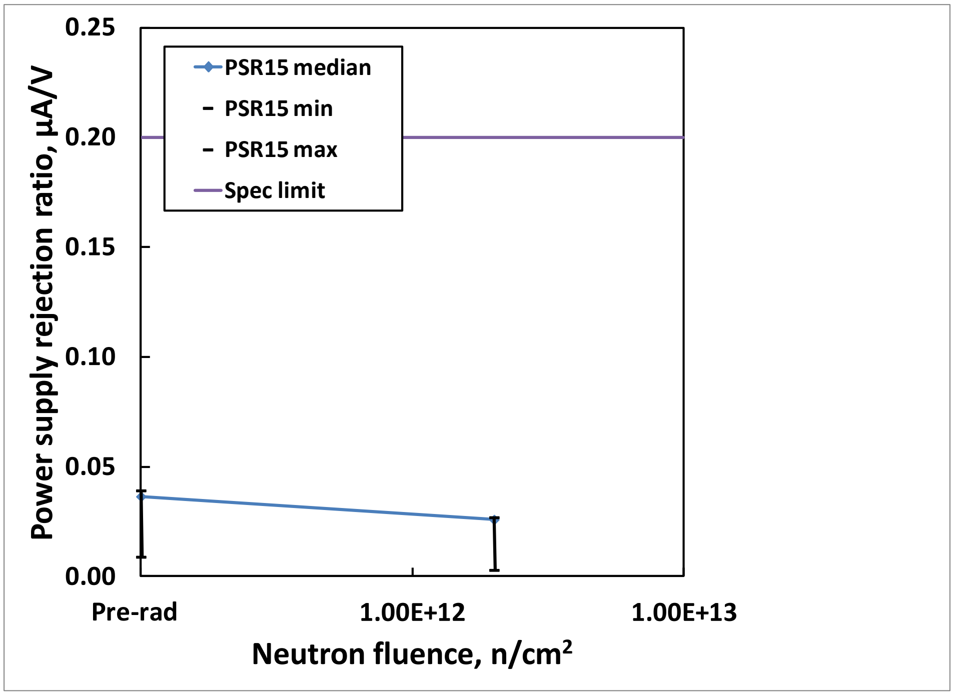

Fig. 3: ISL71590SEH power supply rejection ratio at 15.0V as a function of neutron irradiation, showing the median, minimum and maximum of the populations at each level. The sample size was 5 and the neutron fluence was 2 x 10^{12} n/cm^2, with three control units. The post-total dose irradiation SMD limit is 0.20 µA/V maximum.

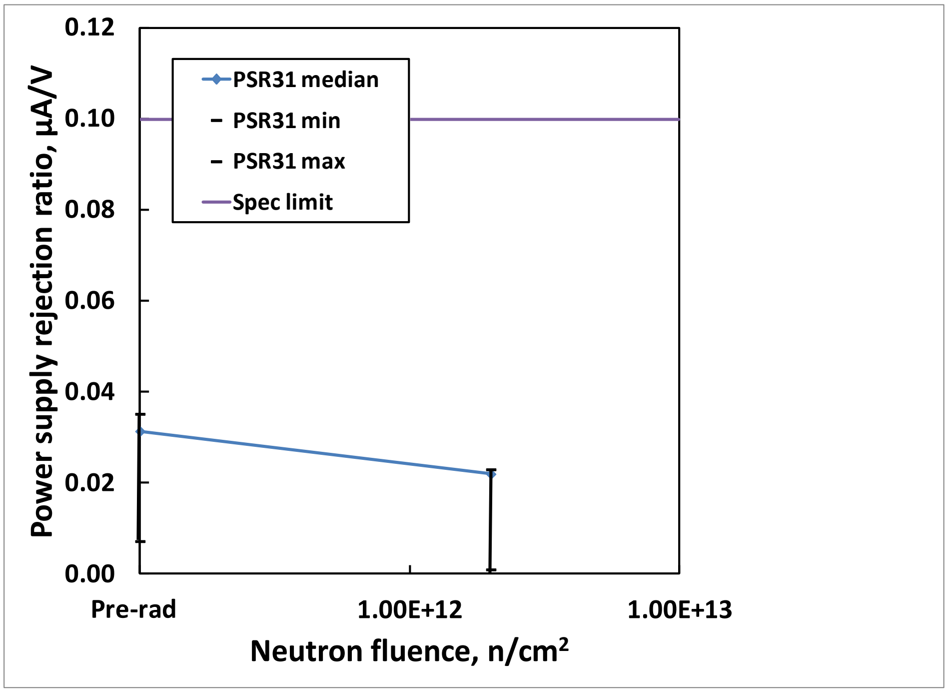

Fig. 4: ISL71590SEH power supply rejection ratio at 31.0V as a function of neutron irradiation, showing the median, minimum and maximum of the populations at each level. The sample size was 5 and the neutron fluence was 2 x 10^{12} n/cm^2, with three control units. The post-total dose irradiation SMD limit is 0.10 µA/V maximum.

5: Discussion and conclusion

This document reports the results of a preliminary single-level neutron test of the ISL71590SEH temperature sensor. Five samples were irradiated to 2 x 10^{12} n/cm^2. ATE characterization testing was performed before and after the irradiations, and three control units were used to insure repeatable data. Variables data for monitored parameters is presented in Figs. 1 through 4. The 2 x 10^{12} n/cm^2 level is of some interest in the context of recent developments in the JEDEC community, where the discrete component vendor community have signed up for characterization testing (but not for acceptance testing) at this level.

The ISL71590SEH is not formally designed for neutron hardness. The part is built in a DI complementary bipolar process. These bipolar transistors are minority carrier devices, obviously, and may be expected to be sensitive to displacement damage (DD) at the higher levels. This expectation turned out to be correct. We will discuss the results on a parameter by parameter basis and then draw some conclusions.

The temperature error is the key parameter (Fig. 1) and showed good stability after 2 x 10^{12} n/cm^2.

The power supply rejection ratio at 4.0V, 15.0V and 31.0V (Figs. 2, 3 and 4, respectively) showed good stability after 2 x 10^{12} n/cm^2 irradiation.

We conclude that the ISL71590SEH is capable of post 2 x 10^{12} n/cm^2 operation within the SMD post-total dose parameters.

6: Appendices

6.1: Reported parameters.

Fig	Parameter	Limit, low	Limit, high	Units	Notes
1	Temperature accuracy	-1.5	+0.5	^{o}C	
2	Power supply rejection ratio	-	0.5	µA/V	4.0V
3	Power supply rejection ratio	-	0.2	µA/V	15.0V
4	Power supply rejection ratio	-	0.1	µA/V	31.0V

7: Document revision history

Revision	Date	Pages	Comments
0	16 October 2013	All	Original issue