ISL71610x

Neutron Testing of the ISL71610x Passive-Input Digital Isolator

Introduction

This report summarizes the 1MeV equivalent neutron testing results of the ISL71610SLHM and ISL71610M passive-input digital signal isolator with a CMOS output. 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 5×10^{11}n/cm^2 to 1×10^{13}n/cm^2.

Product Description

The ISL71610x is a passive-input digital signal isolator with a CMOS output. It has a similar interface as traditional optocouplers but has better performance and higher package density.

The ISL71610x is manufactured with Giant Magnetoresistive (GMR) technology for small size, high speed, and low power. A ceramic/polymer composite barrier provides excellent isolation and an unlimited barrier life. A series external resistor sets the input coil current, and a capacitor in parallel with the current-limiting resistor provides improved dynamic performance. This versatile component can replace various optocouplers and function over a wide range of data rates, edge speeds, and power supply levels. The device output is compatible with 3.3V and 5V supplies, allowing an interface to the controller without additional level shifting. With the coil energized with a minimum of ±8mA (bidirectional current), the ISL71610x is suitable for single-ended and differential drive applications.

The ISL71610x is offered in an 8 Ld 5mm×4mm SNOIC package and is fully specified across the military ambient temperature range of -55°C to +125°C.

The pin assignments for the ISL71610x are shown in Figure 1, and the pin descriptions are in Table 1.

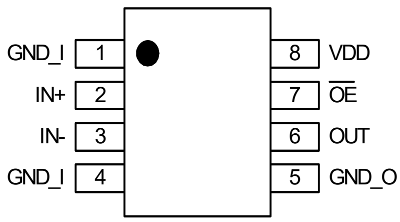

Figure 1. Pin Assignments

Table 1. ISL71610x Pin Descriptions

Pin Number	Pin Name	Description
1, 4	GND_I	No internal connection. Use for input shielding, connect to input side ground.
2	IN+	Coil connection. The voltage applied to IN+ is more negative than IN- to cause the voltage of OUT to switch to V_{OL} (logic low).
3	IN-	Coil connection. The voltage applied to IN- is more positive than IN+ to cause the voltage of OUT to switch to V_{OL} (logic low).
5	GND_O	Ground return for V_{DD}
6	OUT	Data output. The OUT pin logic high is the zero input current state.

Table 1. ISL71610x Pin Descriptions (Cont.)

Pin Number	Pin Name	Description
7	$\overline{OE}$	Output enable, active low. Internally pulled low with 100kΩ to enable the output when this pin is not connected.
8	VDD	Receiver supply voltage.

Contents

1. Test Description

1.1 Irradiation Facilities

Neutron fluence irradiations were performed on the test samples on March 29, 2023, at the University of Massachusetts, Lowell (UMASS Lowell) fast neutron irradiator per Mil-STD-883G, Method 1017.2, with each part unpowered during irradiation. The target irradiation levels were 5×10^{11}n/cm^2, 2×10^{12}n/cm^2, and 1×10^{13}n/cm^2. As neutron irradiation activates many 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 4.2 Test Fixturing

No formal irradiation test fixturing is involved, as these DD tests are bag tests in the sense that the parts are irradiated with all leads unbiased.

1.3 Radiation Dosimetry

Table 2 shows dosimetry from UMASS Lowell, indicating the total accumulated gamma dose and actual neutron fluence exposure levels for each set of samples.

Table 2. ISL71610x Neutron Fluence Dosimetry Data

Irradiation	Requested Fluence (n/cm^2)	Reactor Power (kW)	Time (s)	Flux (n/cm^2-s)[1][2]	Gamma Dose (rad(Si))[3]	Measured Fluence (n/cm^2)[4]
CRF#77981-B	5.00E+11	50	131	3.83E+09	75	5.30E+11
CRF#77981-C	2.00E+12	80	327	6.12E+09	298	2.33E+12
CRF#77981-D	1.00E+13	1000	131	7.65E+10	1492	1.04E+13

1. Dosimetry method: ASTM E-265
2. The neutron fluence rate is determined from *Initial Testing of the New Ex-Core Fast Neutron Irradiator at UMass Lowell* (6/18/02). Validated on 6/07/2011 under the Trident II D5LE neutron facility study by Navy Crane.
3. Based on reactor power at 1000kW, the gamma dose is 41 ±5.3% krad(Si)/hr as mapped by TLD-based dosimetry.
4. Validated by S-32 flux monitors.

1.4 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.

1.5 Experimental Matrix

Testing proceeded in general accordance with the guidelines of MIL-STD-883 TM 1017. The experimental matrix consisted of six samples to be irradiated at 5×10^{11}n/cm^2, six at 2×10^{12}n/cm^2, and six at 1×10^{13}n/cm^2. The actual levels achieved, shown in Table 3, were 5.3×10^{11}n/cm^2, 2.3×10^{12}n/cm^2, and 1×10^{13}n/cm^2. Two control units were used.

The 18 ISL71610x samples were drawn from Lot 212010. Samples were packaged in the standard 8 Ld 5mm×4mm SNOIC package. Samples were processed through burn-in before irradiation and screened to the datasheet limits at room, low, and high temperatures before neutron testing.

2. Results

Neutron testing of the ISL71610x 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 3. ISL71610x Attributes Data

1MeV Fluence, (n/cm^2)		Sample Size	Pass[1]	Fail	Notes
Planned	Actual				
$5{\times}10^{11}$	$5.30{\times}10^{11}$	6	6	0	All passed
$2{\times}10^{12}$	$2.33{\times}10^{12}$	6	6	0	All passed
$1{\times}10^{13}$	$1.04{\times}10^{13}$	6	6	0	All passed

1. A Pass indicates a sample that passes all post-irradiation datasheet limits.

2.2 Key Parameter Variables Data

The plots in Figure 2 through Figure 18 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 also 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 datasheet are also shown, it should be noted that these limits are provided for guidance only as the ISL71610x is not specified for the neutron environment.

All samples passed the post-irradiation datasheet limits after all three exposures up to and including $1.04{\times}10^{13}n/cm^2$.

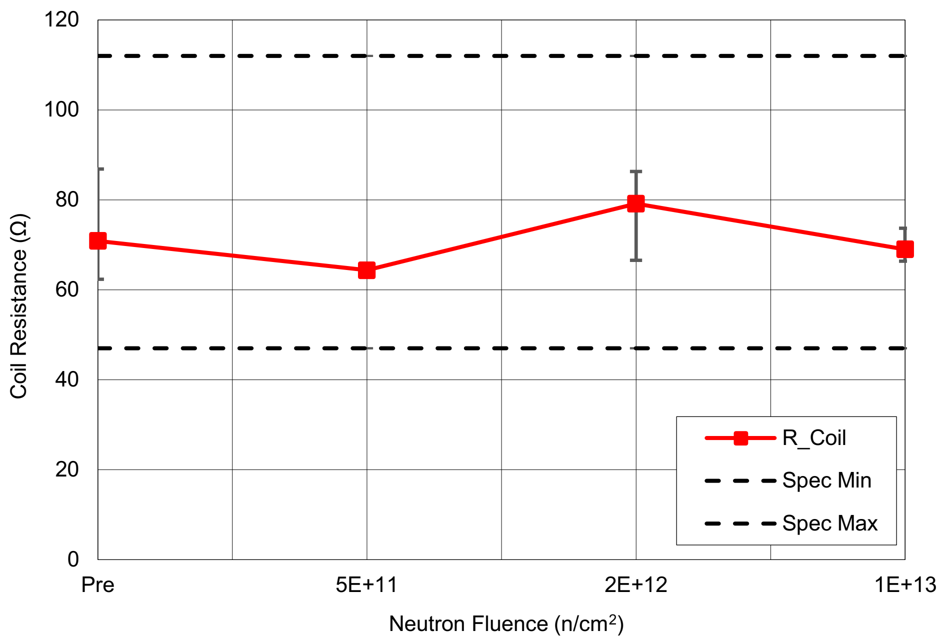

Figure 2. ISL71610x average coil resistance (R_{COIL}) as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limits are 47Ω minimum and 112Ω maximum.

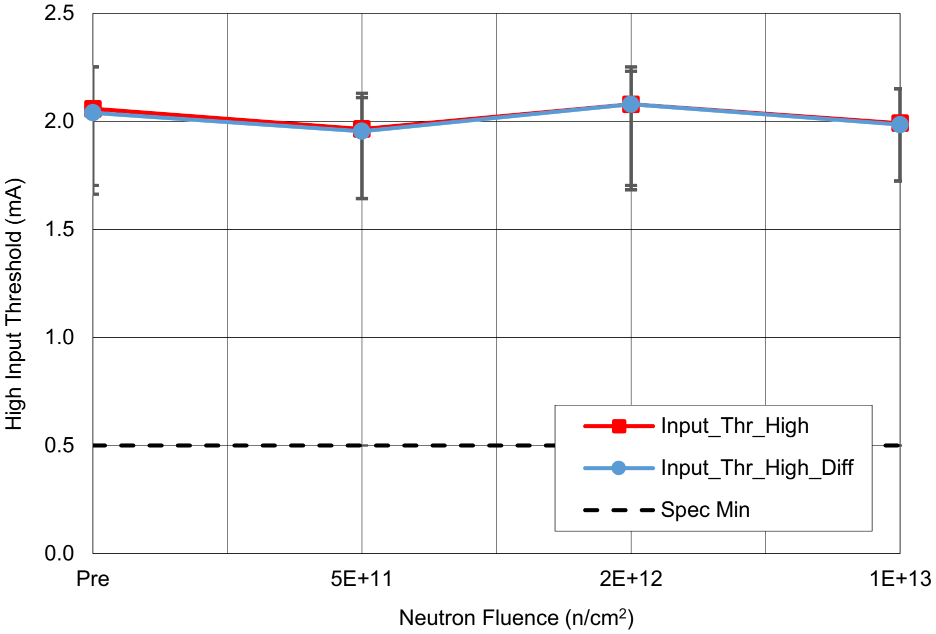

Figure 3. ISL71610x average high input threshold, DC single ended ($I_{INH\text{-}DC}$) and differential ($I_{INH\text{-}DIFF}$) as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limit is 0.5mA minimum.

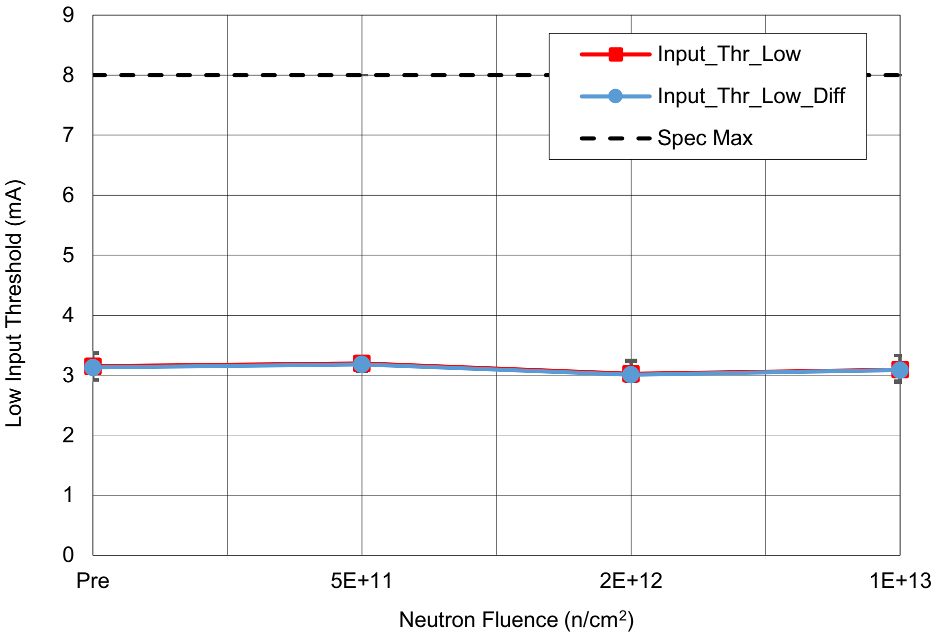

Figure 4. ISL71610x average low input threshold, DC single ended ($I_{INL\text{-}DC}$) and differential ($I_{INL\text{-}DIFF}$) as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limit is 8mA maximum.

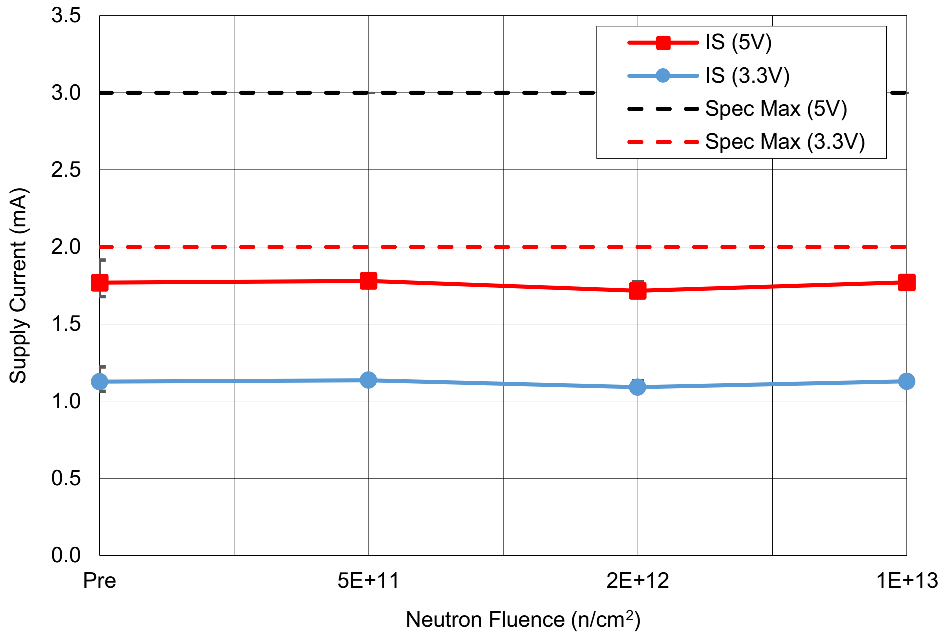

Figure 5. ISL71610x average quiescent current (I_{DDQ}) with V_{DD} = 5.0V and 3.3V and IN+ = IN- = OPEN as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limit is 2mA maximum for 3.3V and 3mA maximum for 5V.

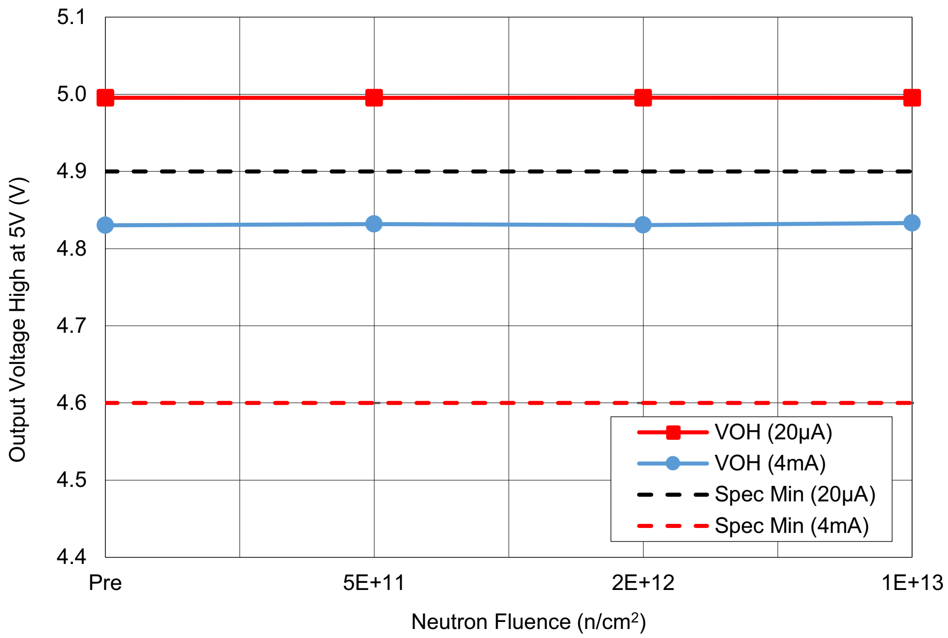

Figure 6. ISL71610x average output voltage high (V_{OH}) with V_{DD} = 5V and I_{OUT} = 20µA and 4mA as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The datasheet limit is 4.9V minimum for 20µA and 4.6V minimum for 4mA.

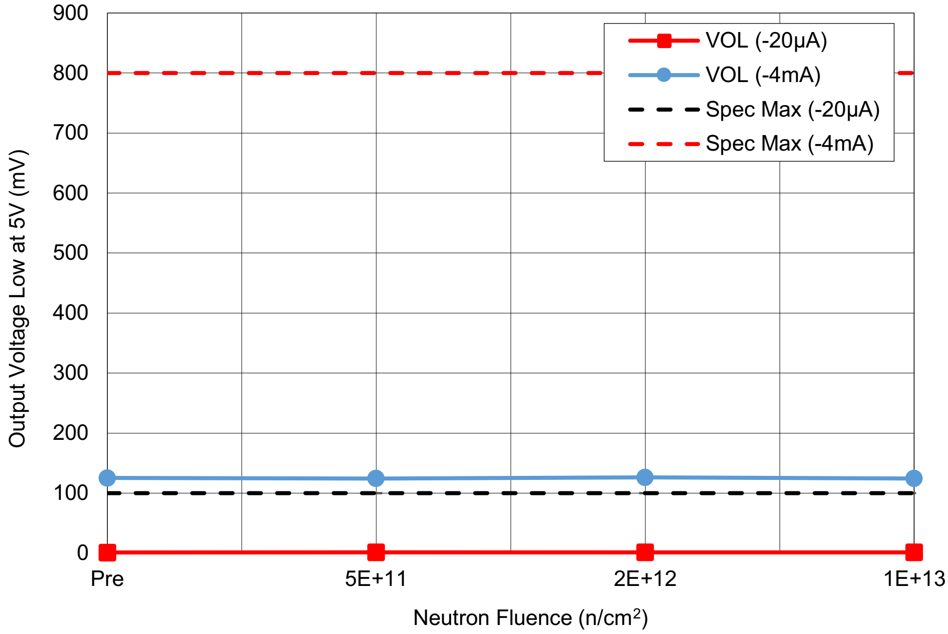

Figure 7. ISL71610x average output voltage low (V_{OL}) with V_{DD} = 5V and I_{OUT} = -20µA and -4mA as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The datasheet limit is 100mV maximum for -20µA and 800mV maximum for -4mA.

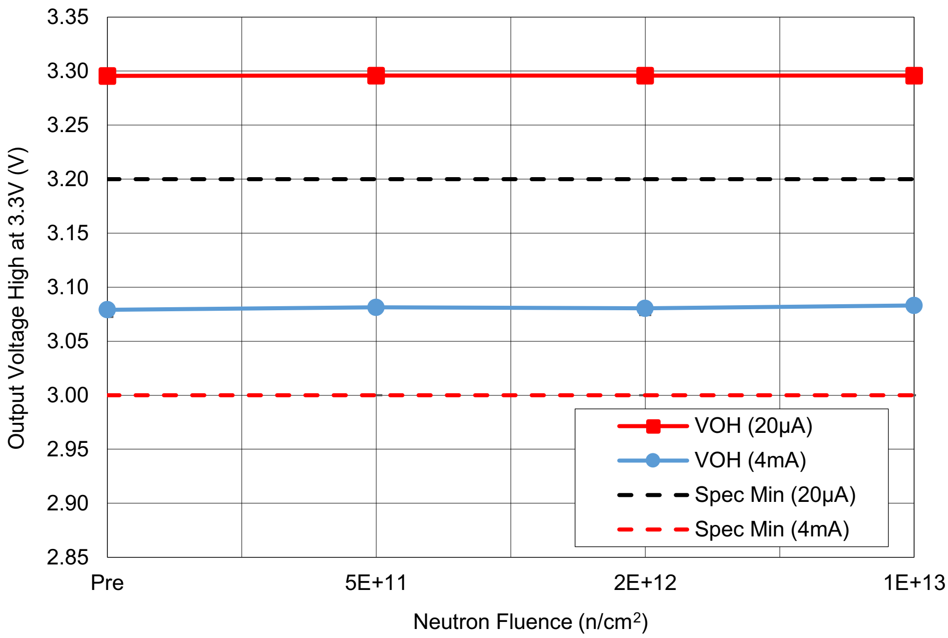

Figure 8. ISL71610x average output voltage high (V_{OH}) with V_{DD} = 3.3V and I_{OUT} = 20µA and 4mA as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The datasheet limit is 3.2V minimum for 20µA and 3.0V minimum for 4mA.

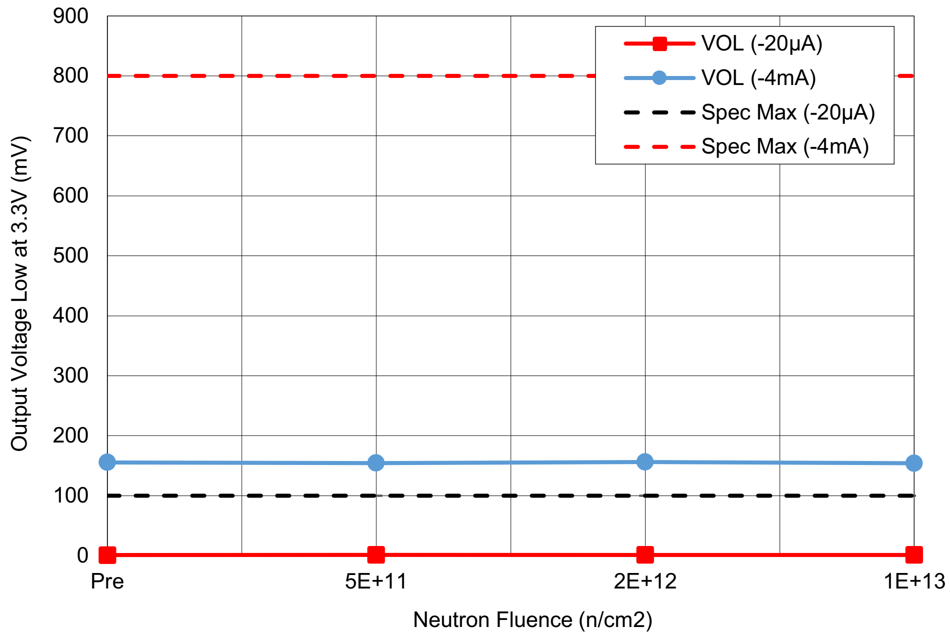

Figure 9. ISL71610x average output voltage low (V_{OL}) with V_{DD} = 3.3V and I_{OUT} = -20µA and -4mA as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The datasheet limit is 100mV maximum for -20µA and 800mV maximum for -4mA.

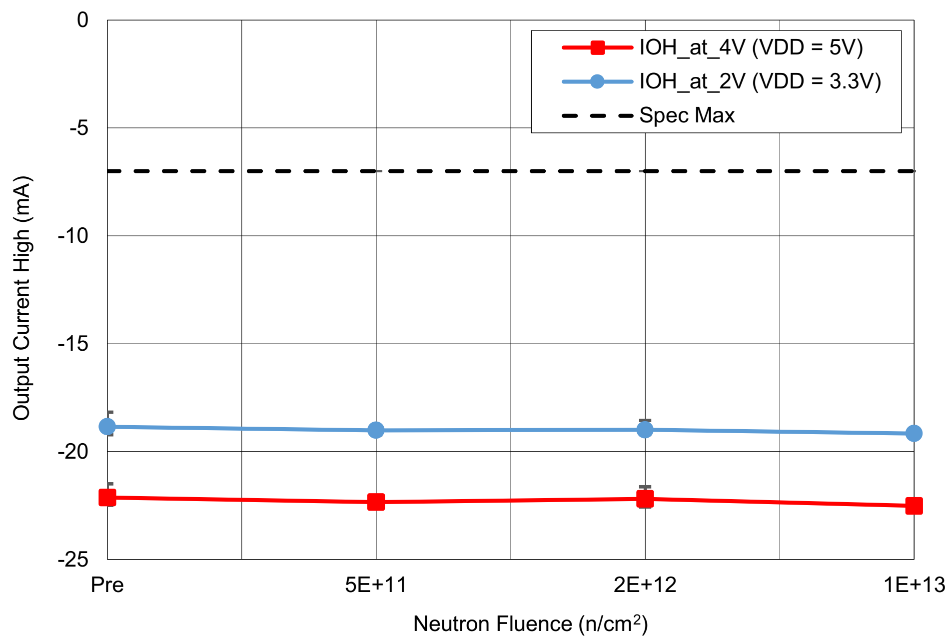

Figure 10. ISL71610x average logic high output drive current (I_{OH}) with V_{DD} = 3.3V and 5V as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limit is -7.0mA maximum.

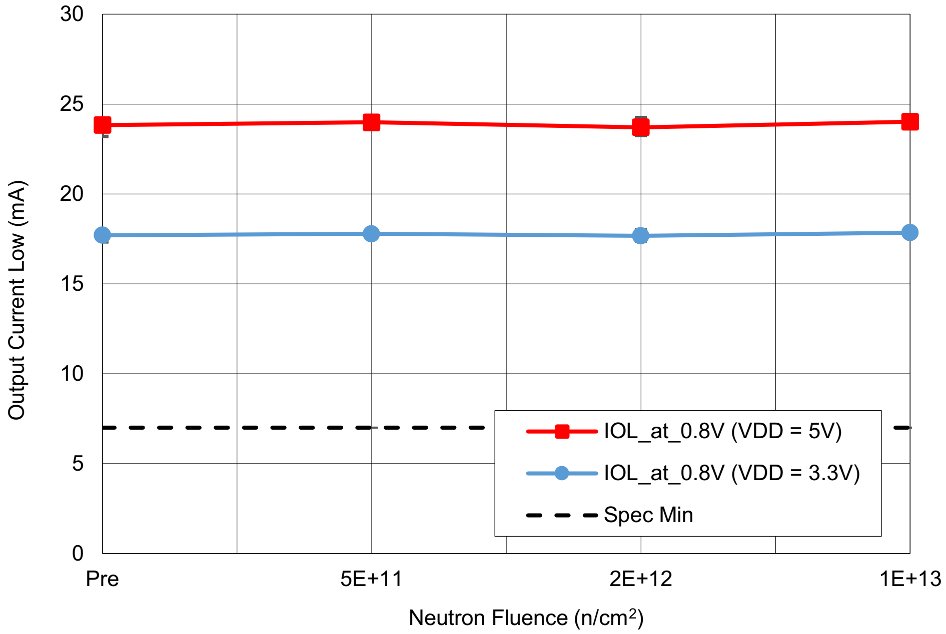

Figure 11. ISL71610x average logic low output drive current (I_{OL}) with V_{DD} = 3.3V and 5V as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limit is 7.0mA minimum.

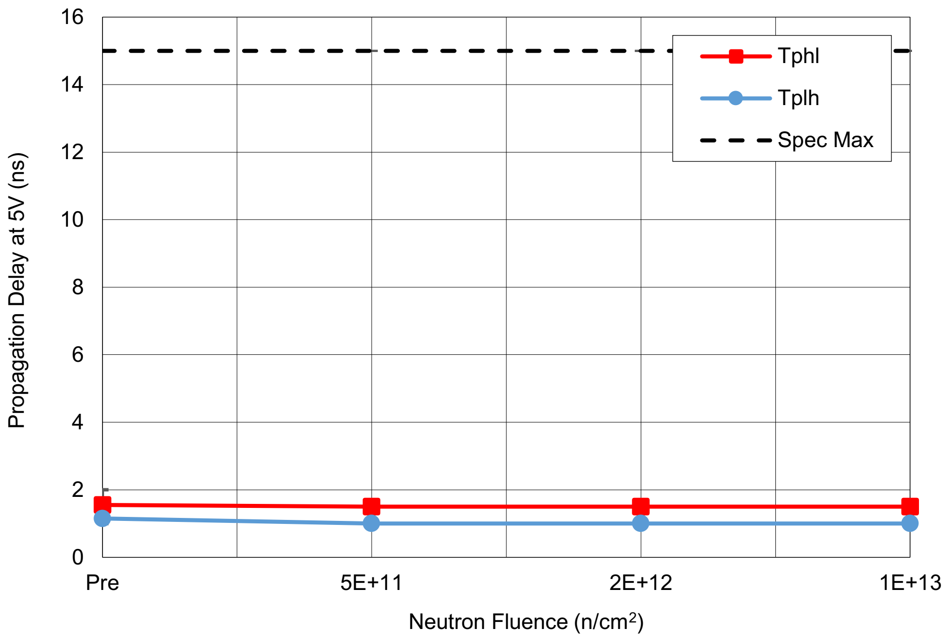

Figure 12. ISL71610x average propagation delay (t_{PHL}, t_{PLH}) with V_{DD} = 5V as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The datasheet limit is 15ns maximum.

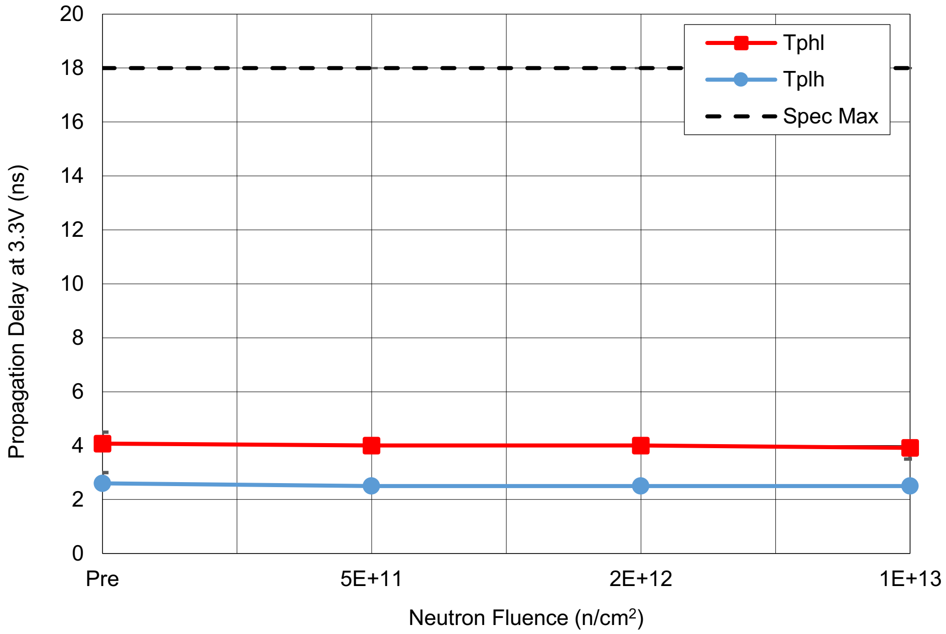

Figure 13. ISL71610x average propagation delay (t_{PHL}, t_{PLH}) with V_{DD} = 3.3V as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The datasheet limit is 18ns maximum.

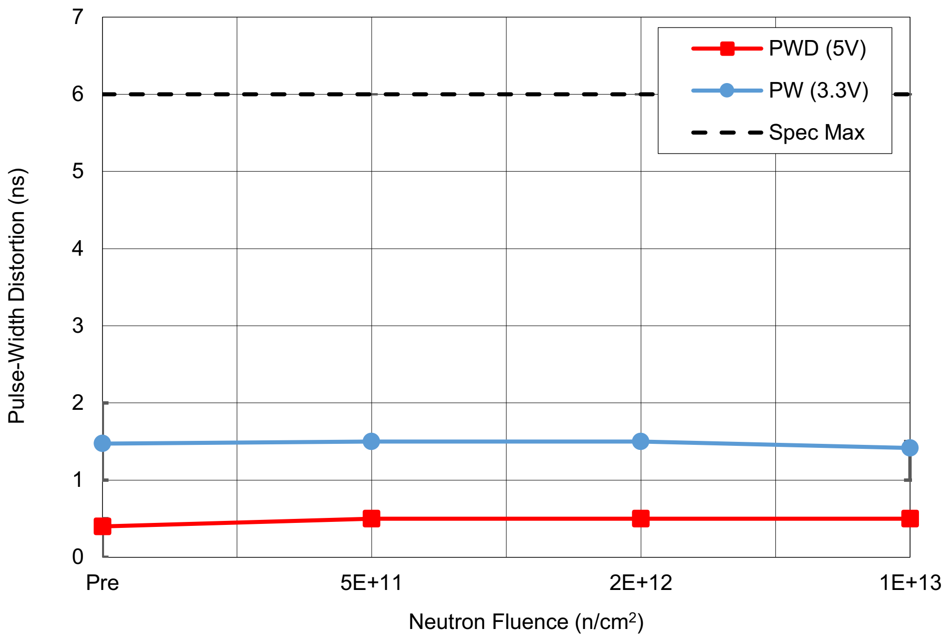

Figure 14. ISL71610x average pulse width distortion (PWD) as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The datasheet limit is 6ns maximum.

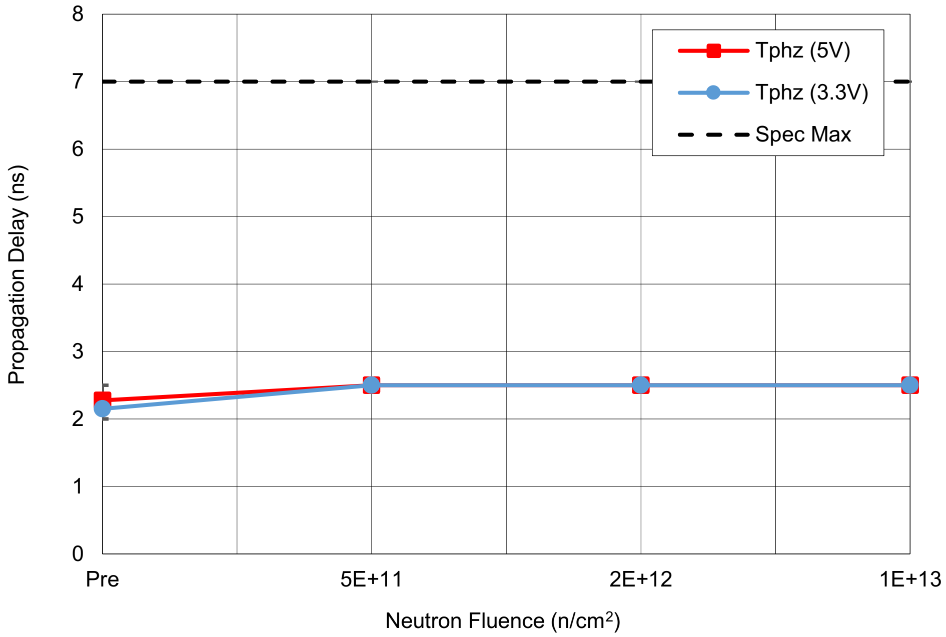

Figure 15. ISL71610x average enable to output propagation delay, high-to-high impedance (t_{PHZ}) with V_{DD} = 3.3V and 5V as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The datasheet limit is 7ns maximum.

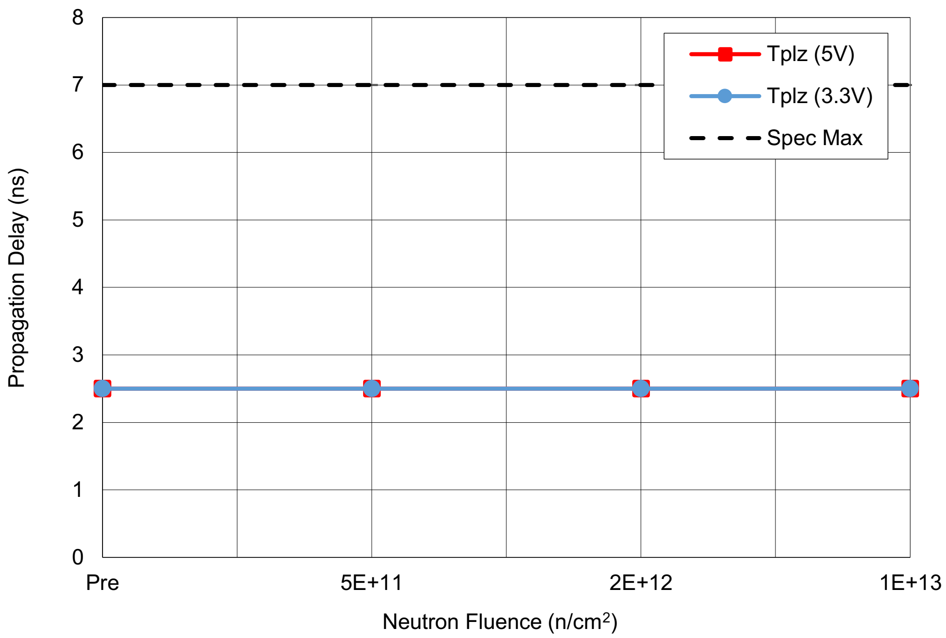

Figure 16. ISL71610x average enable to output propagation delay, low-to-high impedance (t_{PLZ}) with V_{DD} = 3.3V and 5V as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The datasheet limit is 7ns maximum.

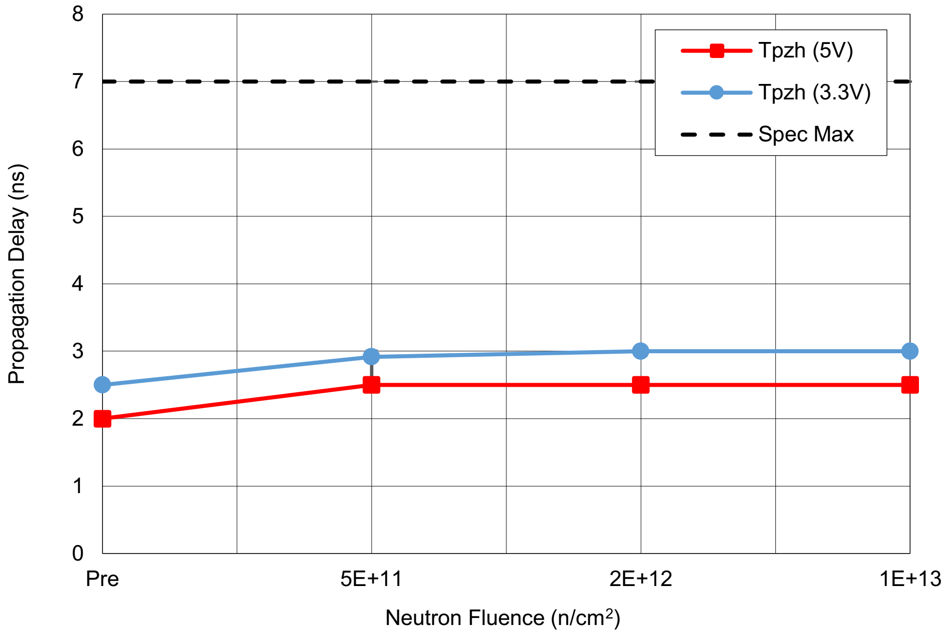

Figure 17. ISL71610x average enable to output propagation delay, high impedance-to-high (t_{PZH}) with V_{DD} = 3.3V and 5V as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The datasheet limit is 7ns maximum.

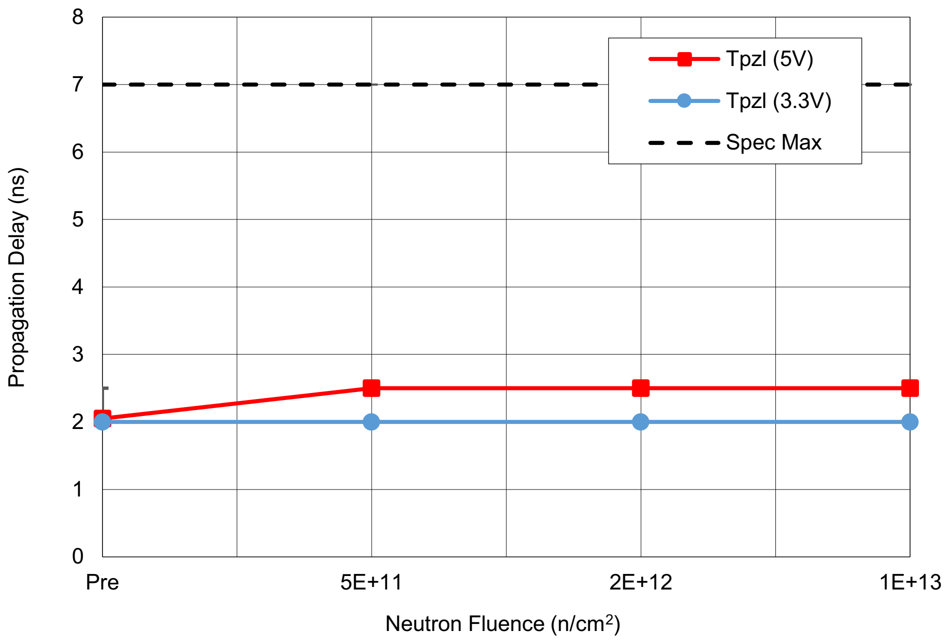

Figure 18. ISL71610x average enable to output propagation delay, high impedance-to-low (t_{PZL}) with V_{DD} = 3.3V and 5V as a function of neutron fluence. The error bars (if visible) represent the minimum and maximum measured values. The datasheet limit is 7ns maximum.

3. Discussion and Conclusion

The 1MeV equivalent neutron testing of the ISL71610x radiation tolerant passive-input digital isolator was reported. Parts were tested at actual fluences of 5.30×10^{11}n/cm^2, 2.33×10^{12}n/cm^2, and 1.04×10^{13}n/cm^2. The results of key parameters before and after irradiation to each level are plotted in Figure 2 through Figure 18. The plots show the mean of each parameter as a function of neutron irradiation, with error bars representing the minimum and maximum measured values. The figures also show the applicable electrical limits taken from the datasheet.

Note: These limits are provided for guidance only as the ISL71610x is not specified for the neutron environment.

All samples passed the datasheet limits with little to no degradation after all exposures up to and including 1.04×1013n/cm2.

4. Revision History

Revision	Date	Description
1.00	May 10, 2023	Initial release.

A. Appendix

A.1 Reported Parameters

Table 4 lists the key parameters that are considered indicative of part performance. These parameters are plotted in Figure 2 through Figure 18. All limits are taken from the ISL71610SLHMBZ/ISL71610MBZ datasheets.

Table 4. ISL71610x Key Parameters (T_A = 25°C)

Fig.	Parameter	Symbol	Conditions	Low Limit	High Limit	Unit
2	Coil Input Resistance	R_{COIL}	V_{DD} = 3.0 - 5.5V	47	112	Ω
3	DC High Input Threshold	I_{INH-DC}	Single-ended circuit, V_{DD} = 4.5 - 5.5V	0.5	-	mA
		$I_{INH-DIFF}$	Differential circuit, V_{DD} = 3.0 - 5.5V, C_{BOOST} = 0pF			
4	DC Low Input Threshold	I_{INL-DC}	Single-ended circuit, V_{DD} = 4.5 - 5.5V	-	8	mA
		$I_{INL-DIFF}$	Differential Circuit, V_{DD} = 3.0 - 5.5V, C_{BOOST} = 0pF			
5	Quiescent Current	I_{DDQ}	V_{DD} = 5.0V, IN+ = IN- = OPEN	-	3	mA
			V_{DD} = 3.3V, IN+ = IN- = OPEN	-	2	
6	Logic High Output Voltage	V_{OH}	V_{DD} = 5V, I_{OUT} = 20µA	4.9	-	V
			V_{DD} = 5V, I_{OUT} = 4mA	4.6	-	
7	Logic Low Output Voltage	V_{OL}	V_{DD} = 5V, I_{OUT} = -20µA	-	0.1	V
			V_{DD} = 5V, I_{OUT} = -4mA	-	0.8	
8	Logic High Output Voltage	V_{OH}	V_{DD} = 3.3V, I_{OUT} = 20µA	3.2	-	V
			V_{DD} = 3.3V, I_{OUT} = 4mA	3.0	-	
9	Logic Low Output Voltage	V_{OL}	V_{DD} = 3.3V, I_{OUT} = -20µA	-	0.1	V
			V_{DD} = 3.3V, I_{OUT} = -4mA	-	0.8	
10	Logic High Output Drive Current	I_{OH}	V_{DD} = 3.3V, 5V	-	-7	mA
11	Logic Low Output Drive Current	I_{OL}	V_{DD} = 3.3V, 5V	7	-	mA
12	Propagation Delay	t_{PHL}	V_{DD} = 5V, single-ended circuit, T_{IR} = T_{IF} = 3ns, C_{BOOST} = C_{OUT} = 16pF, R_{OUT} = 1kΩ	-	15	ns
		t_{PLH}				
13	Propagation Delay	t_{PHL}	V_{DD} = 3.3V, single-ended circuit, T_{IR} = T_{IF} = 3ns, C_{BOOST} = C_{OUT} = 16pF, R_{OUT} = 1kΩ	-	18	ns
		t_{PLH}				
14	Pulse Width Distortion	PWD	V_{DD} = 3.3V, 5V, single-ended circuit, T_{IR} = T_{IF} = 3ns, C_{BOOST} = C_{OUT} = 16pF, R_{OUT} = 1kΩ	-	6	ns
15	Propagation Delay Enable to Output (High-to-High Impedance)	t_{PHZ}	V_{DD} = 3.3V, 5V, C_L = 15pF	-	7	ns
16	Propagation Delay Enable to Output (Low-to-High Impedance)	t_{PLZ}	V_{DD} = 3.3V, 5V, C_L = 15pF	-	7	ns

Table 4. ISL71610x Key Parameters (T_A = 25°C) (Cont.)

Fig.	Parameter	Symbol	Conditions	Low Limit	High Limit	Unit
17	Propagation Delay Enable to Output (High Impedance-to-High)	t_{PZH}	V_{DD} = 3.3V, 5V, C_L = 15pF	-	7	ns
18	Propagation Delay Enable to Output (High Impedance-to-Low)	t_{PZL}	V_{DD} = 3.3V, 5V, C_L = 15pF	-	7	ns

A.2 Related Information

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

- ISL71610SLHM and ISL71610M device pages
- MIL-STD-883 Test Method 1017

Corporate Headquarters

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

Contact Information

For further information on a product, technology, the most up-to-date version of a document, or your nearest sales office, please visit:
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