ISL71091SEH33

Neutron Test Report

Introduction

This report summarizes the results of 1MeV equivalent neutron testing of the ISL71091SEH33 precision voltage reference. The test was conducted to determine the sensitivity of the part to Displacement Damage (DD) caused by neutron or proton environments. Neutron fluences ranged from $5x10^{11}n/cm^2$ to $1x10^{14}n/cm^2$. This project was carried out in collaboration with Honeywell Aerospace in Clearwater, FL, and their support is gratefully acknowledged. This report is also applicable to the other variants (ISL71091SEH20 (2.048V), ISL71091SEH40 (4.096V) and ISL71091SEH10 (10.0V).

Product Description

The ISL71091SEH33 is an ultra-low noise, high DC accuracy precision voltage reference with a wide input voltage range from 4.6V to 30V. It uses the Renesas advanced proprietary bipolar technology, PR40, to achieve $5.2µV_{P-P}$ 0.1Hz to 10Hz noise with an initial voltage accuracy of 0.05% across the operating temperature range of -55°C to +125°C. This device is fabricated on Silicon on Insulator (SOI) and is immune to single event latch-up.

The ISL71091SEH33 offers a 3.3V output voltage option with 6ppm/°C temperature coefficient and also provides excellent line and load regulation. The device is offered in an 8 Ld flatpack package.

Specifications for Rad Hard QML devices are controlled by the Defense Logistics Agency (DLA) in Columbus, OH. The SMD is the controlling document and must be cited when ordering.

Related Literature

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

- ISL71091SEH33, ISL71091SEH20, ISL71091SEH40, ISL71091SEH10 device pages
- MIL-STD-883 test method 1017

1. Test Description

1.1 Irradiation Facility

Neutron fluence irradiations were performed on the test samples on June 25, 2018, at the WSMR Fast Burst Reactor (FBR) per Mil-STD-883G, Method 1017.2, with each part unpowered during irradiation and all leads shorted. The target irradiation levels were $5x10^{11}n/cm^2$, $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, and $1x10^{14}n/cm^2$. As neutron irradiation activates many of the heavier elements found in a packaged integrated circuit, the parts exposed at the higher neutron levels required (as expected) some cooldown time before being shipped back to Renesas (Palm Bay, FL) for electrical testing.

1.2 Test Fixturing

No formal irradiation test fixturing is involved, as these DD tests are considered bag tests, which means the parts are irradiated with all leads shorted together.

1.3 Radiation Dosimetry

Table 1 shows the TLD and Sulfur pellet dosimetry from WSMR indicating the total accumulated gamma dose and actual neutron fluence exposure levels for each set of samples. This dosimetry process is traceable to NIST (IAW ASTM E722).

Table 1. ISL71091SEH33 Neutron Fluence Dosimetry Data

TLD		Sulfur Pellet						
TLD #	cGy(Si)	Pellet #	Distance (inches)	Exposure ID	Flu > 3MeV (n/cm^2)	% Unc	Total Fluence (n/cm^2)	1Mev Si (n/cm^2)
296	1.168E+02	7001	26.6	Free Field	7.611E+10	7.1%	6.154E+11	5.294E+11
276	3.608E+02	6412	13.45	Free Field	2.810E+11	7.1%	2.217E+12	1.966E+12
261	2.295E+03	6486	24	Free Field	1.474E+12	7.1%	1.182E+13	1.023E+13
250	1.575E+04	6465	8	Free Field	1.136E+13	7.1%	8.916E+13	7.965E+13

Notes:

1. 1cGy(Si) = 1rad(Si)
2. The Uncertainty (% Unc) column is applicable only to the Fluence > 3MeV.

1.4 Characterization Equipment and Procedures

Electrical testing was performed before and after irradiation using the production Automated Test Equipment (ATE). All electrical testing was performed at room temperature.

1.5 Experimental Matrix

Testing proceeded in general accordance with the guidelines of MIL-STD-883 TM 1017. The experimental matrix consisted of five samples irradiated at $5x10^{11}n/cm^2$, five irradiated at $2x10^{12}n/cm^2$, five irradiated at $1x10^{13}n/cm^2$, and five irradiated at $1x10^{14}n/cm^2$. Three control units were used.

ISL71091SEH33 samples were drawn from lots WXM8XDB and WXM8AFBA. Samples were packaged in the 8 Ld ceramic flatpack package (package code KCJ). Samples were processed through burn-in before irradiation and screened to the SMD limits at room, low, and high temperatures before the start of neutron testing.

2. Results

Neutron testing of the ISL71091SEH33 is complete and the results are reported in the balance of this report. It should be understood when interpreting the data that each neutron irradiation was performed on a different set of samples; this is not total dose testing, where the damage is cumulative.

2.1 Attributes Data

Table 2 summarizes the neutron exposure test results. The maximum planned fluence of $1x10^{14}$n/cm^2 was not achieved; the actual maximum fluence reached $7.97x10^{13}$n/cm^2.

Table 2. Attributes Data

Fluence, (n/cm^2)		Sample Size	Pass (Note 3)	Fail
Planned	Actual			
$5x10^{11}$	$5.30x10^{11}$	5	5	0
$2x10^{12}$	$1.97x10^{12}$	5	5	0
$1x10^{13}$	$1.02x10^{13}$	5	5	5
$1x10^{14}$	$7.97x10^{13}$	5	0	5

Note:
3. Pass indicates a sample that passes all SMD limits.

2.2 Variables Data

The plots in Figures 1 through 6 show data plots for key parameters before and after irradiation to each level. The plots show the mean of each parameter as a function of neutron irradiation. The plots include error bars at each down-point, representing the minimum and maximum measured values of the samples, although in some plots the error bars might not be visible due to their values compared to the scale of the graph. While the applicable electrical limits taken from the SMD are also shown, it should be noted that these limits are provided for guidance only, the ISL71091SEH33 is not specified for the neutron environment.

All samples passed the post-irradiation SMD limits after all exposures up to and including $1x10^{13}$n/cm^2, but failed at $1x10^{14}$n/cm^2, with one part failing output voltage accuracy, as shown in Figure 1, and all of the parts failing line regulation as shown in Figure 3.

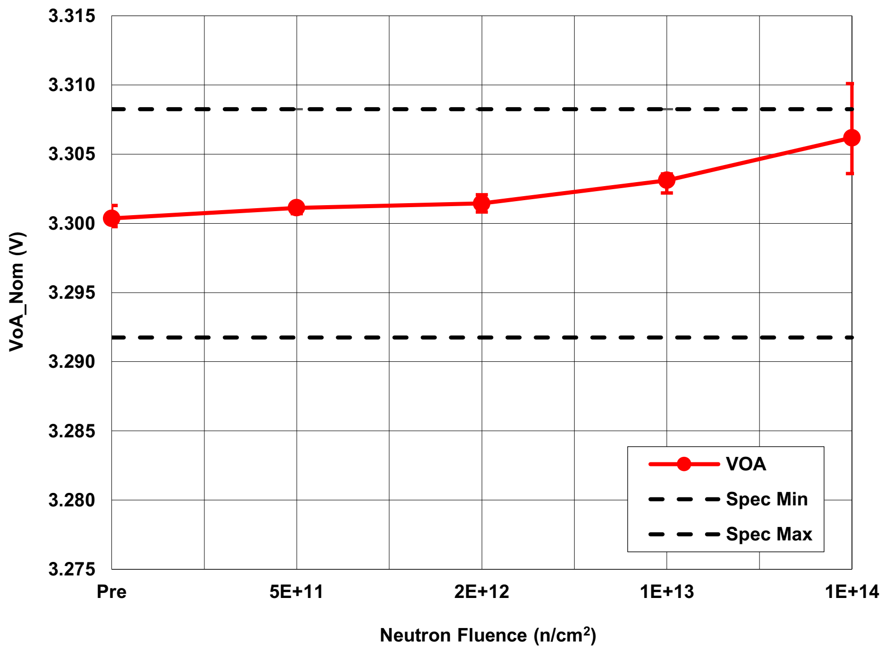

Figure 1. ISL71091SEH33 output voltage (V_{OA}), following irradiation to each neutron fluence level. The error bars, if visible, represent the minimum and maximum measured values. The post-irradiation SMD limits are 3.29175V minimum and 3.30825V maximum (±0.25%).

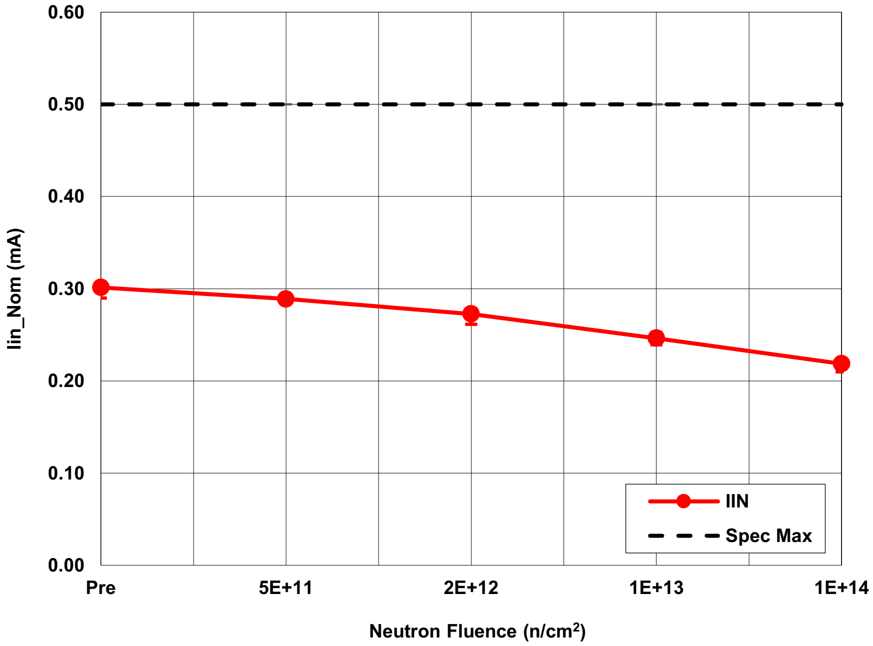

Figure 2. ISL71091SEH33 supply current (I_{IN}), following irradiation to each neutron fluence level. The error bars, if visible, represent the minimum and maximum measured values. The post-irradiation SMD limit is 0.5mA maximum.

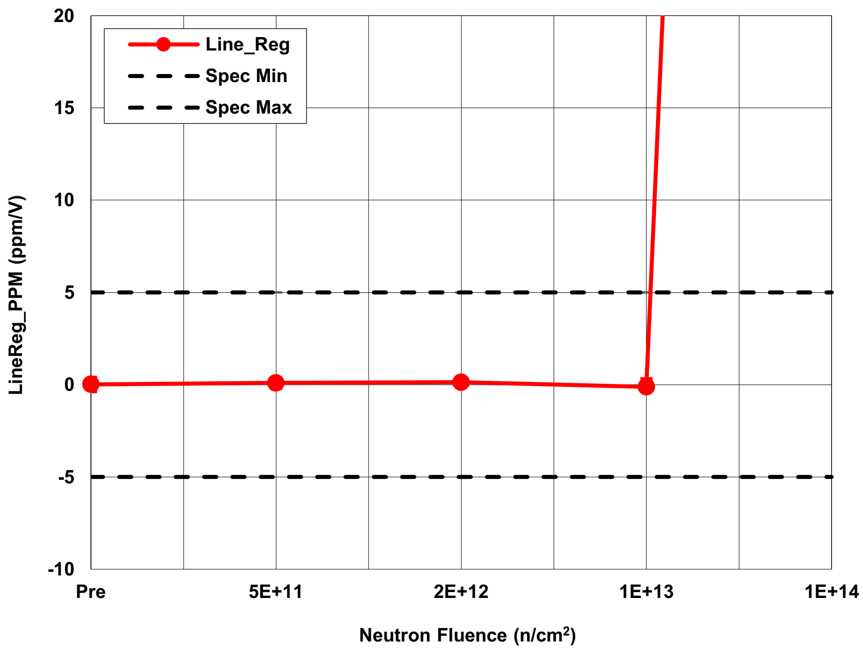

Figure 3. ISL71091SEH33 line regulation ($\Delta V_{OUT}/\Delta V_{IN}$), following irradiation to each neutron fluence level. The error bars, if visible, represent the minimum and maximum measured values. The post-irradiation SMD limits are -5ppm/V minimum and +5ppm/V maximum. Note: The 1E+14n/cm^2 data point is not shown to show the performance of the part below that level (the average value was 228ppm/V).

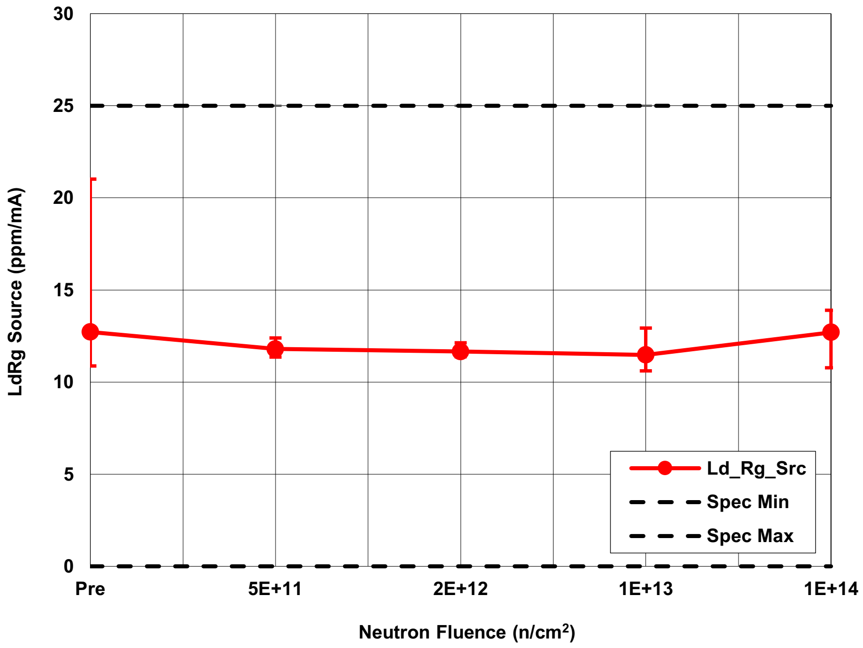

Figure 4. ISL71091SEH33 load regulation sourcing 10mA ($\Delta V_{OUT}/\Delta I_{OUT}$), following irradiation to each neutron fluence level. The error bars, if visible, represent the minimum and maximum measured values. The post-irradiation SMD limit is -25ppm/V minimum and +25ppm/V maximum.

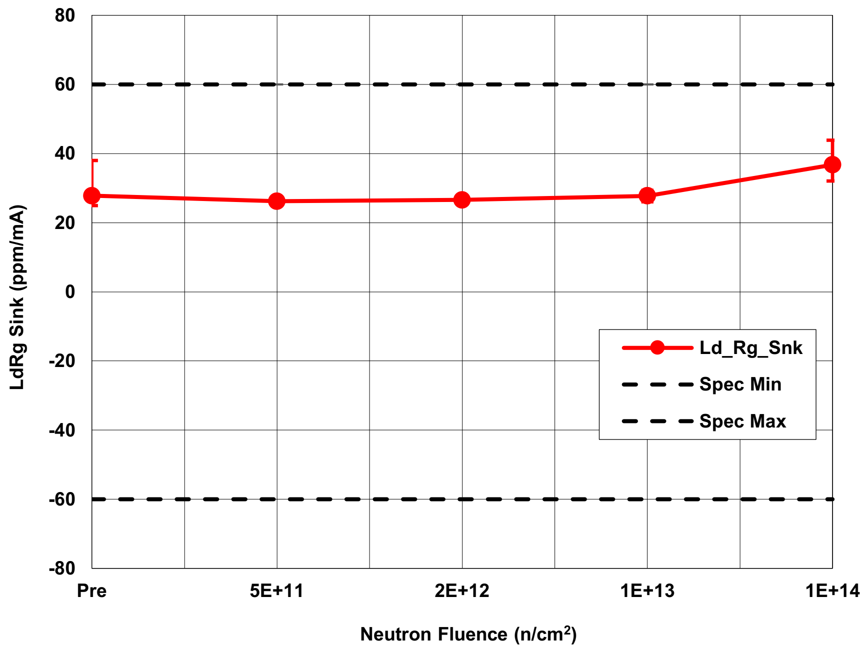

Figure 5. ISL71091SEH33 load regulation sinking 5mA ($\Delta V_{OUT}/\Delta I_{OUT}$), following irradiation to each neutron fluence level. The error bars, if visible, represent the minimum and maximum measured values. The post-irradiation SMD limit -60ppm/V minimum and +60ppm/V maximum.

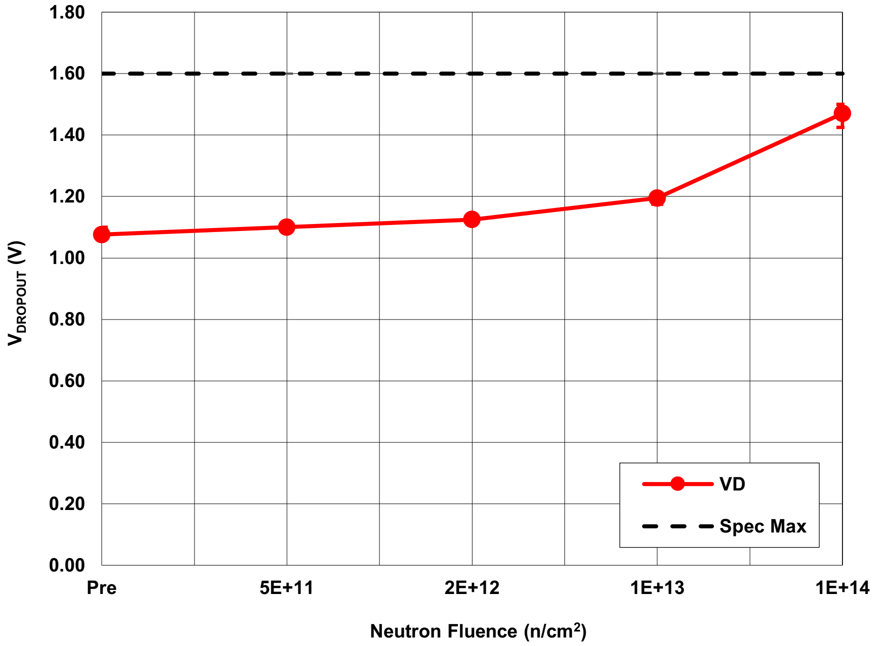

Figure 6. ISL71091SEH33 dropout voltage (V_D), following irradiation to each neutron fluence level. The error bars, if visible, represent the minimum and maximum measured values. The post-irradiation SMD limit is 1.6V maximum.

3. Discussion and Conclusion

The results of 1MeV equivalent neutron testing of the ISL71091SEH33 precision voltage reference were reported. Parts were tested at $5x10^{11}$n/cm^2, $2x10^{12}$n/cm^2, $1x10^{13}$n/cm^2, and $1x10^{14}$n/cm^2. The results of key parameters before and after irradiation to each level are plotted in Figures 1 through 6. The plots show the mean of each parameter as a function of neutron irradiation, with error bars that represent the minimum and maximum measured values. All samples passed the SMD limits after all exposures up to and including $1x10^{13}$n/cm^2, but failed at $1x10^{14}$n/cm^2.

4. Appendices

4.1 Reported Parameters

Figure	Parameter	Symbol	Limit, Low	Limit, High	Units	Notes
1	V_{OUT} Accuracy	V_{OA}	-0.25	0.25	%	3.29175V to 3.30825V
2	Supply Current	I_{IN}	-	0.5	mA	
3	Line Regulation	$\Delta V_{OUT}/\Delta V_{IN}$	-5	5	ppm/V	
4	Load Regulation, Sourcing	$\Delta V_{OUT}/\Delta I_{OUT}$	-25	25	ppm/mA	10mA
5	Load Regulation, Sinking	$\Delta V_{OUT}/\Delta I_{OUT}$	-60	60	ppm/mA	5mA
6	Dropout Voltage	V_D	-	1.6	V	

5. Revision History

Rev.	Date	Description
1.00	Oct.21.19	Initial release

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