ISL71610x

High Dose Rate Total Dose Testing of the ISL71610x Passive-Input Digital Isolator

Introduction

This report documents the results of high dose rate (HDR) total dose testing of the ISL71610SLHM and ISL71610M passive-input digital signal isolator with a CMOS output. The tests were conducted to provide an assessment of the HDR performance of the part and to provide an estimate of bias sensitivity. Parts were irradiated biased and unbiased at 69.2rad(Si)/s. The ISL71610SLHMBZ is rated at 75krad(Si) at a low dose rate (LDR), and the ISL71610MBZ is rated at 30krad(Si) at LDR. Neither part type is rated at HDR.

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 5 mm x 4 mm SNOIC package and is fully specified across the military ambient temperature range of -55°C to +125°C.

The pinout for the ISL71610x is shown in Figure 1, with the pin descriptions shown in Table 1.

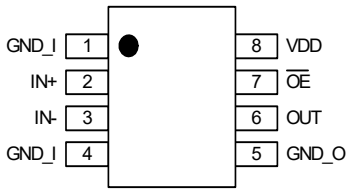

Figure 1. ISL71610x Package and Pin Assignments - Top View

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.
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.

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1. Test Description

1.1 Irradiation Facilities

The irradiation was performed at 69.2rad(Si)/s using a Gammacell 220 irradiator located in the Palm Bay, Florida, Renesas facility. This irradiator uses PbAl spectrum hardening filters to shield the test board and devices under test against low-energy secondary gamma radiation.

1.2 Test Fixturing

Figure 2 shows the configurations used for biased irradiation.

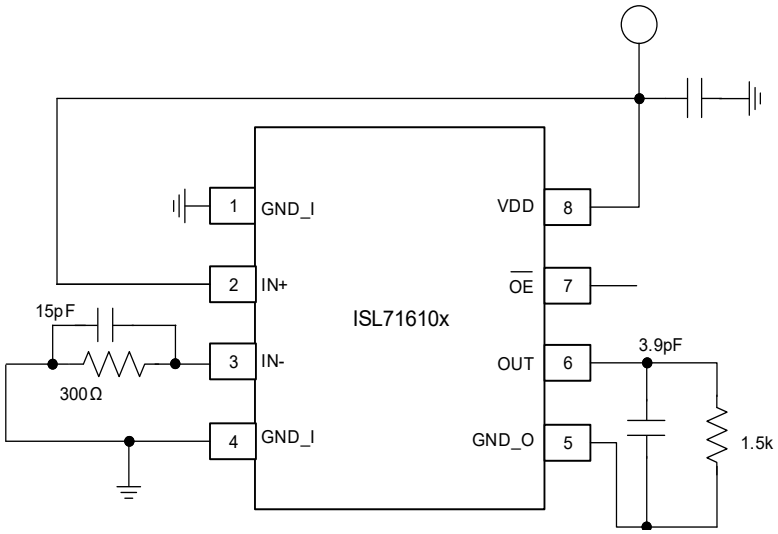

Figure 2. ISL71610x TID Bias Schematic (V_{DD} = 5.5V)

1.3 Characterization Equipment and Procedures

All electrical testing was performed at room temperature outside the irradiator, using production automated test equipment (ATE) with data logging at each down point.

1.4 Experimental Matrix

Irradiation was performed in accordance with the guidelines of MIL-STD-883 Test Method 1019. The experimental matrix consisted of eight samples irradiated under bias and seven samples irradiated with all pins grounded.

The ISL71610x samples were drawn from wafer lot 212010. All samples were packaged in the standard 8 Ld SOIC. Samples were processed through the standard burn-in cycle before irradiation.

1.5 Down-points

Down-points for the tests were 0, 10, 20, 30, 50, 75, 100, 125, and 150krad(Si). No anneal was performed.

2. Test Results

2.1 Attributes Data

The HDR characterization of the ISL71610x is complete. All datasheet parameters passed the datasheet limits. Table 2 summarizes the results.

Table 2. ISL71610x Total Dose Test Attributes Data

Dose Rate (rad(Si)/s)	Condition	Sample Size	Down-point	Pass[1]	Fail
69.2	Biased (Figure 2)	8	Pre-irradiation	8	
			10krad(Si)	8	0
			20krad(Si)	8	0
			30krad(Si)	8	0
			50krad(Si)	8	0
			75krad(Si)	8	0
			100krad(Si)	8	0
			125krad(Si)	8	0
			150krad(Si)	8	0
69.2	GND	7	Pre-irradiation	7	
			10krad(Si)	7	0
			20krad(Si)	7	0
			30krad(Si)	7	0
			50krad(Si)	7	0
			75krad(Si)	7	0
			100krad(Si)	7	0
			125krad(Si)	7	0
			150krad(Si)	7	0

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

2.2 Key Parameter Variables Data

The plots in Figure 3 through Figure 20 illustrate the HDR total ionizing dose response of selected parameters as shown in Table 3 in the Appendix. One leakage parameter (Figure 20) is informational and is not specified in the datasheet. The plots show the average tested values of the key parameters as a function of the total dose for both conditions, biased and grounded. 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 are not visible due to their values compared to the scale of the graph.

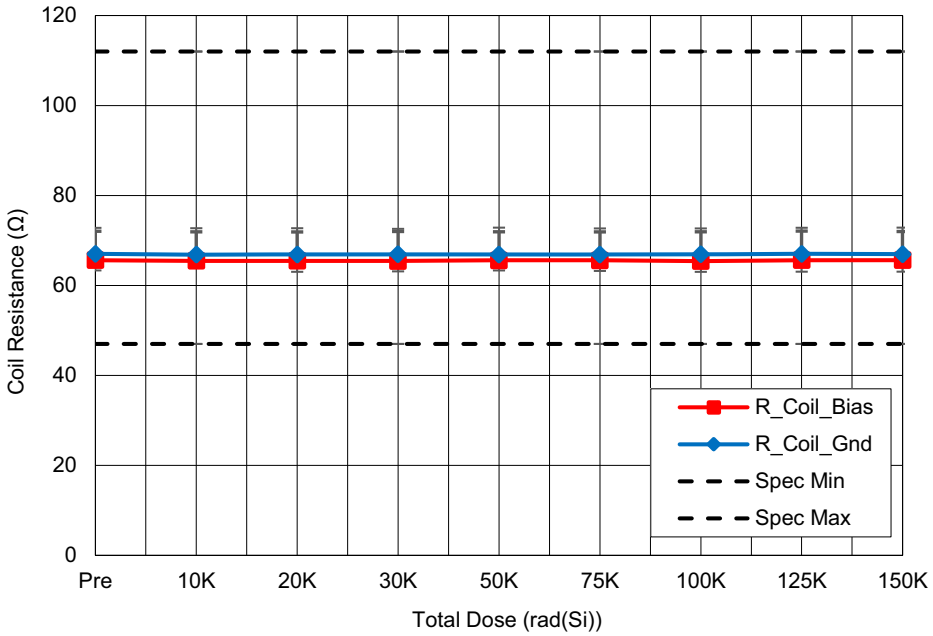

Figure 3. ISL71610x average coil resistance (R_{COIL}) as a function of HDR irradiation. The error bars represent the minimum and maximum measured values. The datasheet limits are 47Ω minimum and 112Ω maximum.

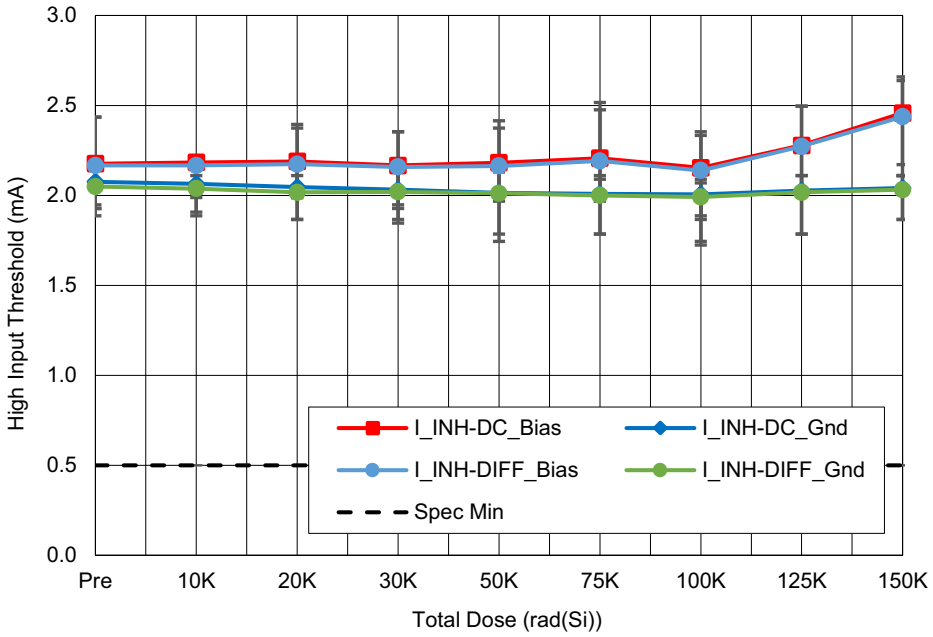

Figure 4. ISL71610x average high input threshold, DC single-ended (I_{INH-DC}) and differential ($I_{INH-DIFF}$) as a function of HDR irradiation. The error bars represent the minimum and maximum measured values. The datasheet limit is 0.5mA minimum.

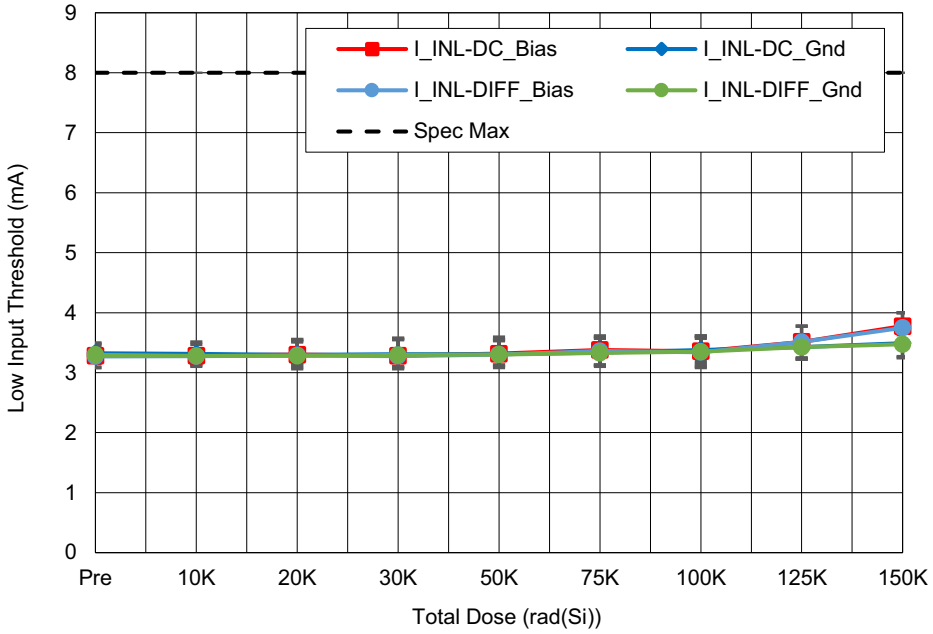

Figure 5. ISL71610x average low input threshold, DC single ended (I_{INL-DC}) and differential ($I_{INL-DIFF}$) as a function of HDR irradiation. The error bars represent the minimum and maximum measured values. The datasheet limit is 8mA maximum.

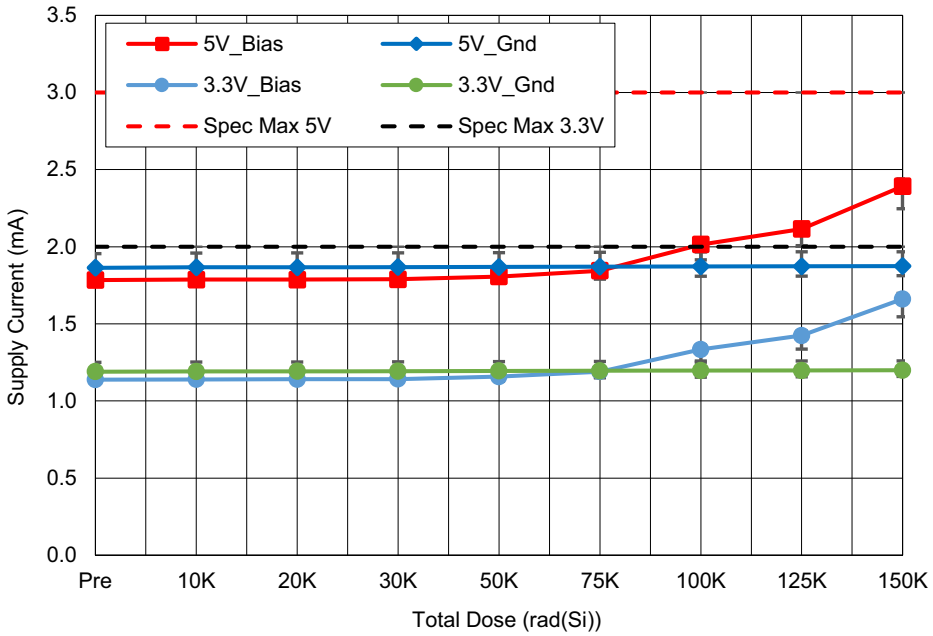

Figure 6. ISL71610x average quiescent current (I_{DDQ}) with V_{DD} = 5.0V and 3.3V and IN+ = IN- = OPEN as a function of HDR irradiation. The error bars represent the minimum and maximum measured values. The datasheet limit is 2mA maximum for 3.3V and 3mA maximum for 5V.

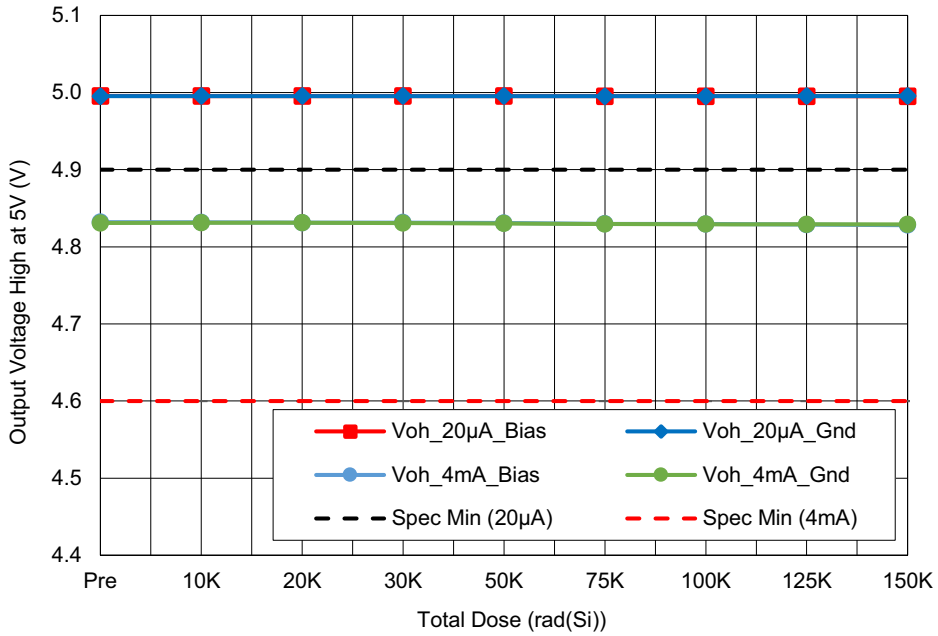

Figure 7. ISL71610x average output voltage high (V_{OH}) with V_{DD} = 5V and I_{OUT} = 20µA and 4mA as a function of HDR irradiation. The error bars (if visible) represent the minimum and maximum measured values. The datasheet limit is 4.9V minimum for 20µA and 4.6V minimum for 4mA.

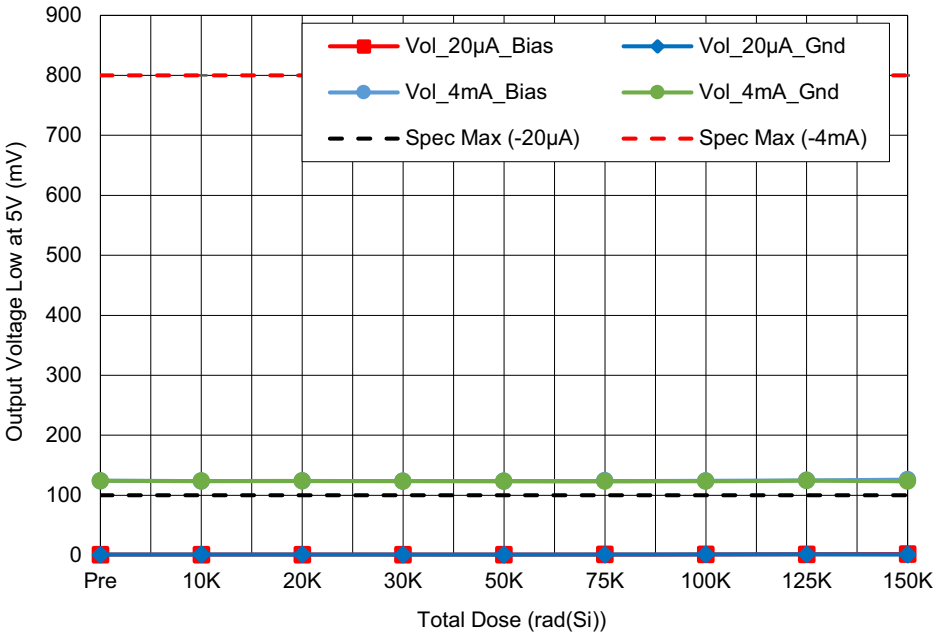

Figure 8. ISL71610x average output voltage low (V_{OL}) with V_{DD} = 5.0V and I_{OUT} = -20µA and -4mA as a function of HDR irradiation. The error bars (if visible) represent the minimum and maximum measured values. The datasheet limit is 100mV maximum for -20µA and 800mV maximum for -4mA.

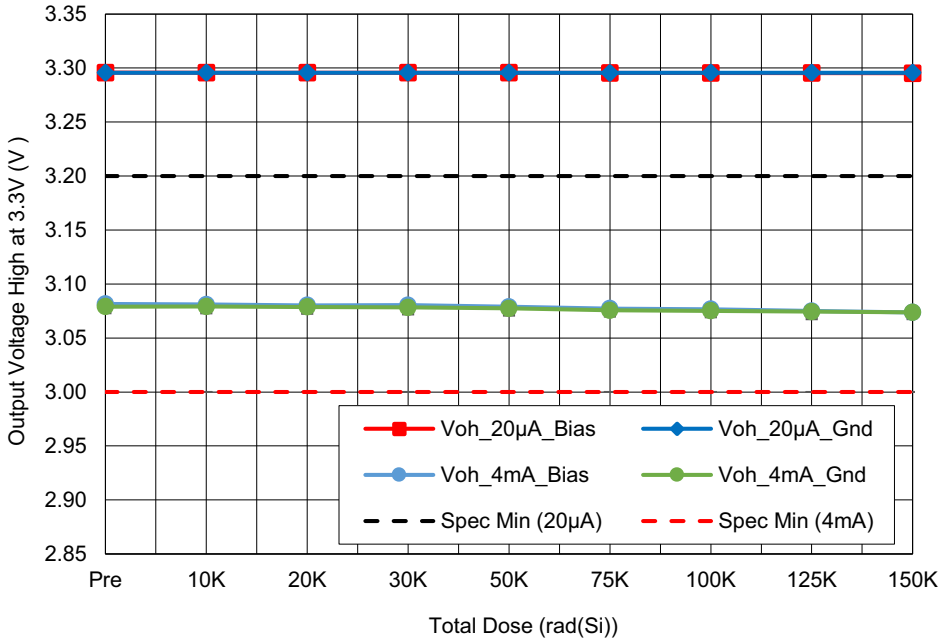

Figure 9. ISL71610x average output voltage high (V_{OH}) with V_{DD} = 3.3V and I_{OUT} = 20µA and 4mA as a function of HDR irradiation. The error bars (if visible) represent the minimum and maximum measured values. The datasheet limit is 3.2V minimum for 20µA and 3.0V minimum for 4mA.

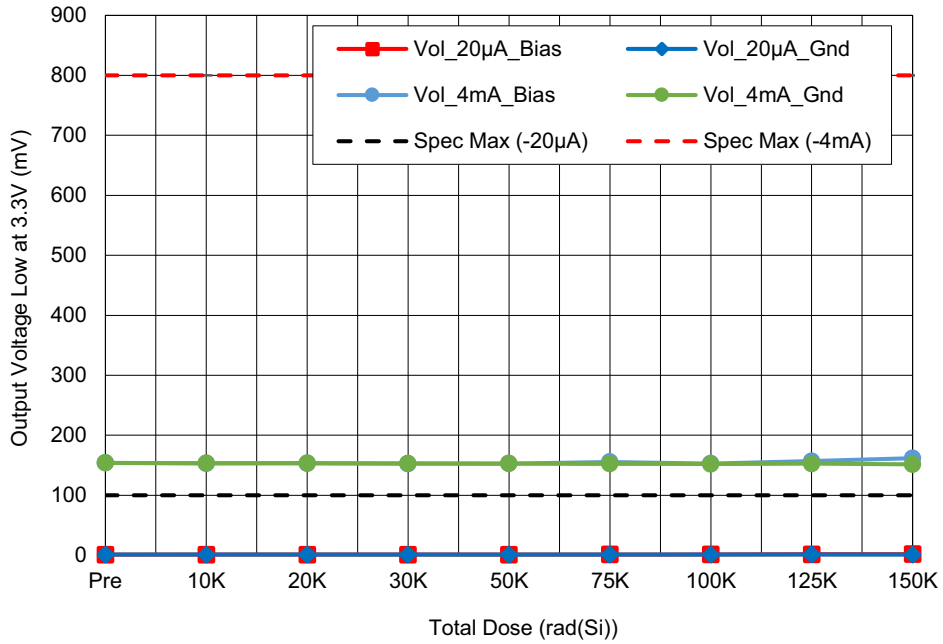

Figure 10. ISL71610x average output voltage low (V_{OL}) with V_{DD} = 3.3V and I_{OUT} = -20µA and -4mA as a function of HDR irradiation. The error bars (if visible) represent the minimum and maximum measured values. The datasheet limit is 100mV maximum for -20µA and 800mV maximum for -4mA.

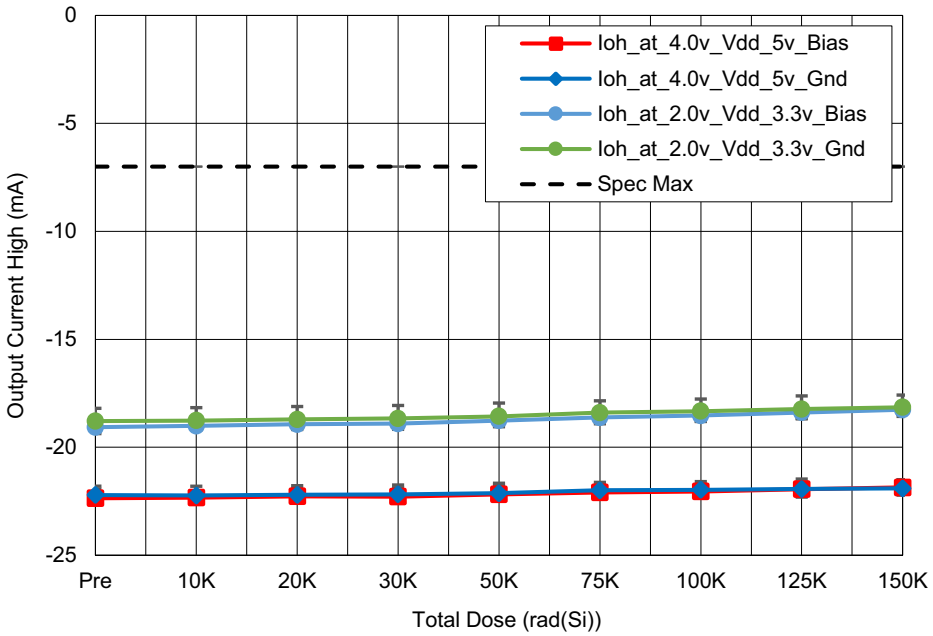

Figure 11. ISL71610x average logic high output drive current (I_{OH}) with V_{DD} = 3.3V and 5V as a function of HDR irradiation. The error bars represent the minimum and maximum measured values. The datasheet limit is -7.0mA maximum.

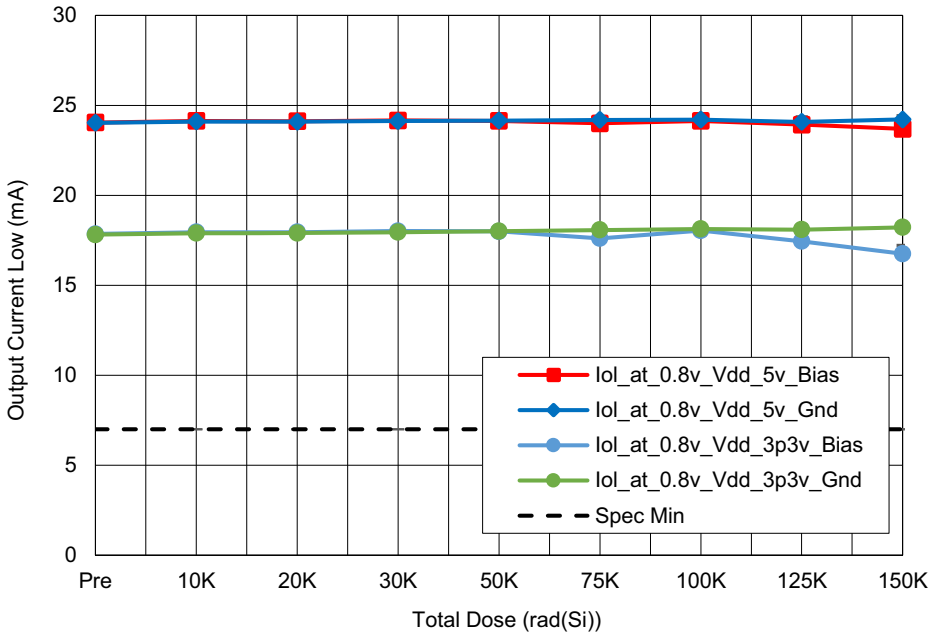

Figure 12. ISL71610x average logic low output drive current (I_{OL}) with V_{DD} = 3.3V and 5V as a function of HDR irradiation. The error bars represent the minimum and maximum measured values. The datasheet limit is 7.0mA minimum.

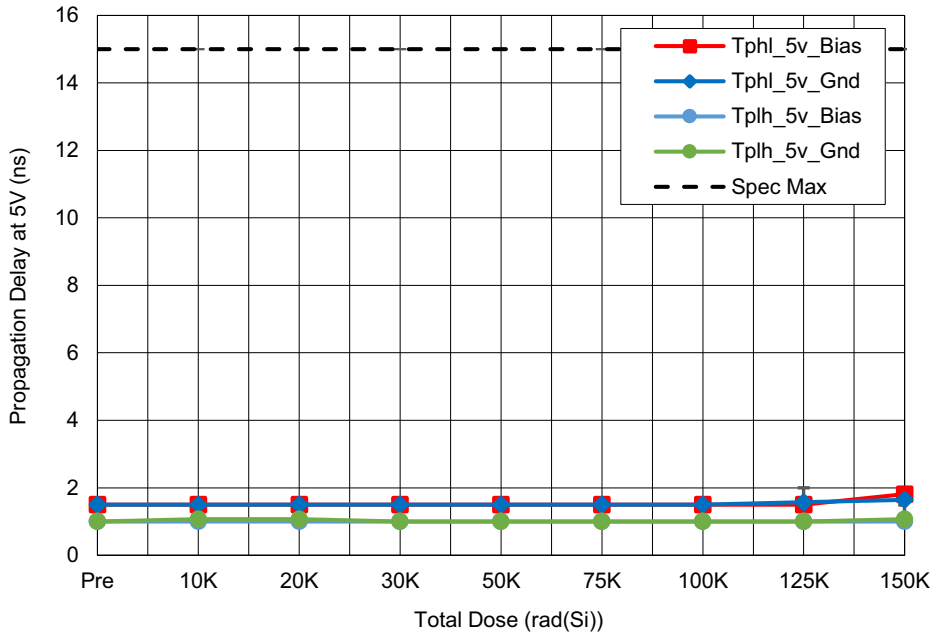

Figure 13. ISL71610x average propagation delay (t_{PHL}, t_{PLH}) with V_{DD} = 5V as a function of HDR irradiation. The error bars (if visible) represent the minimum and maximum measured values. The datasheet limit is 15ns maximum.

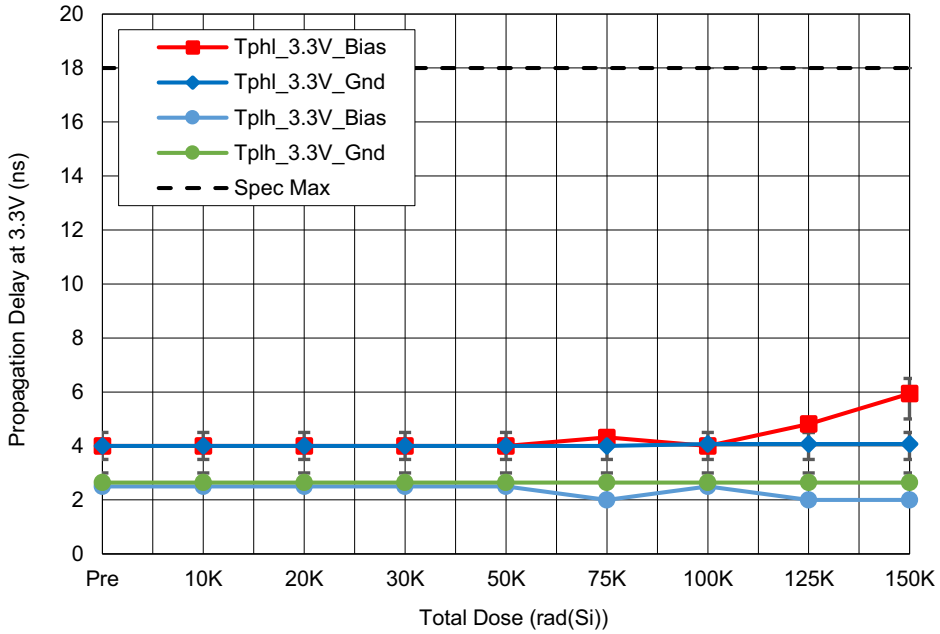

Figure 14. ISL71610x average propagation delay (t_{PHL}, t_{PLH}) with V_{DD} = 3.3V as a function of HDR irradiation. The error bars (if visible) represent the minimum and maximum measured values. The datasheet limit is 18ns maximum.

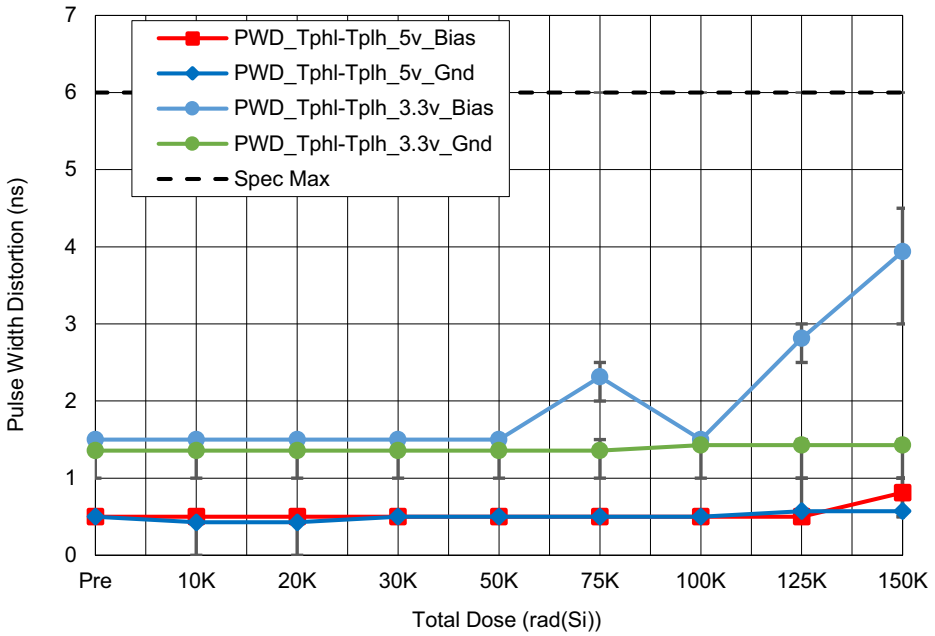

Figure 15. ISL71610x average pulse width distortion (PWD) as a function of HDR irradiation. The error bars represent the minimum and maximum measured values. The datasheet limit is 6ns maximum.

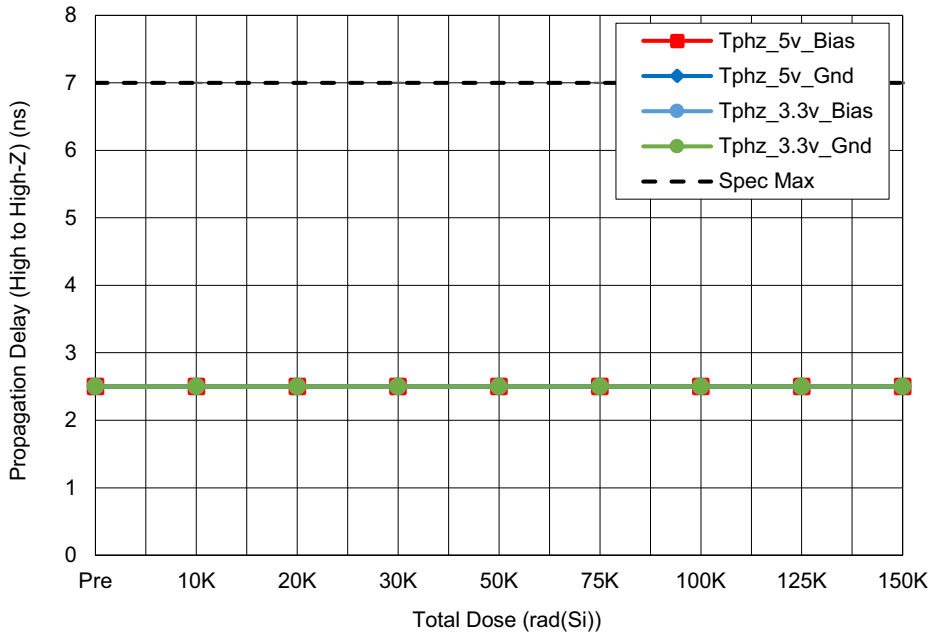

Figure 16. ISL71610x average enable to output propagation delay, high to high impedance (t_{PHZ}) with V_{DD} = 3.3V and 5V as a function of HDR irradiation. The error bars (if visible) represent the minimum and maximum measured values. The datasheet limit is 7ns maximum.

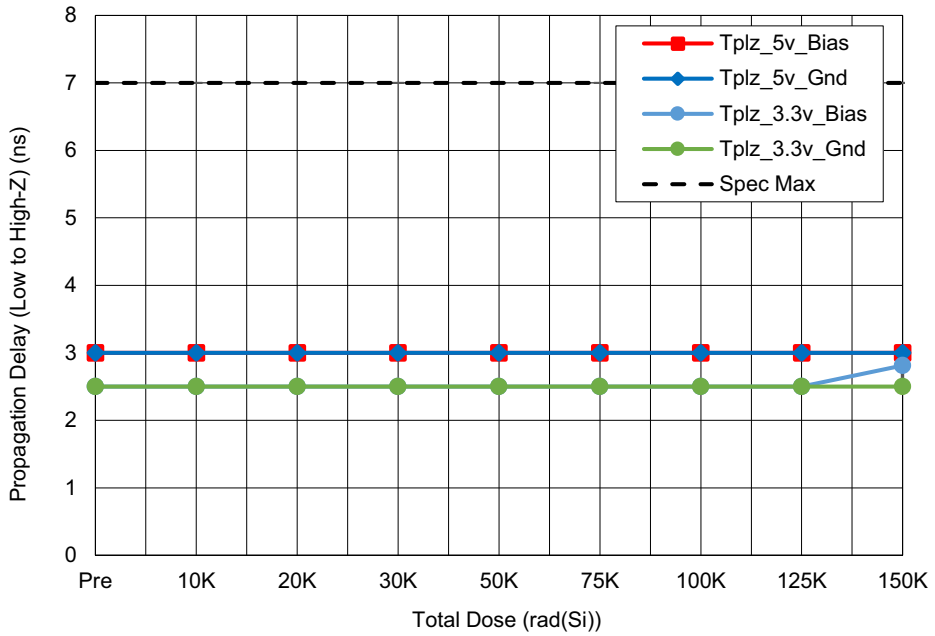

Figure 17. ISL71610x average enable to output propagation delay, low to high impedance (t_{PLZ}) with V_{DD} = 3.3V and 5V as a function of HDR irradiation. The error bars (if visible) represent the minimum and maximum measured values. The datasheet limit is 7ns maximum.

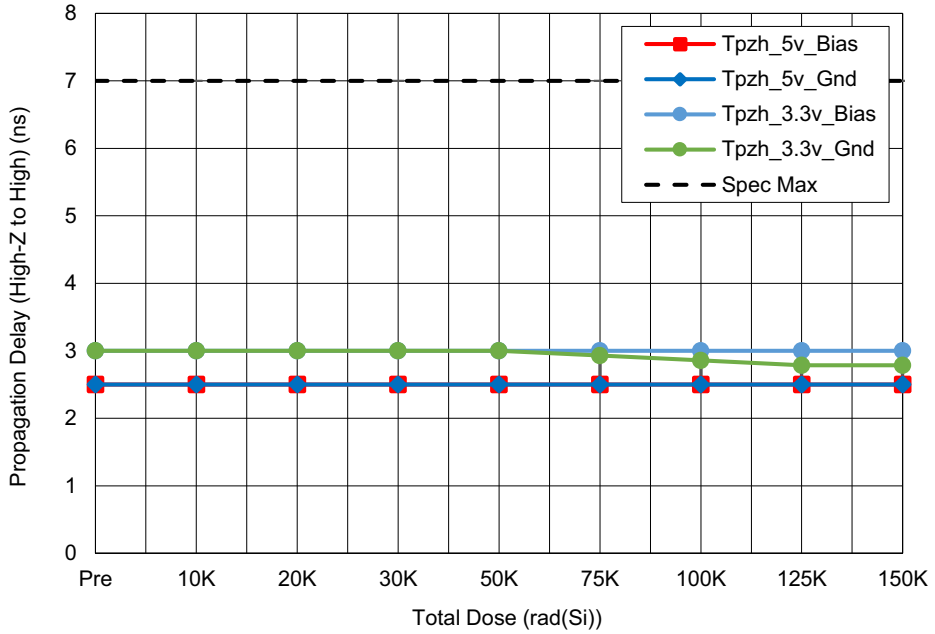

Figure 18. ISL71610x average enable to output propagation delay, high impedance to high (t_{PZH}) with V_{DD} = 3.3V and 5V as a function of HDR irradiation. The error bars (if visible) represent the minimum and maximum measured values. The datasheet limit is 7ns maximum.

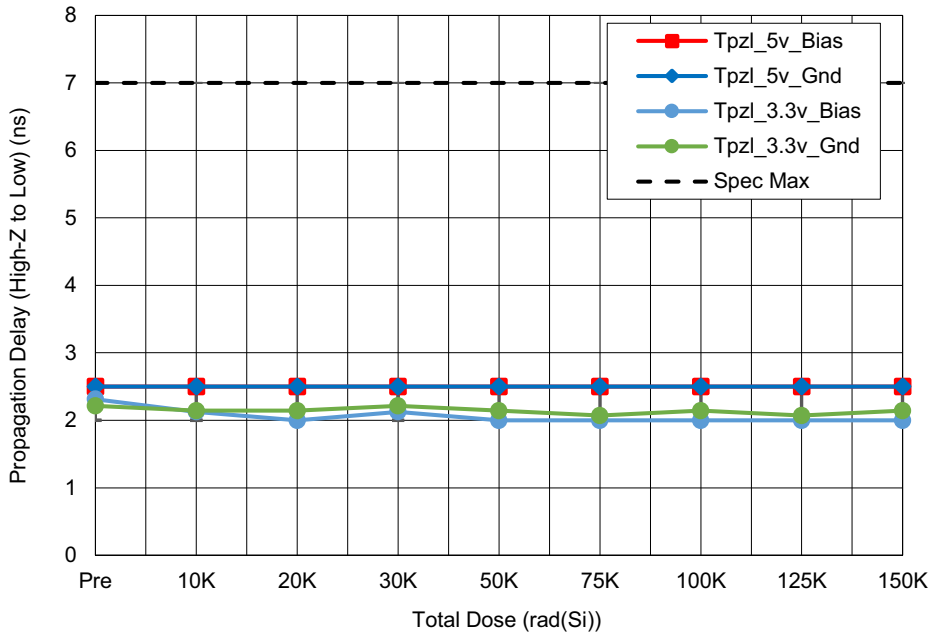

Figure 19. ISL71610x average enable to output propagation delay, high impedance to low (t_{PZL}) with V_{DD} = 3.3V and 5V as a function of HDR irradiation. The error bars (if visible) represent the minimum and maximum measured values. The datasheet limit is 7ns maximum.

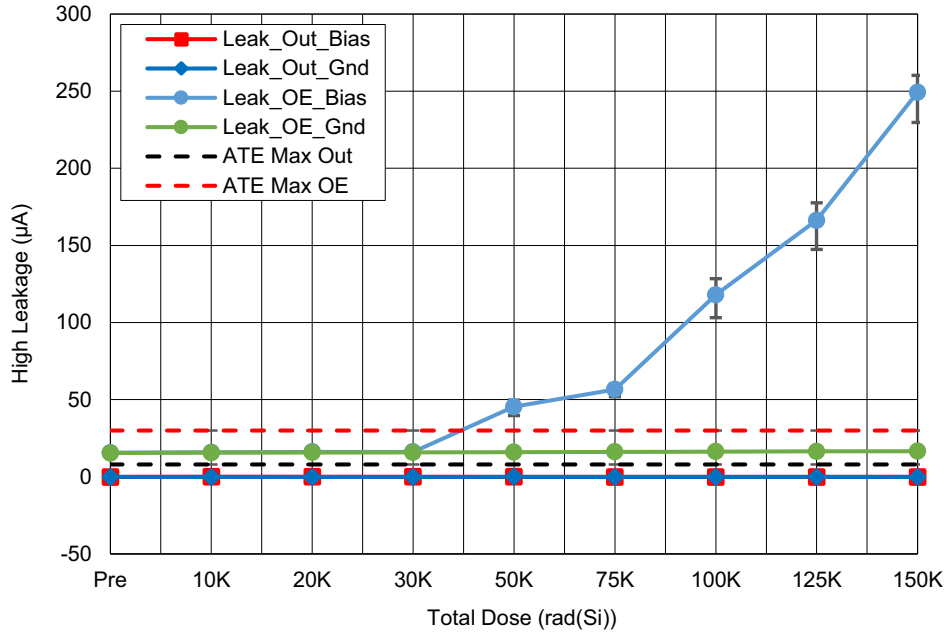

Figure 20. ISL71610x average leakage current on the OUT and $\overline{OE}$ pins as a function of HDR irradiation. The error bars (if visible) represent the minimum and maximum measured values. The ATE limit for the OUT pin is 8µA maximum, and the ATE limit for the $\overline{OE}$ pin is 30µA.

3. Discussion and Conclusion

We reported the results of the HDR characterization of the ISL71610x radiation tolerant passive-input digital isolator, consisting of irradiating eight biased and seven grounded samples to 150krad(Si). All parts passed all datasheet parameters at all down points. However, all biased samples failed one informational-only parameter, leakage in the high state on the $\overline{OE}$ pin at ≥50krad(Si). This failure is shown in Figure 20. Also, some evidence of bias dependence was observed in the supply current (I_{DDQ}) after 75krad(Si), as shown in Figure 6.

4. Revision History

Revision	Date	Description
1.00	May 10, 2023	Initial release.

A. Appendix

A.1 Reported Parameters

Table 3 lists the key parameters that are considered indicative of part performance. These parameters are plotted in Figure 3 through Figure 20. All limits, except Leakage High (Figure 20), as it is informational only, are taken from the ISL71610SLHMBZ/ISL71610MBZ datasheet.

Table 3. ISL71610x Key Total Dose Parameters (T_A = 25°C)

Fig.	Parameter	Symbol	Conditions	Low Limit	High Limit	Unit
3	Coil Input Resistance	R_{COIL}	V_{DD} = 3.0 - 5.5V	47	112	Ω
4	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			
5	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			
6	Quiescent Current	I_{DDQ}	V_{DD} = 5.0V, IN+ = IN- = OPEN	-	3	mA
			V_{DD} = 3.3V, IN+ = IN- = OPEN	-	2	
7	Logic High Output Voltage	V_{OH}	V_{DD} = 5V, I_{OUT} = 20uA	4.9	-	V
			V_{DD} = 5V, I_{OUT} = 4mA	4.6	-	
8	Logic Low Output Voltage	V_{OL}	V_{DD} = 5V, I_{OUT} = -20uA	-	0.1	V
			V_{DD} = 5V, I_{OUT} = -4mA	-	0.8	
9	Logic High Output Voltage	V_{OH}	V_{DD} = 3.3V, I_{OUT} = 20uA	3.2	-	V
			V_{DD} = 3.3V, I_{OUT} = 4mA	3.0	-	
10	Logic Low Output Voltage	V_{OL}	V_{DD} = 3.3V, I_{OUT} = -20uA	-	0.1	V
			V_{DD} = 3.3V, I_{OUT} = -4mA	-	0.8	
11	Logic High Output Drive Current	I_{OH}	V_{DD} = 3.3V, 5V	-	-7	mA
12	Logic Low Output Drive Current	I_{OL}	V_{DD} = 3.3V, 5V	7	-	mA
13	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}				
14	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}				
15	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
16	Propagation Delay Enable to Output (High-to-High Impedance)	t_{PHZ}	V_{DD} = 3.3V, 5V, C_L = 15pF	-	7	ns

Table 3. ISL71610x Key Total Dose Parameters (T_A = 25°C) (Cont.)

Fig.	Parameter	Symbol	Conditions	Low Limit	High Limit	Unit
17	Propagation Delay Enable to Output (Low-to-High Impedance)	t_{PLZ}	V_{DD} = 3.3V, 5V, C_L = 15pF	-	7	ns
18	Propagation Delay Enable to Output (High Impedance-to-High)	t_{PZH}	V_{DD} = 3.3V, 5V, C_L = 15pF	-	7	ns
19	Propagation Delay Enable to Output (High Impedance-to-Low)	t_{PZL}	V_{DD} = 3.3V, 5V, C_L = 15pF	-	7	ns
20	Leakage High (OUT pin)	I_{IH}	V_{DD} = 5.5V	-	8	µA
	Leakage High ($\overline{OE}$ pin)			-	30	

A.2 Related Information

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

- ISL71610SLHM and ISL71610M device pages
- MIL-STD-883 Test Method 1019

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