ISL71041M/ISL71043M

Neutron Testing of the ISL7104xM Radiation Tolerant Single-Ended Current Mode PWM Controllers

Introduction

This report summarizes results of 1MeV equivalent neutron testing of the ISL7104xM current mode PWM controller. The test was conducted to determine the sensitivity of the part to the Displacement Damage (DD) caused by the neutron environment. Neutron fluences ranged from 2×10^{11}n/cm^2 to 1×10^{14}n/cm^2.

Part Description

The ISL71043M and ISL71041M are PWM controllers suitable for a wide range of power conversion applications including boost, flyback, and isolated output configurations. Fast signal propagation and output switching characteristics make these ideal products for existing and new designs.

Features include up to 13.2V operation, 2.9mA operating current, 90µA typical start-up current, adjustable operating frequency to 1MHz and, 1A current drive capability with 35ns rise and 29ns fall times.

The ISL71041M and ISL71043M are available in an 8 LD TDFN package and the ISL71043M is also available in an 8 LD SOIC package. Both packages are specified across the extended temperature range of -55°C to +125°C.

Contents

1. Test Description

1.1 Irradiation Facilities

Neutron irradiation was performed 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 shorted together. As neutron irradiation activates many of the elements found in a packaged integrated circuit, the parts exposed at the higher neutron levels required (as expected) significant cooldown time before being shipped back to Renesas (Palm Bay, FL) for electrical testing.

1.2 Characterization Equipment and Procedures

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

1.3 Experimental Matrix

Testing proceeded in general accordance with the guidelines of MIL-STD-883 Test Method 1017. The experimental matrix consisted of six samples irradiated at 2.2×10^{11}n/cm^2, six samples irradiated at 4.4×10^{11}n/cm^2, six samples irradiated at 6.6×10^{11}n/cm^2, three samples irradiated at 1×10^{12}n/cm^2, three samples irradiated at 1×10^{13}n/cm^2, and five samples irradiated at 1×10^{14}n/cm^2. Two control units were used to ensure repeatability. Samples were taken from current production inventory.

2. Results

2.1 Test Results

Neutron testing of the ISL7104xM is complete and the results are reported in the balance of this report. When reviewing the data, take note that each neutron irradiation was made on a different 6- or 3-unit sample; this is not total dose testing, where the damage is cumulative.

2.2 Variables Data

The plots in Figure 1 through Figure 20 show data plots for key parameters before and after irradiation to each level. The plots show the median, minimum, and maximum of each parameter for each of the four amplifier channels as a function of neutron irradiation. The median was plotted because of the small sample sizes involved. The applicable electrical limits taken from the datasheet are also shown.

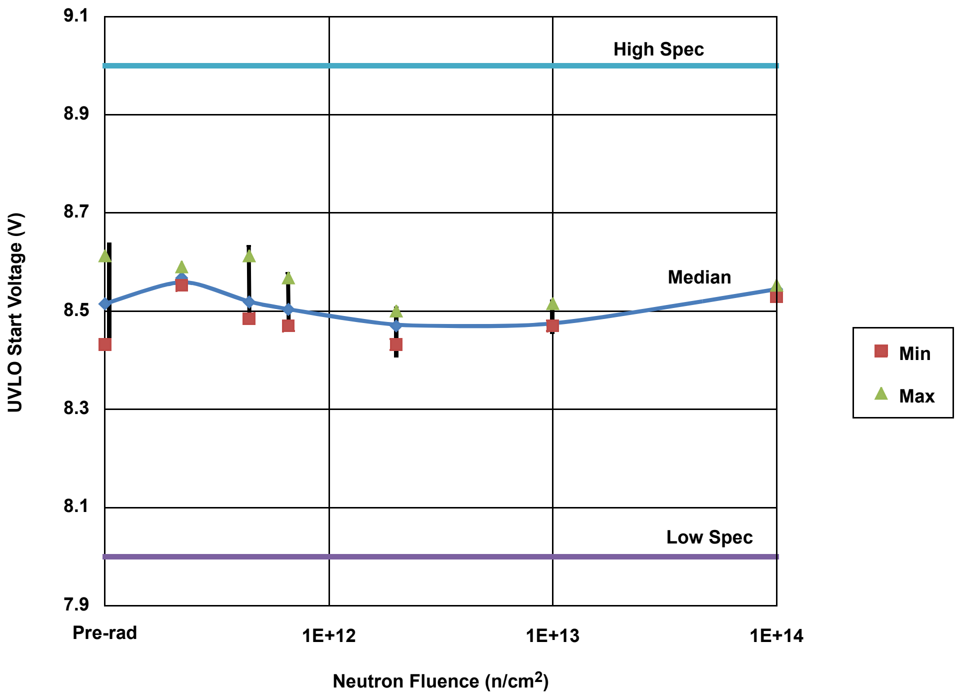

Figure 1. Undervoltage Lockout (UVLO) START threshold voltage as a function of neutron irradiation, showing the median, minimum and maximum of the populations following irradiation to each level. Neutron fluences and sample sizes (in parentheses) were 2.2×10^{11}n/cm^2 (6 samples), 4.4×10^{11}n/cm^2 (6 samples), 6.6×10^{11}n/cm^2 (6 samples), 1×10^{12}n/cm^2 (3 samples), 1×10^{13}n/cm^2 (3 samples) and 1×10^{14}n/cm^2 (3 samples). The datasheet limits are 8V to 9V.

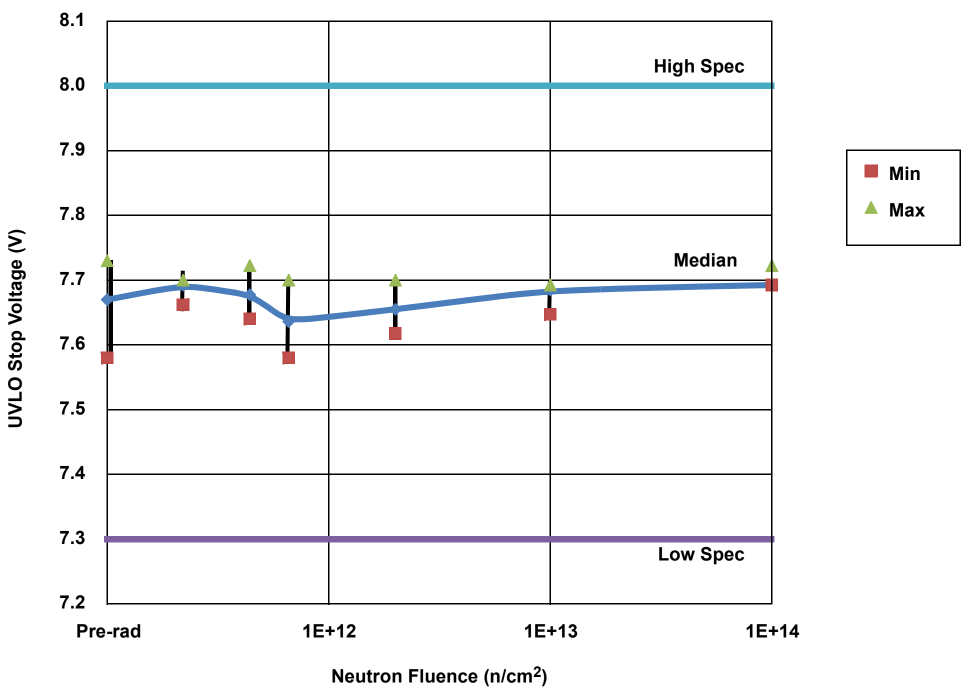

Figure 2. UVLO STOP threshold voltage as a function of neutron irradiation, showing the median, minimum and maximum of the populations at each level. Neutron fluences and sample sizes (in parentheses) were 2.2×10^{11}n/cm^2 (6 samples), 4.4×10^{11}n/cm^2 (6 samples), 6.6×10^{11}n/cm^2 (6 samples), 1×10^{12}n/cm^2 (3 samples), 1×10^{13}n/cm^2 (3 samples) and 1×10^{14}n/cm^2 (3 samples). The datasheet limits are 7.3V to 8V.

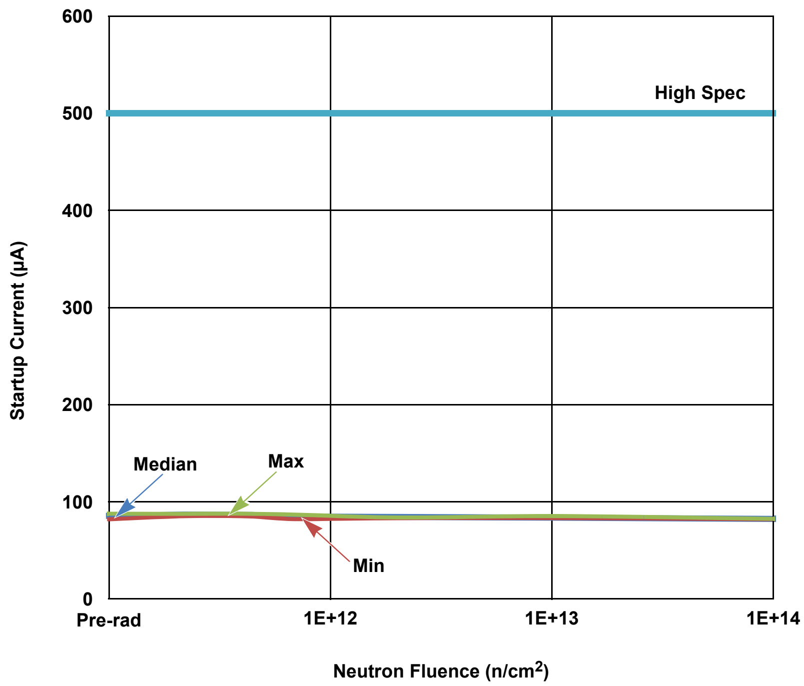

Figure 3. Startup current as a function of neutron irradiation, showing the median, minimum and maximum of the populations at each level. Neutron fluences and sample sizes (in parentheses) were 2.2×10^{11}n/cm^2 (6 samples), 4.4×10^{11}n/cm^2 (6 samples), 6.6×10^{11}n/cm^2 (6 samples), 1×10^{12}n/cm^2 (3 samples), 1×10^{13}n/cm^2 (3 samples) and 1×10^{14}n/cm^2 (3 samples). The datasheet limit is 500µA.

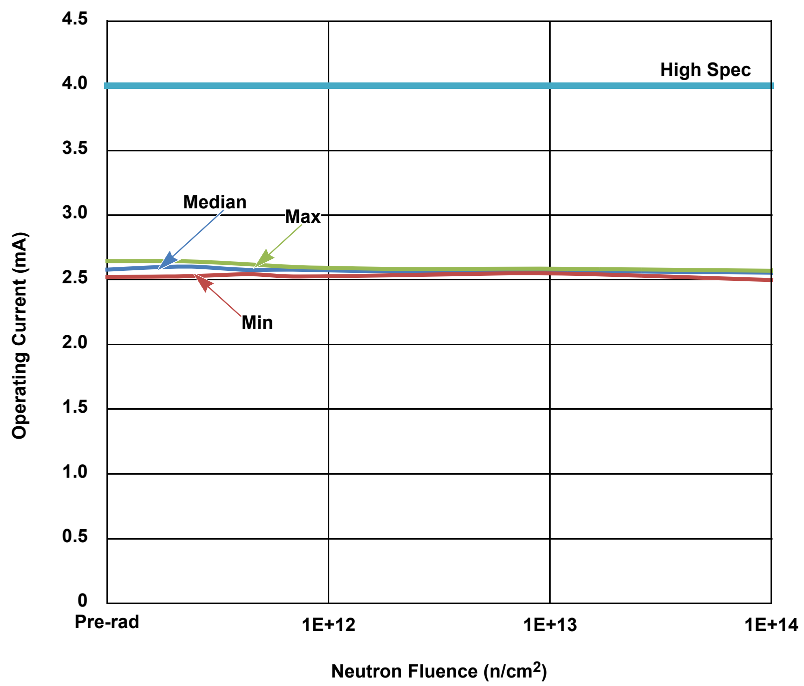

Figure 4. operating current as a function of neutron irradiation, showing the median, minimum and maximum of the populations at each level. Neutron fluences and sample sizes (in parentheses) were 2.2×10^{11}n/cm^2 (6 samples), 4.4×10^{11}n/cm^2 (6 samples), 6.6×10^{11}n/cm^2 (6 samples), 1×10^{12}n/cm2 (3 samples), 1×10^{13}n/cm^2 (3 samples) and $1\times10^{14 n/cm2}$ (3 samples). The datasheet limit is 4mA maximum.

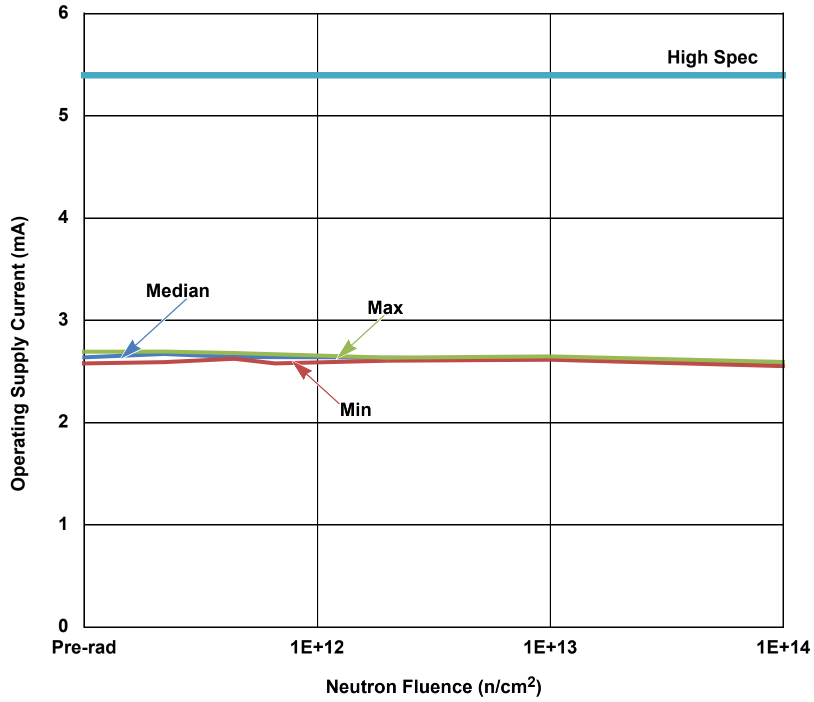

Figure 5. Operating supply current as a function of neutron irradiation, showing the median, minimum and maximum of the populations at each level. Neutron fluences and sample sizes (in parentheses) were 2.2×10^{11}n/cm^2 (6 samples), 4.4×10^{11}n/cm^2 (6 samples), 6.6×10^{11}n/cm^2 (6 samples), 1×10^{12}n/cm^2 (3 samples), 1×10^{13}n/cm^2 (3 samples) and 1×10^{14}n/cm^2 (3 samples). The datasheet limit is 5.5mA maximum.

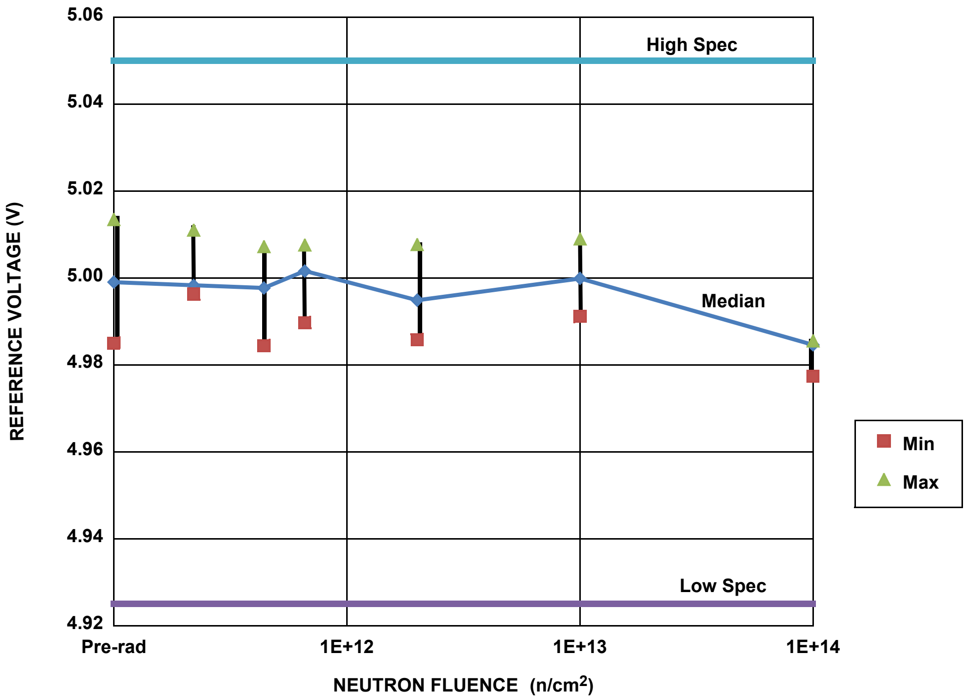

Figure 6. Reference voltage accuracy as a function of neutron irradiation, showing the median, minimum and maximum of the populations at each level. Neutron fluences and sample sizes (in parentheses) were 2.2×10^{11}n/cm^2 (6 samples), 4.4×10^{11}n/cm^2 (6 samples), 6.6×10^{11}n/cm^2 (6 samples), 1×10^{12}n/cm^2 (3 samples), 1×10^{13}n/cm^2 (3 samples) and 1×10^{14}n/cm^2 (3 samples). The datasheet limits are 4.925V to 5.050V.

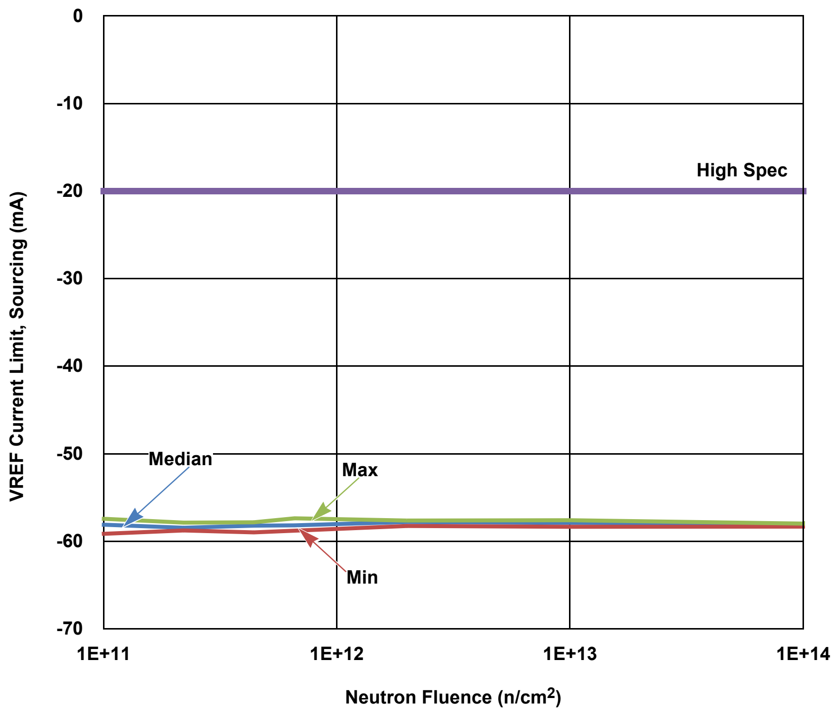

Figure 7. Reference current limit, sourcing, as a function of neutron irradiation, showing the median, minimum and maximum of the populations at each level. Neutron fluences and sample sizes (in parentheses) were 2.2×10^{11}n/cm^2 (6 samples), 4.4×10^{11}n/cm^2 (6 samples), 6.6×10^{11}n/cm^2 (6 samples), 1×10^{12}n/cm^2 (3 samples), 1×10^{13}n/cm^2 (3 samples) and 1×10^{14}n/cm^2 (3 samples). The datasheet limit is -20mA minimum.

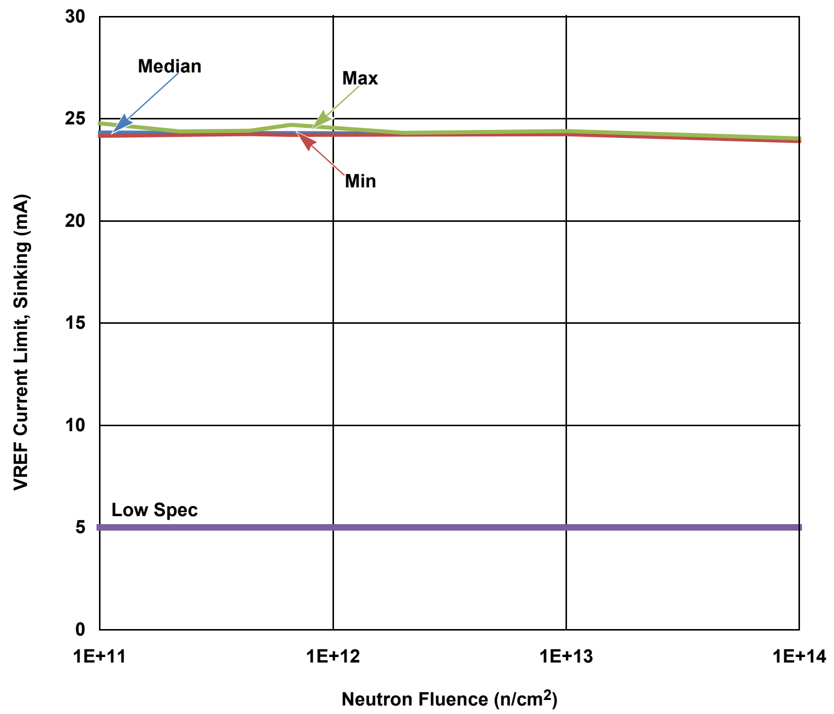

Figure 8. Reference current limit, sinking, as a function of neutron irradiation, showing the median, minimum and maximum of the populations at each level. Neutron fluences and sample sizes (in parentheses) were 2.2×10^{11}n/cm^2 (6 samples), 4.4×10^{11}n/cm^2 (6 samples), 6.6×10^{11}n/cm^2 (6 samples), 1×10^{12}n/cm^2 (3 samples), 1×10^{13}n/cm^2 (3 samples) and 1×10^{14}n/cm^2 (3 samples). The datasheet limit is 5mA minimum.

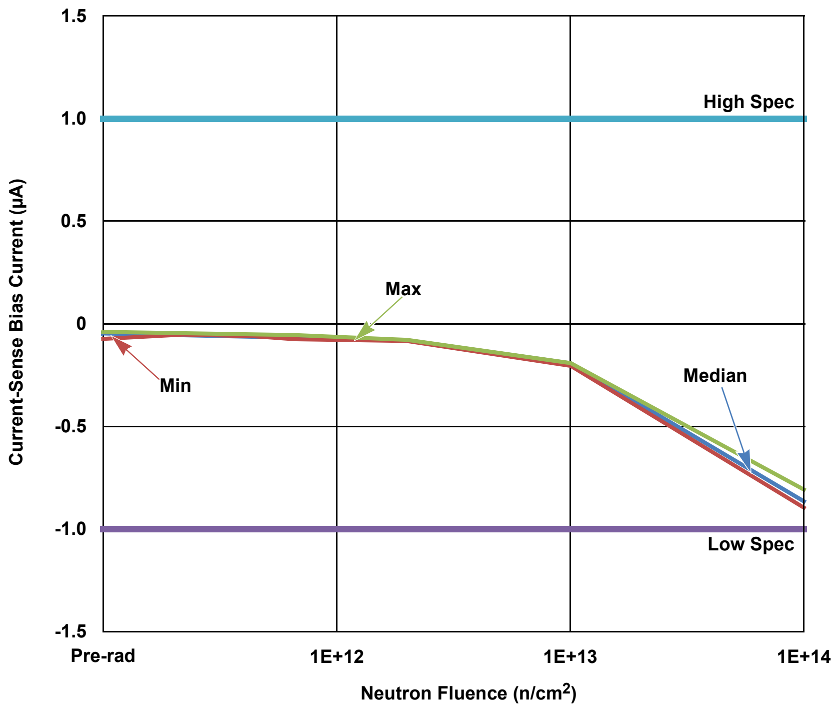

Figure 9. Current-sense input bias current as a function of neutron irradiation, showing the median, minimum and maximum of the populations at each level. Neutron fluences and sample sizes (in parentheses) were $2.2{\times}10^{11}n/cm^2$ (6 samples), $4.4{\times}10^{11}n/cm^2$ (6 samples), $6.6{\times}10^{11}n/cm^2$ (6 samples), $1{\times}10^{12}n/cm^2$ (3 samples), $1{\times}10^{13}n/cm^2$ (3 samples) and $1{\times}10^{14}n/cm^2$ (3 samples). The datasheet limits are -1µA to 1µA.

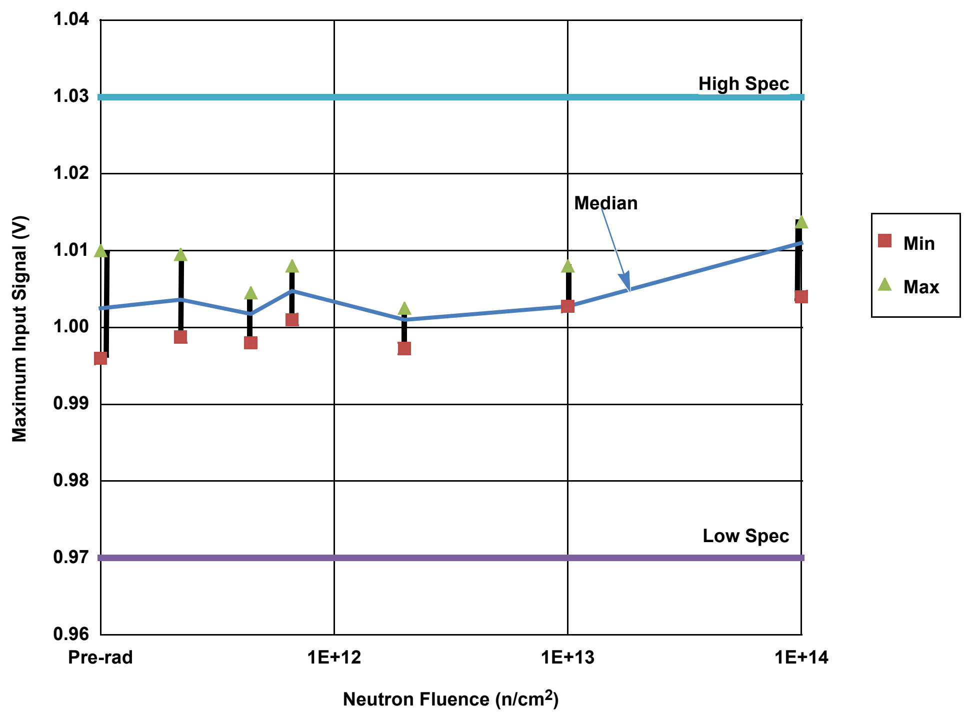

Figure 10. Current-sense maximum input signal as a function of neutron irradiation, showing the median, minimum and maximum of the populations at each level. Neutron fluences and sample sizes (in parentheses) were $2.2{\times}10^{11}n/cm^2$ (6 samples), $4.4{\times}10^{11}n/cm^2$ (6 samples), $6.6{\times}10^{11}n/cm^2$ (6 samples), $1{\times}10^{12}n/cm^2$ (3 samples), $1{\times}10^{13}n/cm^2$ (3 samples) and $1{\times}10^{14}n/cm^2$ (3 samples). The datasheet limits are 0.97V to 1.03V.

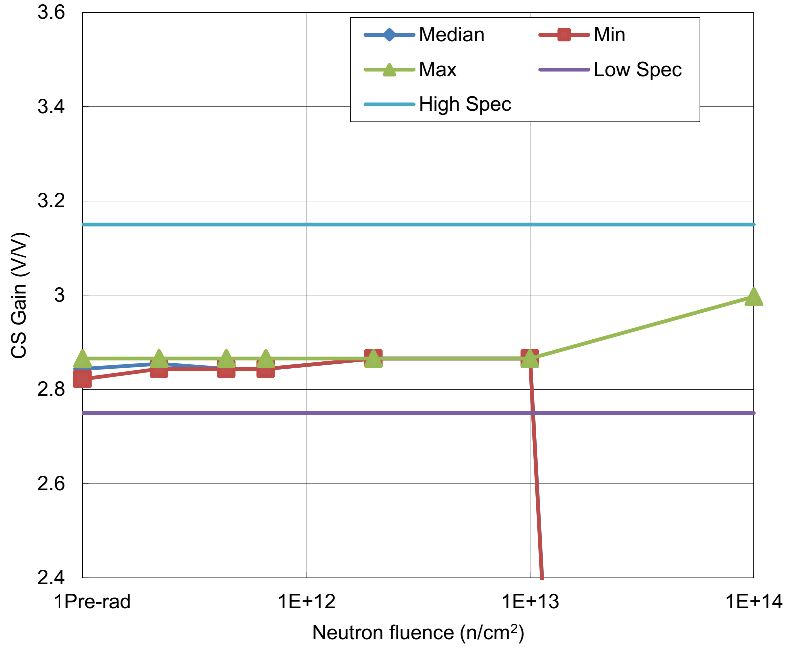

Figure 11. Current-sense gain ($A_{CS} = \Delta V_{COMP} / \Delta V_{CS}$) as a function of neutron irradiation, showing the median, minimum and maximum of the populations at each level. Neutron fluences and sample sizes (in parentheses) were 2.2×10^{11}n/cm^2 (6 samples), 4.4×10^{11}n/cm^2 (6 samples), 6.6×10^{11}n/cm^2 (6 samples), 1×10^{12}n/cm^2 (3 samples), 1×10^{13}n/cm^2 (3 samples) and 1×10^{14}n/cm^2 (3 samples). The datasheet limits are 2.75V/V to 3.15V/V. Two out of three samples were nonfunctional after irradiation to 1×10^{14}n/cm^2.

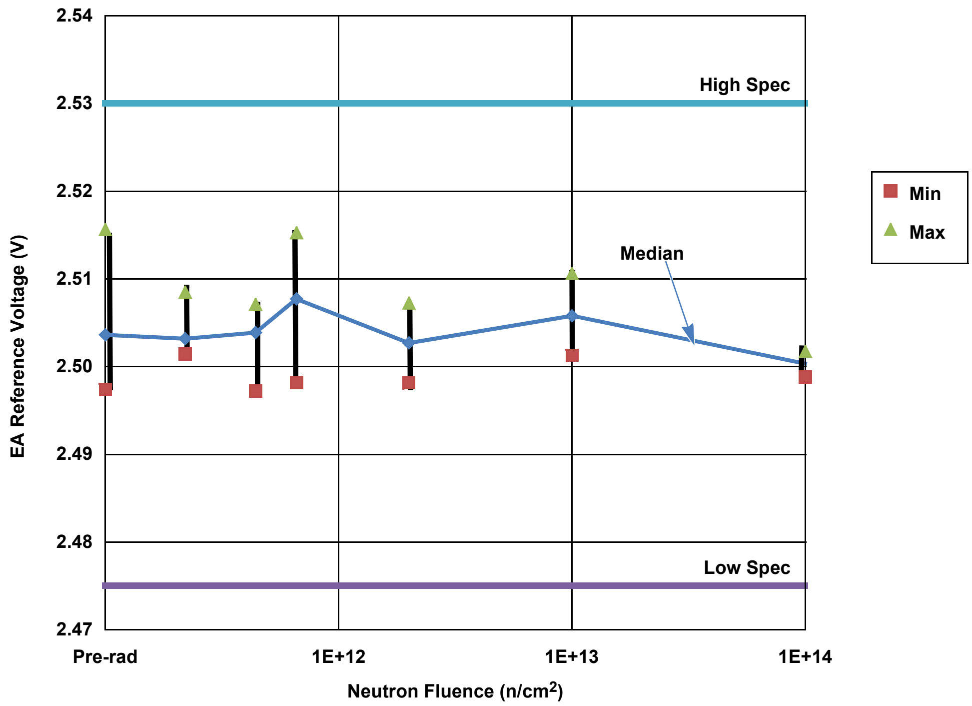

Figure 12. Error amplifier reference as a function of neutron irradiation, showing the median, minimum and maximum of the populations at each level. Neutron fluences and sample sizes (in parentheses) were 2.2×10^{11}n/cm^2 (6 samples), 4.4×10^{11}n/cm^2 (6 samples), 6.6×10^{11}n/cm^2 (6 samples), 1×10^{12}n/cm^2 (3 samples), 1×10^{13}n/cm^2 (3 samples) and 1×10^{14}n/cm^2 (3 samples). The datasheet limits are 2.475V to 2.530V.

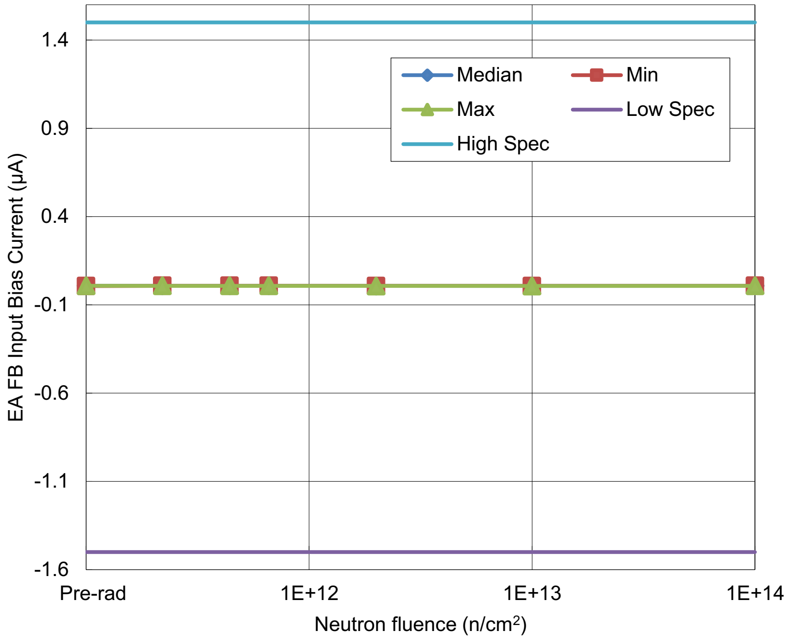

Figure 13. Error amplifier input bias current as a function of neutron irradiation, showing the median, minimum and maximum of the populations at each level. Neutron fluences and sample sizes (in parentheses) were 2.2×10^{11}n/cm^2 (6 samples), 4.4×10^{11}n/cm^2 (6 samples), 6.6×10^{11}n/cm^2 (6 samples), 1×10^{12}n/cm^2 (3 samples), 1×10^{13}n/cm^2 (3 samples) and 1×10^{14}n/cm^2 (3 samples). The datasheet limits are -1.5µA to 1.5µA.

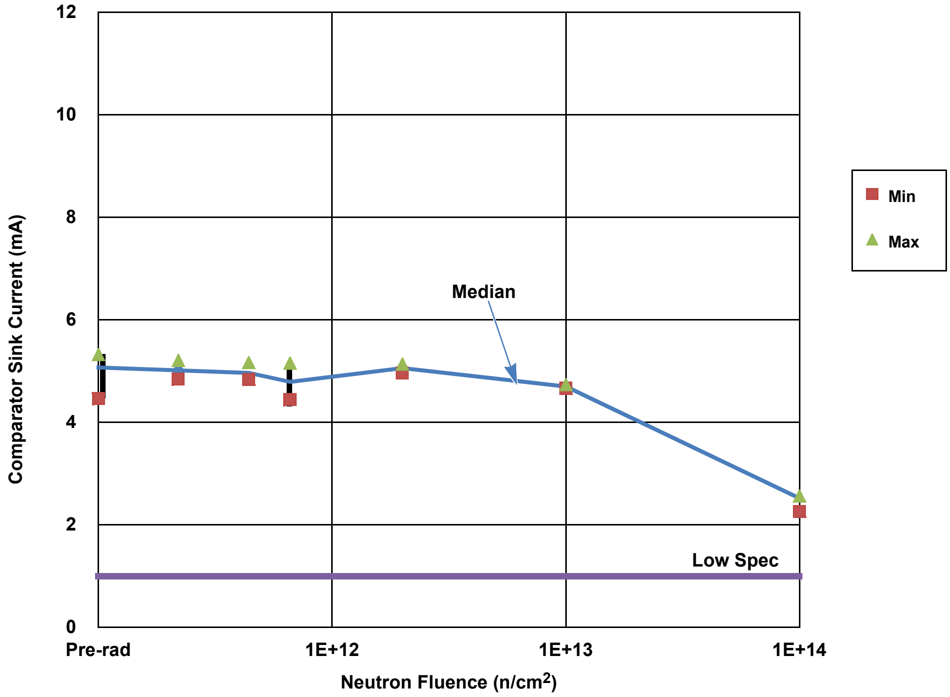

Figure 14. Error amplifier sink current as a function of neutron irradiation, showing the median, minimum and maximum of the populations at each level. Neutron fluences and sample sizes (in parentheses) were 2.2×10^{11}n/cm^2 (6 samples), 4.4×10^{11}n/cm^2 (6 samples), 6.6×10^{11}n/cm^2 (6 samples), 1×10^{12}n/cm^2 (3 samples), 1×10^{13}n/cm^2 (3 samples) and 1×10^{14}n/cm^2 (3 samples). The datasheet limit is 1mA minimum.

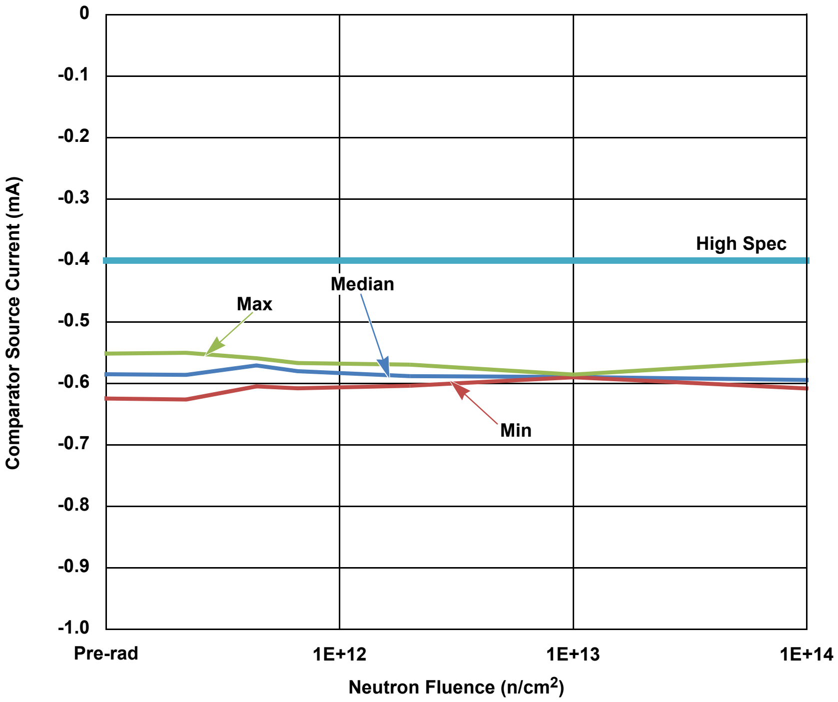

Figure 15. Error amplifier source current as a function of neutron irradiation, showing the median, minimum and maximum of the populations at each level. Neutron fluences and sample sizes (in parentheses) were 2.2×10^{11}n/cm^2 (6 samples), 4.4×10^{11}n/cm^2 (6 samples), 6.6×10^{11}n/cm^2 (6 samples), 1×10^{12}n/cm^2 (3 samples), 1×10^{13}n/cm^2 (3 samples) and 1×10^{14}n/cm^2 (3 samples). The datasheet limit is -0.4mA minimum.

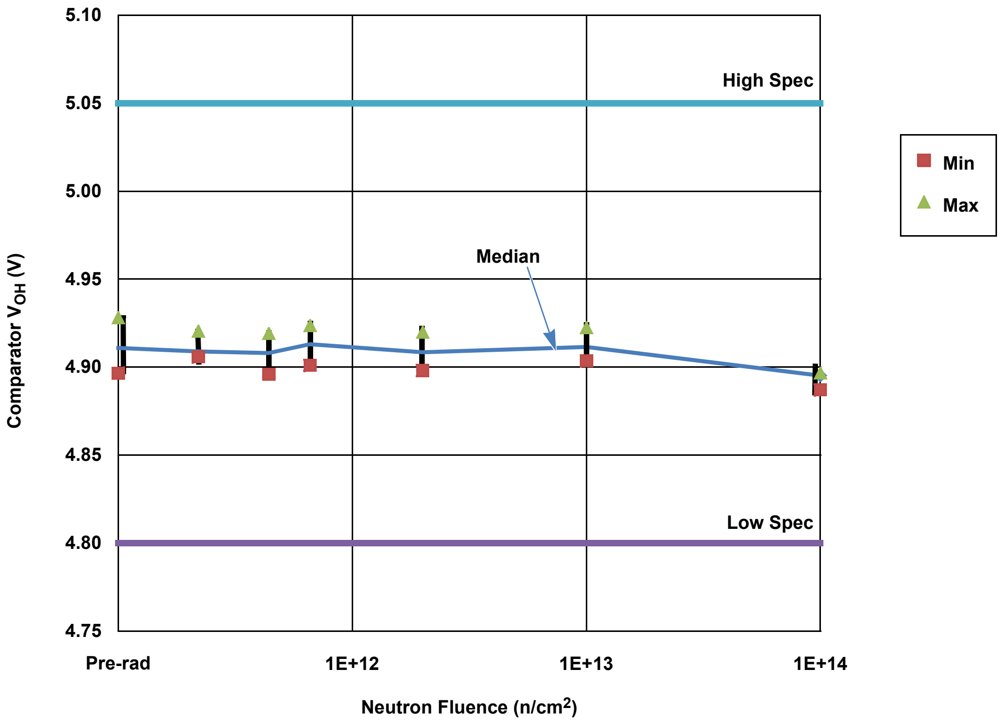

Figure 16. Error amplifier HIGH output voltage as a function of neutron irradiation, showing the median, minimum and maximum of the populations at each level. Neutron fluences and sample sizes (in parentheses) were 2.2×10^{11}n/cm^2 (6 samples), 4.4×10^{11}n/cm^2 (6 samples), 6.6×10^{11}n/cm^2 (6 samples), 1×10^{12}n/cm^2 (3 samples), 1×10^{13}n/cm^2 (3 samples) and 1×10^{14}n/cm^2 (3 samples). The datasheet limits are 4.80V to 5.050V.

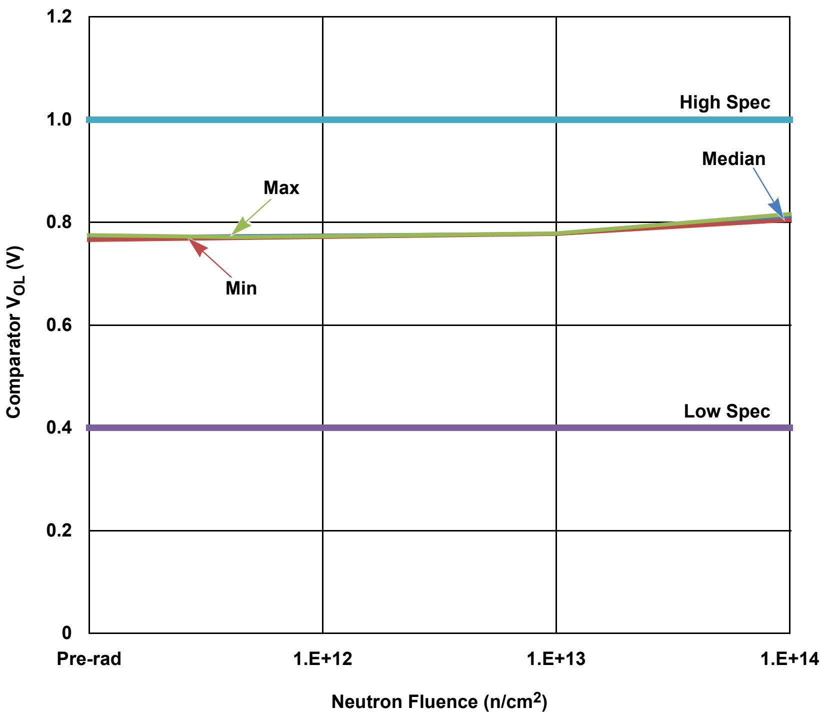

Figure 17. Error amplifier LOW output voltage as a function of neutron irradiation, showing the median, minimum and maximum of the populations at each level. Neutron fluences and sample sizes (in parentheses) were 2.2×10^{11}n/cm^2 (6 samples), 4.4×10^{11}n/cm^2 (6 samples), 6.6×10^{11}n/cm^2 (6 samples), 1×10^{12}n/cm^2 (3 samples), 1×10^{13}n/cm^2 (3 samples) and 1×10^{14}n/cm^2 (3 samples). The datasheet limits are 0.4V to 1V.

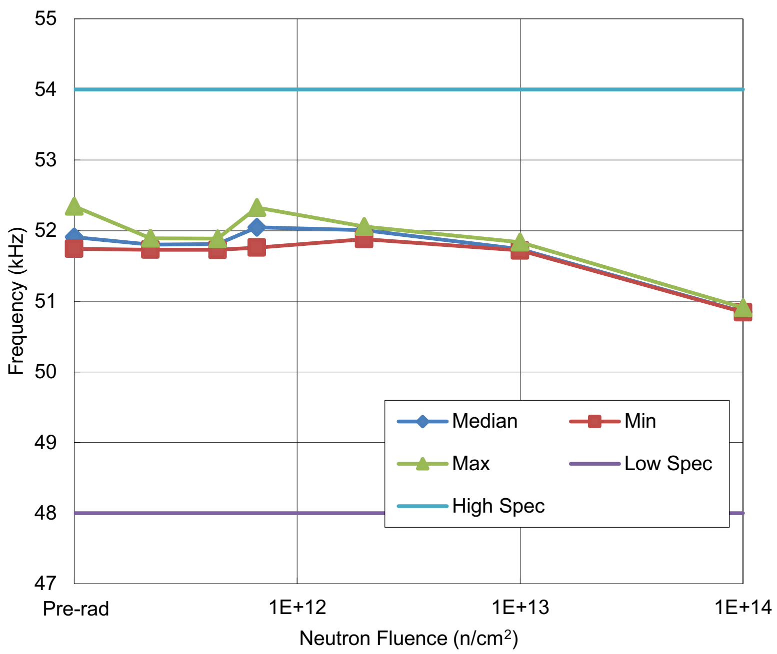

Figure 18. Oscillator frequency as a function of neutron irradiation, showing the median, minimum and maximum of the populations at each level. Neutron fluences and sample sizes (in parentheses) were 2.2×10^{11}n/cm^2 (6 samples), 4.4×10^{11}n/cm^2 (6 samples), 6.6×10^{11}n/cm^2 (6 samples), 1×10^{12}n/cm^2 (3 samples), 1×10^{13}n/cm^2 (3 samples) and 1×10^{14}n/cm^2 (3 samples). The datasheet limits are 48kHz to 54kHz.

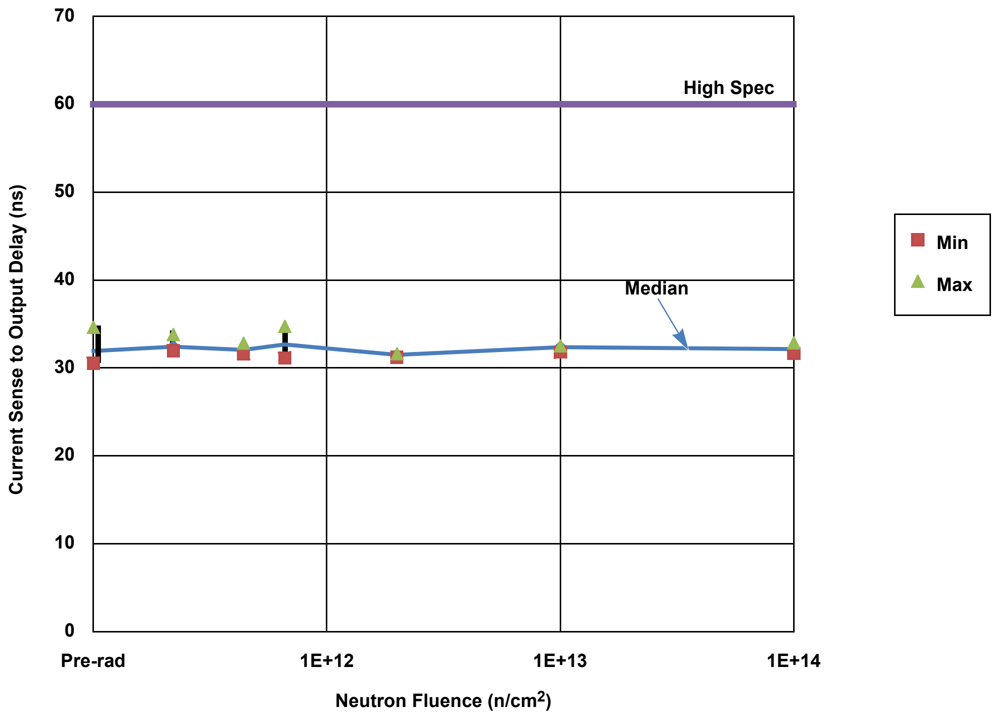

Figure 19. Current sense to output delay as a function of neutron irradiation, showing the median, minimum and maximum of the populations at each level. Neutron fluences and sample sizes (in parentheses) were 2.2×10^{11}n/cm^2 (6 samples), 4.4×10^{11}n/cm^2 (6 samples), 6.6×10^{11}n/cm^2 (6 samples), 1×10^{12}n/cm^2 (3 samples), 1×10^{13}n/cm^2 (3 samples) and 1×10^{14}n/cm^2 (3 samples). The datasheet limit is 60ns maximum.

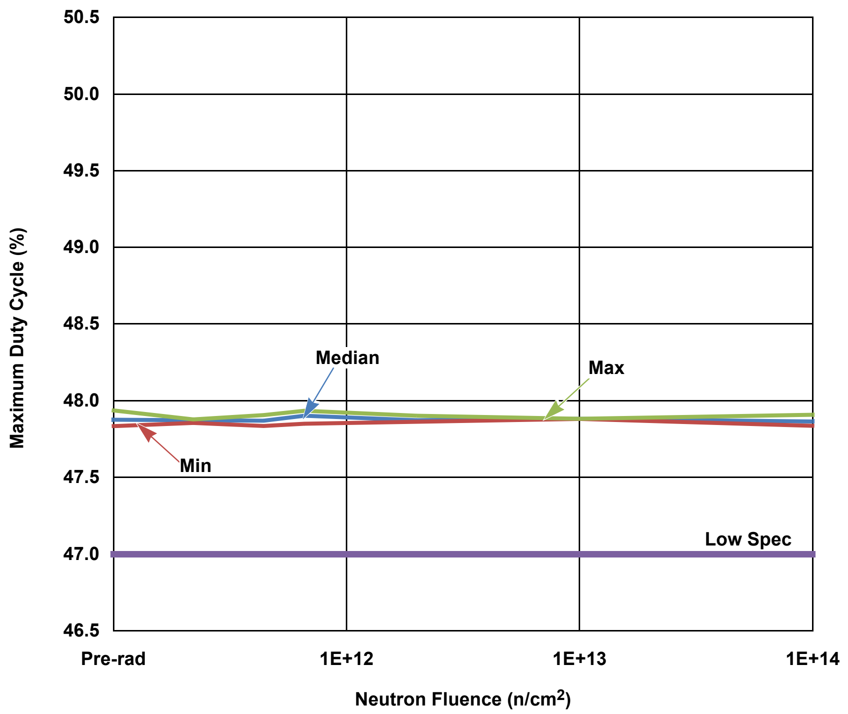

Figure 20. Maximum duty cycle as a function of neutron irradiation, showing the median, minimum and maximum of the populations at each level. Neutron fluences and sample sizes (in parentheses) were 2.2×10^{11}n/cm^2 (6 samples), 4.4×10^{11}n/cm^2 (6 samples), 6.6×10^{11}n/cm^2 (6 samples), 1×10^{12}n/cm^2 (3 samples), 1×10^{13}n/cm^2 (3 samples) and 1×10^{14}n/cm^2 (3 samples). The datasheet limit is 47% minimum.

3. Discussion and Conclusion

The results of neutron testing for the ISL7104xM current mode PWM controllers were reported. Samples were irradiated to levels of $2.2{\times}10^{11}n/cm^2$, $4.4{\times}10^{11}n/cm^2$, $6.6{\times}10^{11}n/cm^2$, $1{\times}10^{12}n/cm^2$, $1{\times}10^{13}n/cm^2$, and $1{\times}10^{14}n/cm^2$, with sample sizes of six each for the first three cells and three each for the last three cells. It should again be carefully realized when interpreting the attributes and variables data that each neutron irradiation was performed on a different sample; this is not total dose testing, where a single set of samples is used and the damage is cumulative. ATE characterization testing was performed before and after the irradiations, and two control units were used to ensure repeatable data. Variables data for monitored parameters is presented in Figure 1 through Figure 20.

The devices are built in a junction-isolated sub-micron BiCMOS process; the bipolar transistors are minority carrier devices, obviously, and may be expected to be sensitive to Displacement Damage (DD) at the higher neutron levels. This expectation turned out to be correct.

- The Undervoltage Lockout (UVLO) START and STOP threshold voltages (Figure 1 and Figure 2) showed good stability after all neutron levels.
- The startup current, operating current and operating supply current (Figure 3 through Figure 5) showed excellent stability after all neutron levels.
- The reference voltage accuracy (Figure 6) showed good stability after all neutron levels, with a gradually decreasing range at the higher levels.
- The reference sourcing and sinking current limits (Figure 7 and Figure 8) showed excellent stability after all neutron levels.
- The current sense input bias current (Figure 9) showed good stability to the $1{\times}10^{13}n/cm^2$ level but decreased significantly after $1{\times}10^{14}n/cm^2$. The parameter was near the lower datasheet limit after $1{\times}10^{14}n/cm^2$.
- The current sense maximum input signal (Figure 10) showed some degradation at the highest two neutron levels but remained well within the datasheet limits.
- The current sense gain (Figure 11) showed good stability at the lower levels but was nonfunctional after $1{\times}10^{14}n/cm^2$, with two of the three samples failing this test.
- The error amplifier reference voltage (Figure 12) showed good stability after all neutron levels.
- The error amplifier input bias current and sink current (Figure 13 and Figure 14) showed good stability to the $1{\times}10^{13}n/cm^2$ level but decreased significantly after $1{\times}10^{14}n/cm^2$. Both parameters remained within the datasheet limits.
- The error amplifier source current (Figure 15) showed good stability after all neutron levels.
- The error amplifier HIGH and LOW output voltages (Figure 16 and Figure 17) showed good stability to the $1{\times}10^{13}n/cm^2$ level with slight decreases after $1{\times}10^{14}n/cm^2$.
- The oscillator frequency (Figure 18) showed good stability to the $1{\times}10^{13}n/cm^2$ level but decreased significantly after $1{\times}10^{14}n/cm^2$. The parameter remained well within the datasheet limits.
- The current sense to output delay (Figure 19) showed good stability after all neutron levels.
- The maximum duty cycle (Figure 20) showed good stability after all neutron levels.

Based on these results, it can be concluded that the ISL7104xM devices are capable of post-irradiation operation at $1{\times}10^{13}n/cm^2$, likely with some relaxation of parametric specifications, while remaining within the datasheet post-total dose parameters. The part is not capable of post $1{\times}10^{14}n/cm^2$ operation as it was nonfunctional, failing the current-sense gain parameter.

4. Revision History

Revision	Date	Description
1.00	Apr 20, 2026	Initial release.

A. Appendix

Table 1 lists the datasheet parameters that are considered indicative of part performance. These parameters are plotted in Figure 1 through Figure 20. All limits are taken from the *ISL71041M/ISL71043M Datasheet*, which has more details about the test conditions.

Table 1. Reported Parameters

Figure	Parameter	Low Limit	High Limit	Unit
1	UVLO START Threshold Voltage (Only ISL71043M shown)	8	9	V
2	UVLO STOP Threshold Voltage (Only ISL71043M shown)	7.3	8	V
3	Startup Current	-	500	µA
4	Operating Current	-	4	mA
5	Operating Supply Current	-	5.5	mA
6	Reference Voltage Accuracy	4.925	5.050	V
7	Reference Current Limit, Sourcing	-20	-	mA
8	Reference Current Limit, Sinking	5	-	mA
9	Current Sense Input Bias Current	-1	1	µA
10	Current Sense Maximum Input Signal	0.97	1.03	V
11	Current Sense Gain	2.75	3.15	V/V
12	Error Amplifier Reference Voltage	2.475	2.530	V
13	Error Amplifier Input Bias Current	-1.5	1.5	µA
14	Error Amplifier Sink Current	1	-	mA
15	Error Amplifier Source Current	-0.4	-	mA
16	Error Amplifier HIGH Output Voltage	4.80	5.05	V
17	Error Amplifier LOW Output Voltage	0.4	1	V
18	Oscillator Frequency	48	54	kHz
19	Current Sense To Output Delay	-	60	ns
20	Maximum Duty Cycle	47	-	%

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TOYOSU FORESIA, 3-2-24 Toyosu,
Koto-ku, Tokyo 135-0061, Japan
www.renesas.com

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