ISL72814SEH, ISL73814SEH

Neutron Test Results of the ISL72814SEH and ISL73814SEH 16-Channel Current Drivers

Introduction

This report summarizes the 1MeV equivalent neutron testing results of the ISL72814SEH and ISL73814SEH 16-Channel Current Drivers. These parts differ only in their TID rating. 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 $5\times10^{11}n/cm^2$ to $1\times10^{13}n/cm^2$.

Product Description

The ISL72814SEH and ISL73814SEH are radiation hardened, high-voltage, high-current, driver circuit ICs fabricated using the Renesas proprietary PR40 Silicon-On-Insulator (SOI) bipolar process technology to mitigate single-event effects. The devices integrate 16 driver channels with a high-voltage (42V), high-current (700mA) open-emitter PNP output stage.

To further reduce solution size, the ISL7x814SEH integrates a 4-bit, 16-channel decoder with Enable. This feature allows users to select 1 of 16 available driver channels or disable all channels. The inputs to the decoder are TTL and CMOS compatible, allowing an easy interface to FPGAs and microprocessors. A block diagram is shown in Figure 1.

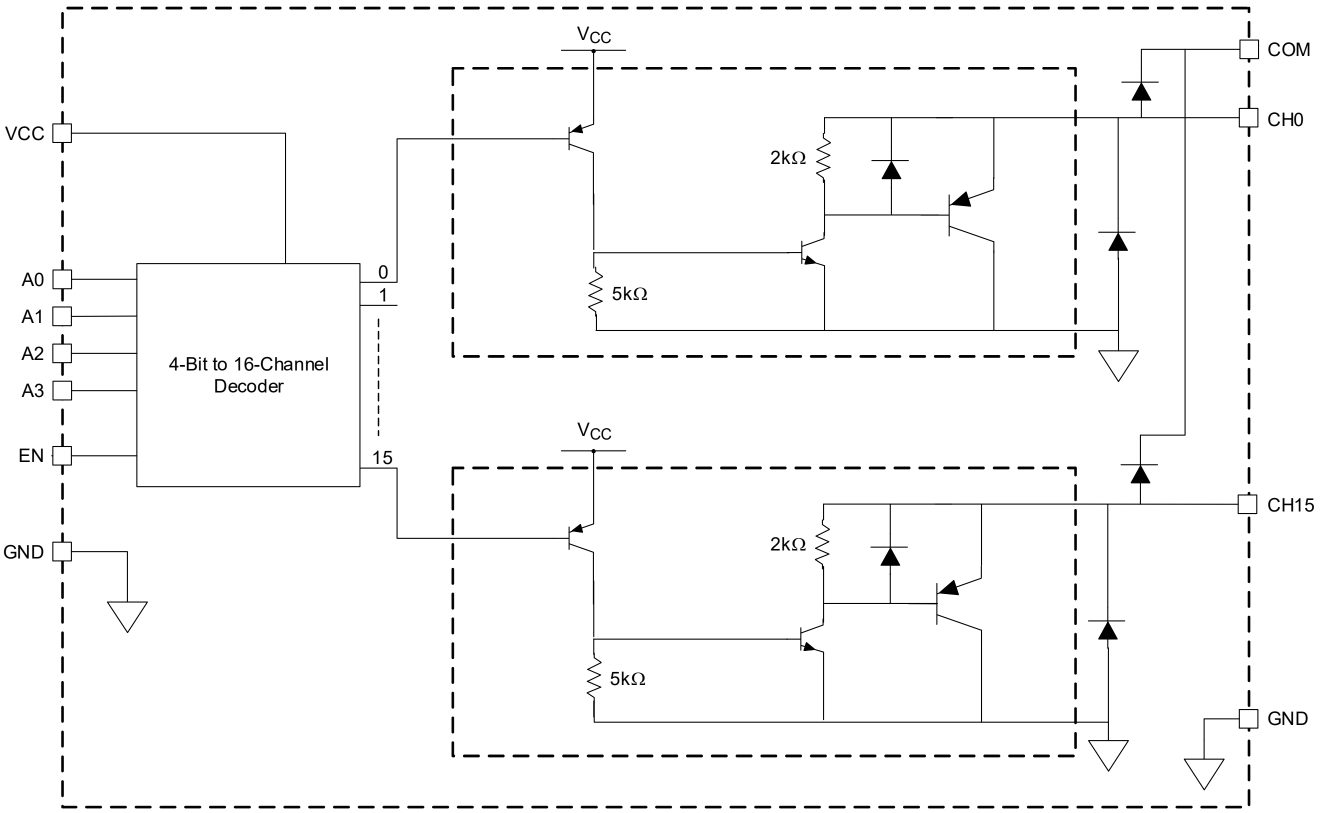

Figure 1. ISL7x814SEH Block Diagram

The ISL7x814SEH devices operate across the military temperature range from -55°C to +125°C and are available in a 28-lead hermetically sealed Ceramic Dual Flatpack (CDFP) package or die. Detailed Electrical Specifications for these devices are contained in SMD 5962-18221.

The package pin assignments of the ISL7x814SEH are shown in Figure 2.

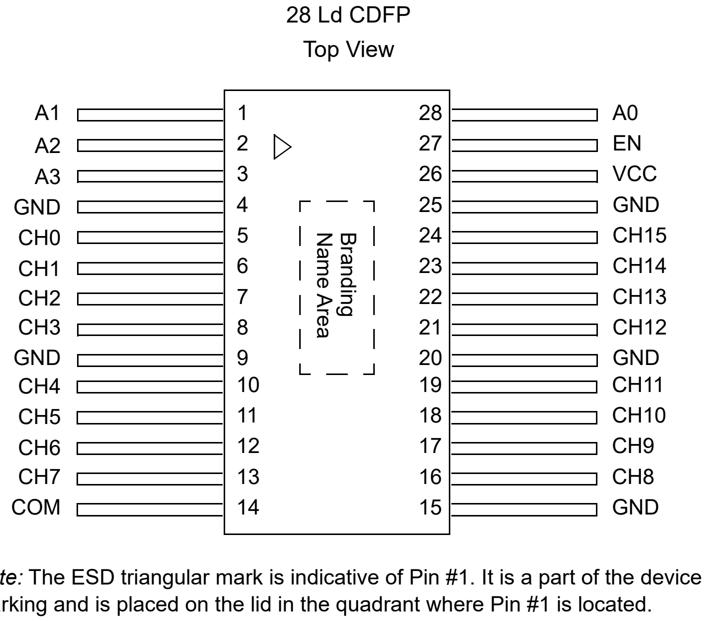

Figure 2. ISL7x814SEH Pin Assignments

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 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 ‘bag tests’ in the sense that the parts are irradiated with all leads unbiased.

1.3 Radiation Dosimetry

Table 1 shows dosimetry from UMASS Lowell, indicating the total accumulated gamma dose and actual neutron fluence exposure levels for each set of samples.

Table 1. ISL7x814SEH 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 1×10^{13}n/cm^2. The actual levels achieved were 5.3×10^{11}n/cm^2, 2.3×10^{12}n/cm^2, and 1×10^{13}n/cm^2, as shown in Table 2. Two control units were used.

The eighteen ISL7x814SEH samples were drawn from Lot XDD2AB. Samples were packaged in the standard 28 lead hermetically sealed Ceramic Dual Flatpack. Samples were processed through burn-in before irradiation and screened to the SMD limits at room, low, and high temperatures before the neutron testing started.

2. Results

Neutron testing of the ISL7x814SEH 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. ISL7x814SEH Attributes Data

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

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

2.2 Key Parameter Variables Data

The plots in Figure 3 through Figure 20 show data plots for key parameters before and after irradiation to each neutron fluence level. The plots show the mean of each parameter as a function of neutron irradiation. Each marker represents a different set of six samples. The line connecting them is for trend visualization only. The plots also include error bars at each down-point, representing the minimum and maximum measured values of the samples. However, in some plots, the error bars might not be visible due to their values compared to the scale of the graph. All samples passed the post-irradiation SMD limits after all three exposures up to and including $1.04\times10^{13}n/cm^2$.

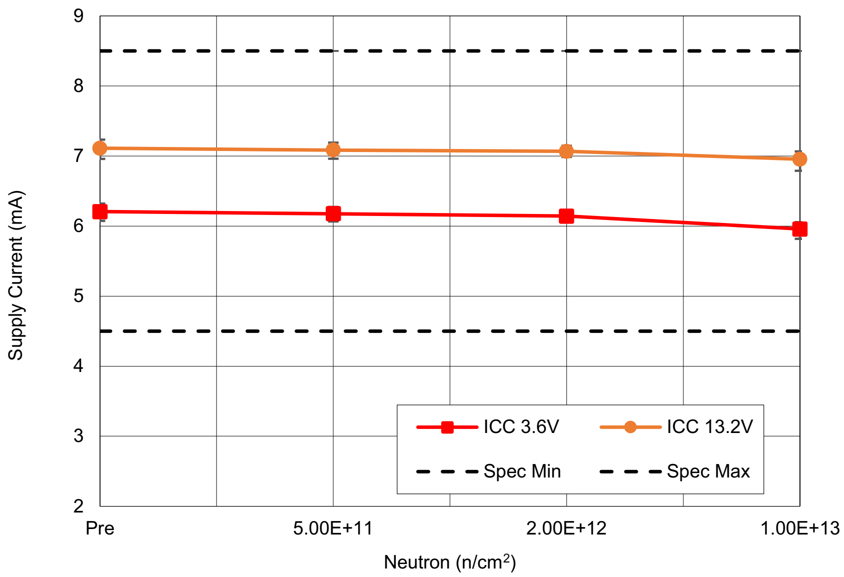

Figure 3. ISL7x814SEH average supply current (I_{CC}) at V_{CC} = 3.6V and 13.2V, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The SMD limits are 4.5mA minimum and 8.5mA maximum.

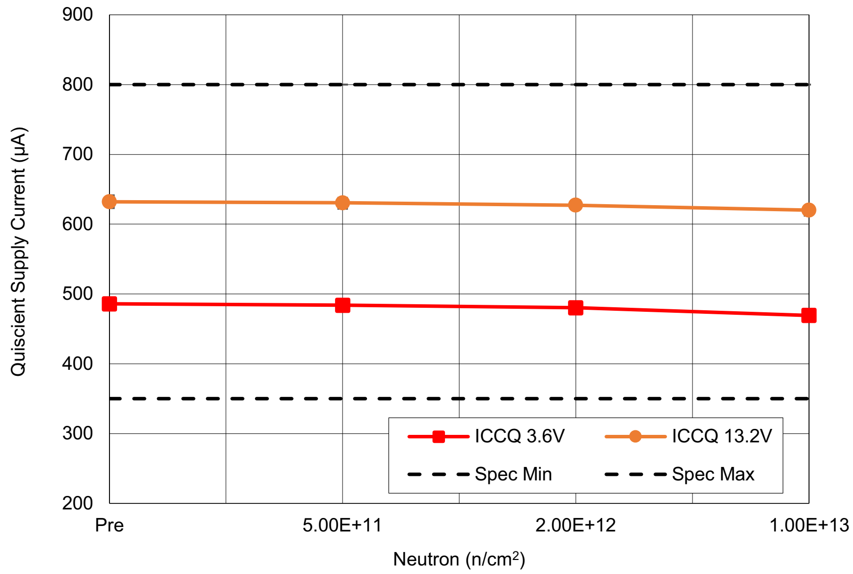

Figure 4. ISL7x814SEH average quiescent supply current (I_{CCQ}) at V_{CC} = 3.6V and 13.2V as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The SMD limits are 350µA minimum and 800µA maximum.

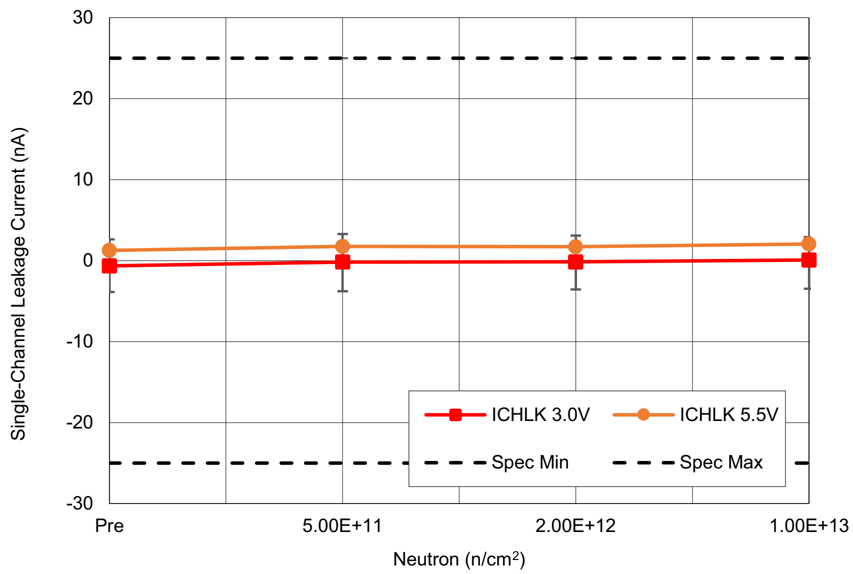

Figure 5. ISL7x814SEH average single-channel leakage current (I_{CHLK}) at V_{CC} = 3V and 5.5V as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The SMD limits are -25nA minimum and 25nA maximum.

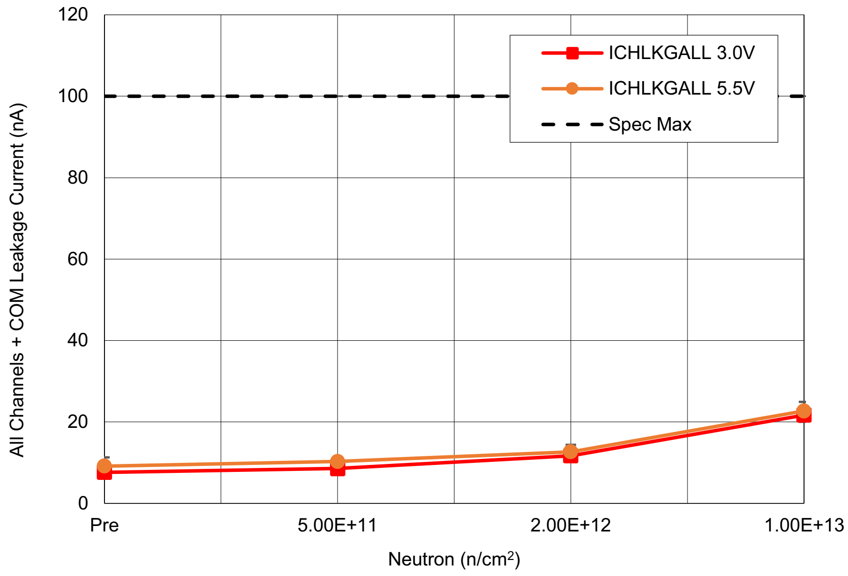

Figure 6. ISL7x814SEH average all channels + COM leakage current ($I_{TOTCHLK}$) at V_{CC} = 3V and 5.5V, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The SMD limits are -30nA minimum and 100nA maximum.

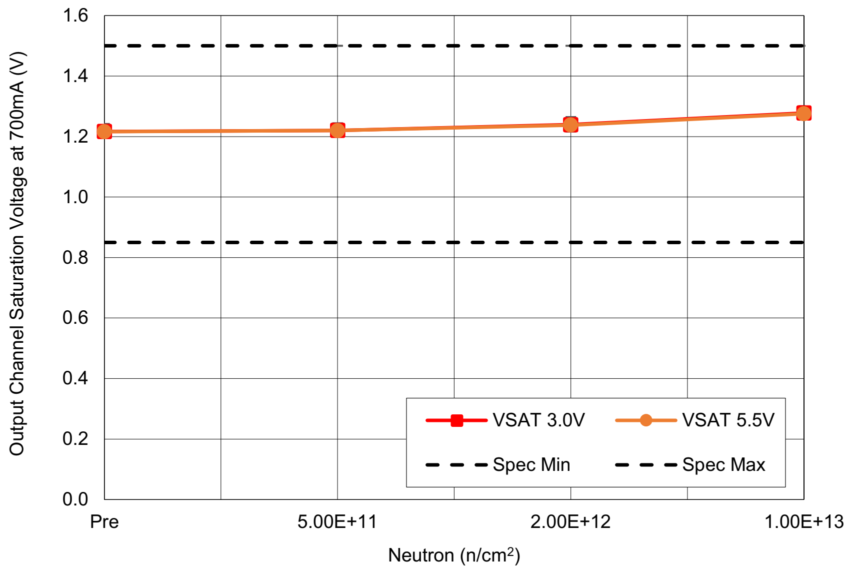

Figure 7. ISL7x814SEH average output channel saturation voltage ($V_{CH(Sat)}$), at V_{CC} = 3V and 5.5V, with I_{CHx} = 700mA, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The SMD limits are 0.85V minimum and 1.5V maximum.

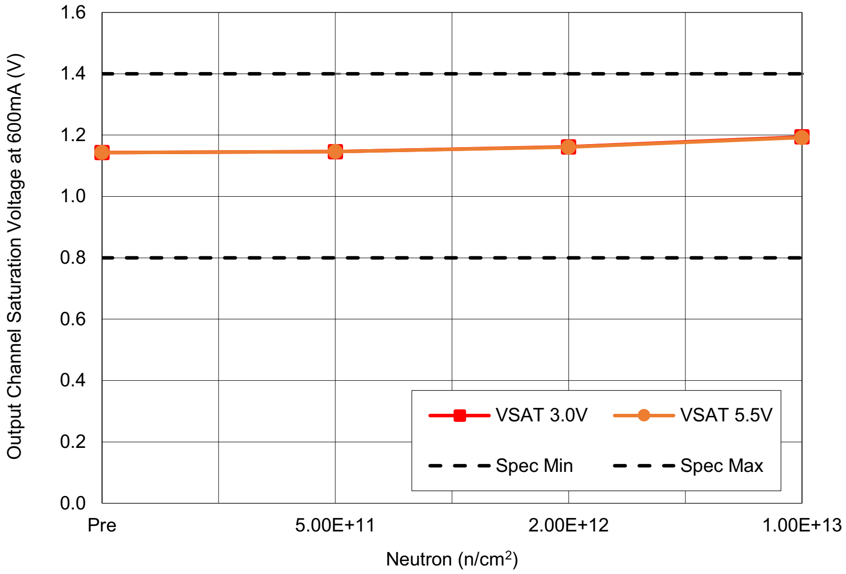

Figure 8. ISL7x814SEH average output channel saturation voltage ($V_{CH(Sat)}$), at V_{CC} = 3V and 5.5V, with I_{CHx} = 600mA, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The SMD limits are 0.8V minimum and 1.4V maximum.

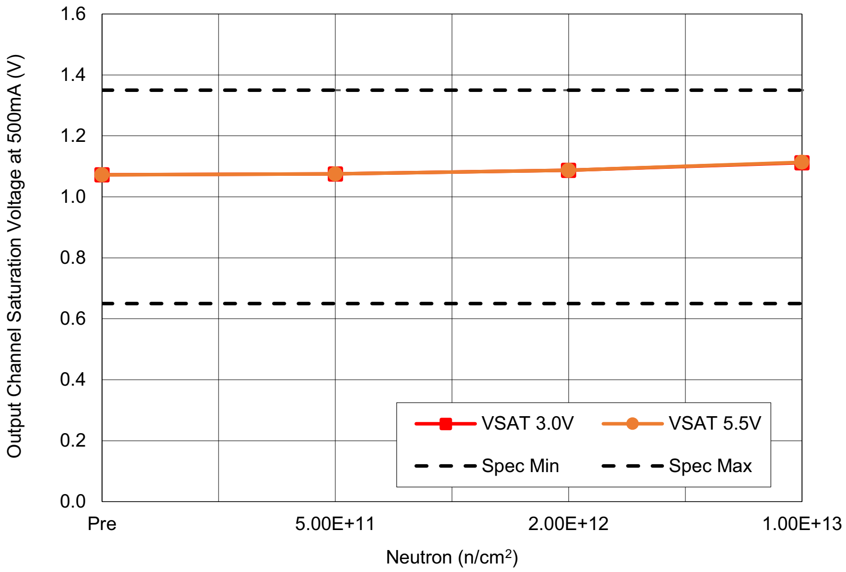

Figure 9. ISL7x814SEH average output channel saturation voltage ($V_{CH(Sat)}$), at V_{CC} = 3V and 5.5V, with I_{CHx} = 500mA, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The SMD limits are 0.65V minimum and 1.35V maximum.

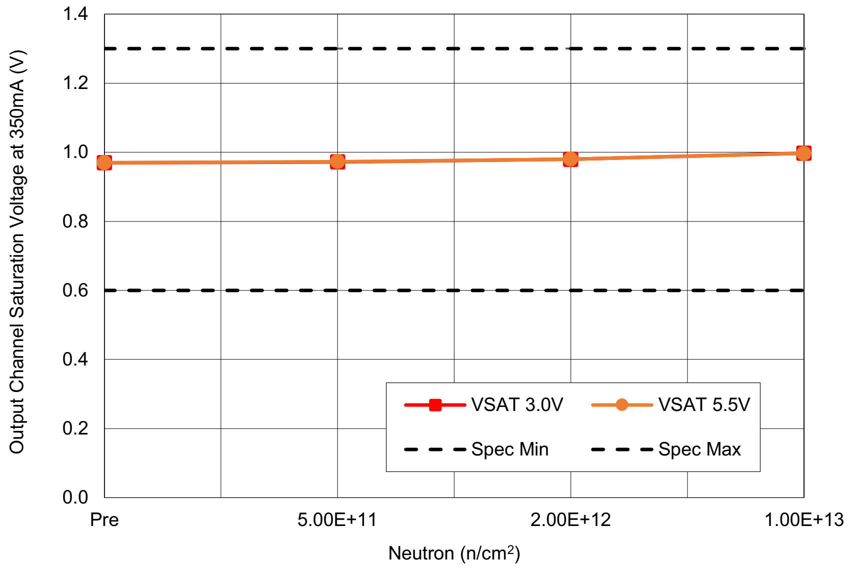

Figure 10. ISL7x814SEH average output channel saturation voltage ($V_{CH(Sat)}$), at V_{CC} = 3V and 5.5V, with I_{CHx} = 350mA, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The SMD limits are 0.60V minimum and 1.30V maximum.

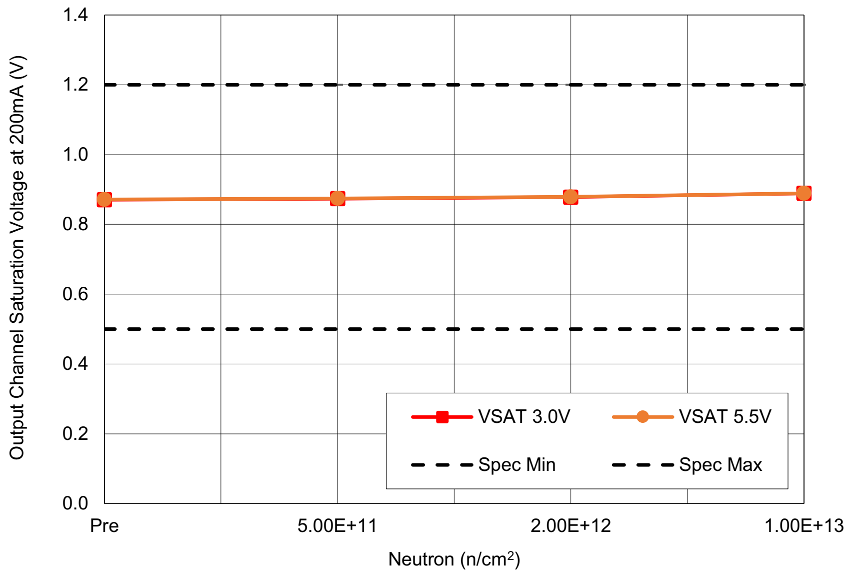

Figure 11. ISL7x814SEH average output channel saturation voltage ($V_{CH(Sat)}$), at V_{CC} = 3V and 5.5V, with I_{CHx} = 200mA, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The SMD limits are 0.50V minimum and 1.20V maximum.

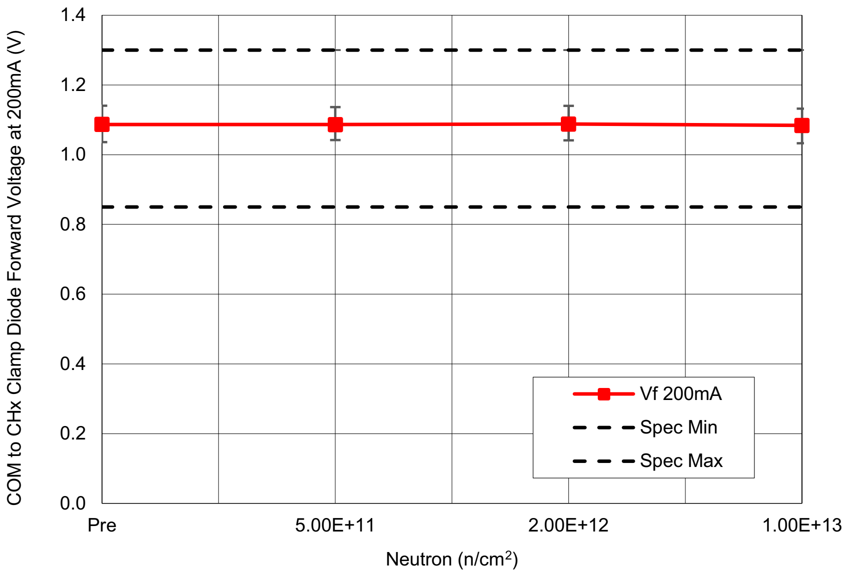

Figure 12. ISL7x814SEH average COM to CHx clamp diode forward voltage (V_F), with I_{CHx} = 200mA, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The SMD limits are 0.85V minimum and 1.30V maximum.

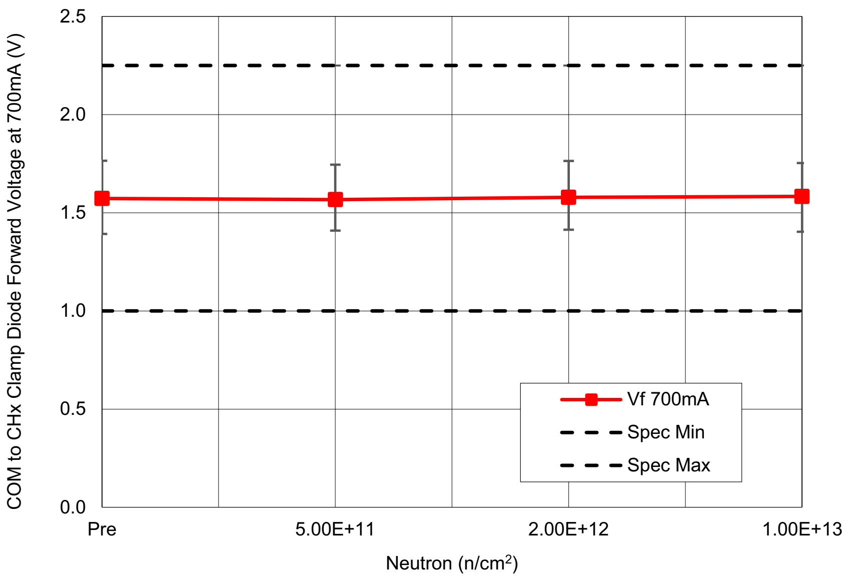

Figure 13. ISL7x814SEH average COM to CHx clamp diode forward voltage (V_F), with I_{CHx} = 700mA, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The SMD limits are 1.0V minimum and 2.25V maximum.

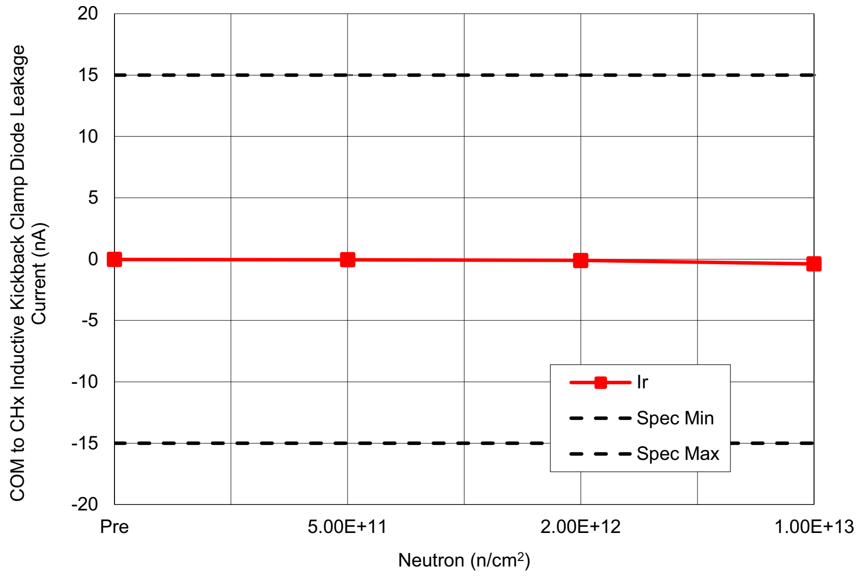

Figure 14. ISL7x814SEH average COM to CHx inductive kickback clamp diode leakage current (I_R), as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The SMD limits are -15nA minimum and 15nA maximum.

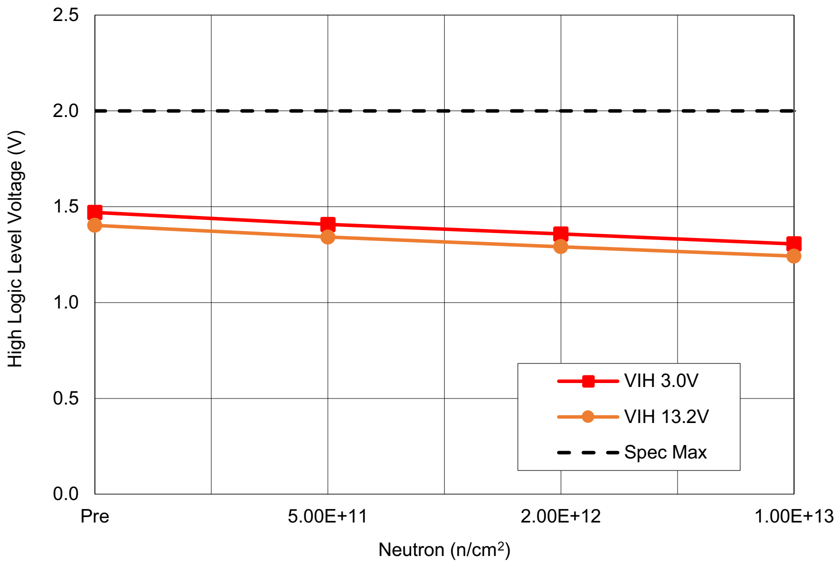

Figure 15. ISL7x814SEH average high logic level voltage (V_{IH}), at V_{CC} = 3V and 13.2V, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The SMD limit is 2.0V maximum.

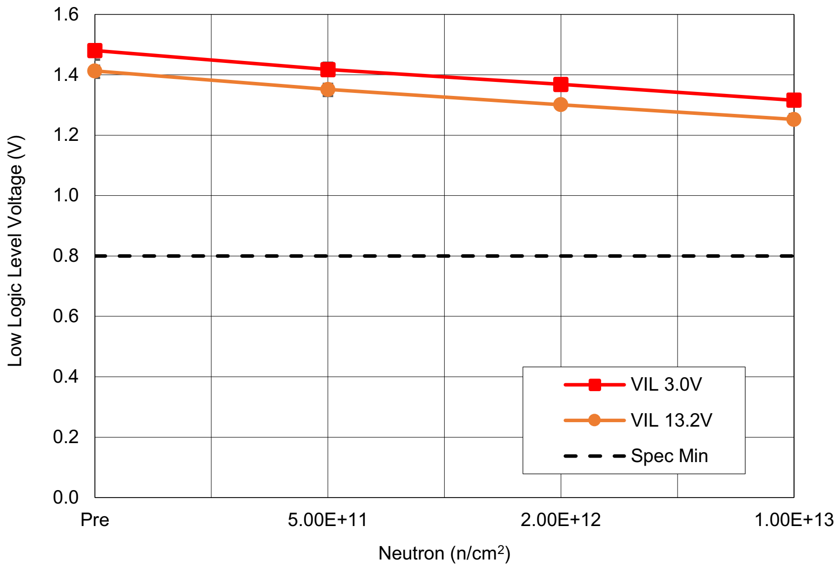

Figure 16. ISL7x814SEH average low logic level voltage (V_{IL}), at V_{CC} = 3V and 13.2V, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The SMD limit is 0.8V minimum.

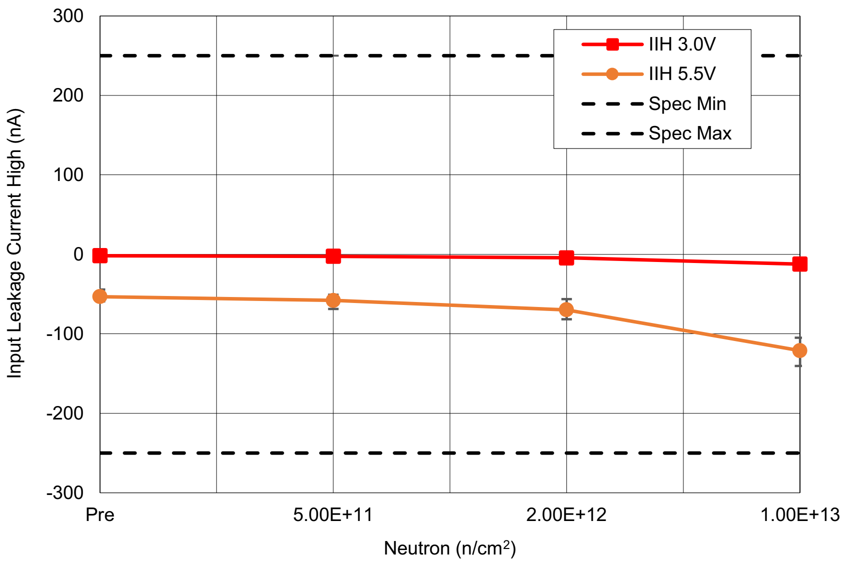

Figure 17. ISL7x814SEH average input high current (I_{IH}), at V_{CC} = 3V and 5.5V, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The SMD limits are -250nA minimum and 250nA maximum.

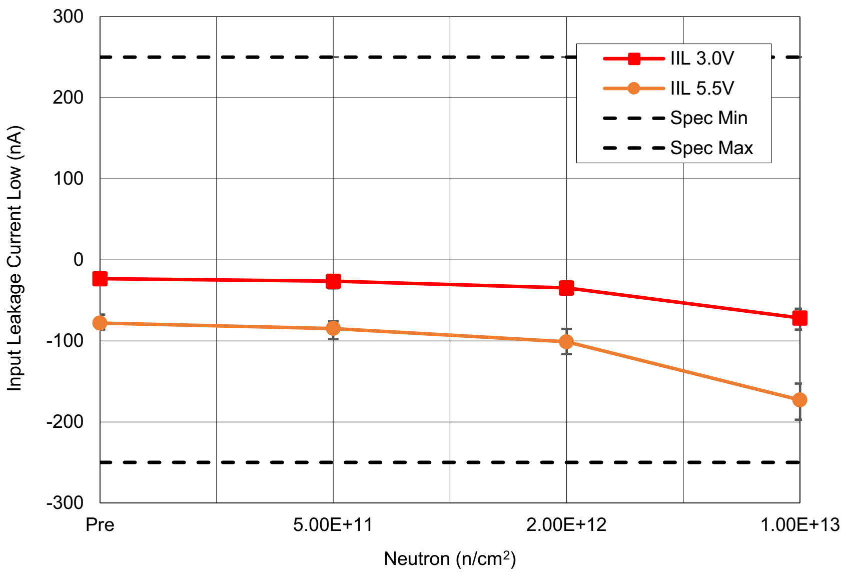

Figure 18. ISL7x814SEH average input low current (I_{IL}), at V_{CC} = 3V and 5.5V, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The SMD limits are -250nA minimum and 250nA maximum.

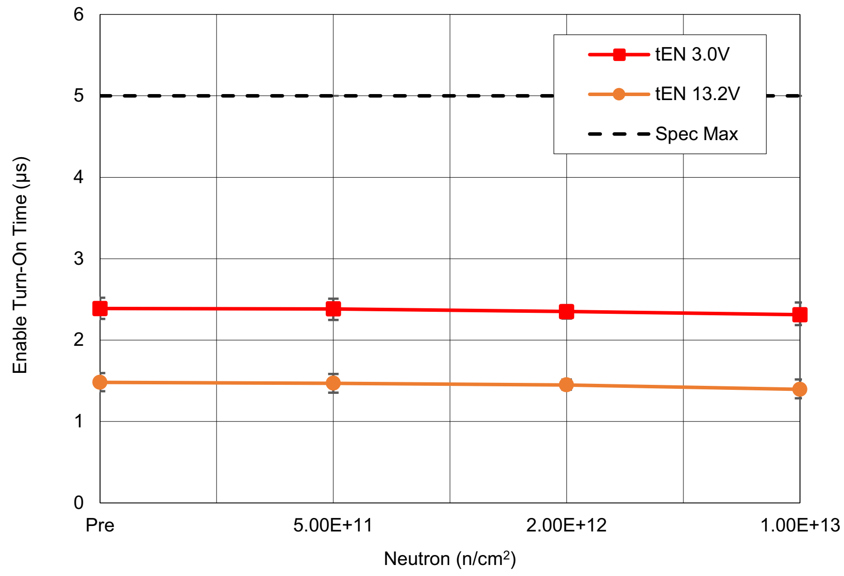

Figure 19. ISL7x814SEH average enable turn-on time (t_{EN}), at V_{CC} = 3V and 13.2V, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The SMD limit is 5µs maximum.

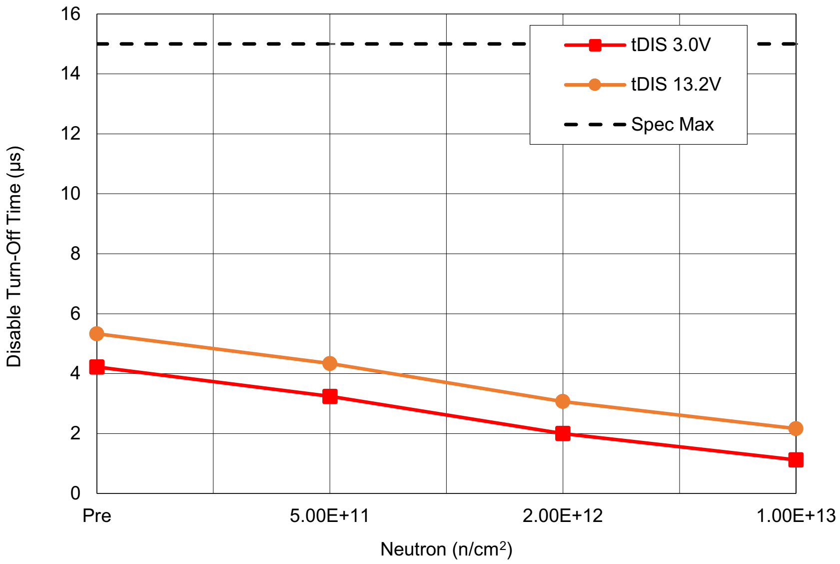

Figure 20. ISL7x814SEH average disable turn-off time (t_{DIS}), at V_{CC} = 3V and 13.2V, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The SMD limit is 15µs maximum.

3. Discussion and Conclusion

The results of 1MeV equivalent neutron testing of the ISL7x814SEH radiation-hardened 16-Channel Current Driver were 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 Figures 3 through 20. 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. The figures also show the applicable electrical limits taken from the SMD. All samples passed the SMD limits with little to no degradation after all exposures up to and including 1.04×10^{13}n/cm^2.

4. Revision History

Revision	Date	Description
1.01	Jan 30, 2025	Removed wording that part is not specified for the neutron environment.
1.00	Jul 3, 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 are taken from the ISL7x814SEH SMD.

Table 3. ISL7x814SEH Key Parameters (T_A = 25°C)

Fig.	Parameter	Symbol	Conditions	Low Limit	High Limit	Unit
3	Supply Current	I_{CC}	V_{CC} = 3.6V, 13.2V, CHx = OPEN, EN = V_{CC}, COM= 0V, A0-A3 = 0V	4.5	8.5	mA
4	Quiescent Supply Current	I_{CCQ}	V_{CC} = 3.6V, 13.2V, CHx = OPEN, EN = 0V, COM= 0V, A0-A3 = 0V	350	800	µA
5	Single Channel Leakage Current	I_{CHLK}	V_{CHX} (under test) = 34V, All other V_{CHX} channels= 35V, V_{CC} = 3V, 5.5V, COM = 35V, A0-A3 = 0V, EN = 0V	-25	25	nA
6	All Channels + COM Leakage Current	$I_{TOTCHLK}$	$V_{CH0\ -\ CH15}$ = COM = 34V, V_{CC} = 3V, 5.5V, A0-A3= 0V, EN = 0V	-30	100	nA
7	Output Channel Saturation Voltage (I_{CHx} = 700mA)	$V_{CHX(SAT)}$	I_{CHx} = 700mA, V_{CC} = 3V, 5.5V, COM = 35V, EN=V_{CC}	0.85	1.5	V
8	Output Channel Saturation Voltage (I_{CHx} = 600mA)		I_{CHx} = 600mA, V_{CC} = 3V, 5.5V, COM = 35V, EN=V_{CC}	0.8	1.4	
9	Output Channel Saturation Voltage (I_{CHx} = 500mA)		I_{CHx} = 500mA, V_{CC} = 3V, 5.5V, COM = 35V, EN=V_{CC}	0.65	1.35	
10	Output Channel Saturation Voltage (I_{CHx} = 350mA)		I_{CHx} = 350mA, V_{CC} = 3V, 5.5V, COM = 35V, EN=V_{CC}	0.6	1.3	
11	Output Channel Saturation Voltage (I_{CHx} = 200mA)		I_{CHx} = 200mA, V_{CC} = 3V, 5.5V, COM = 35V, EN=V_{CC}	0.5	1.2	
12	COM to CHx Inductive Kickback Clamp Diode Forward Voltage (I_{CHx} = 200mA)	V_F	I_{CHx} = 200mA, COM = 0V, V_{CC} = 0V, A0-A3 = 0V, EN = 0V	0.85	1.3	V
13	COM to CHx Inductive Kickback Clamp Diode Forward Voltage (I_{CHx} = 700mA)		I_{CHx} = 700mA, COM = 0V, V_{CC} = 0V, A0-A3 = 0V, EN = 0V	1.0	2.25	
14	COM to CHx Inductive Kickback Clamp Diode Leakage Current	I_R	V_{COM} = 34V, V_{CC} = 0V, A0-A3 = 0V, EN = 0V, CHx channel under test = 0V, other CHx channels = open	-15	15	nA
15	High Logic Level Voltage	V_{IH}	V_{CC} = 3V, 13.2V, COM = V_{CC}	-	2	V
16	Low Logic Level Voltage	V_{IL}		0.8	-	
17	Input High Current	I_{IH}	V_{CC} = 3V, 5.5V, COM = V_{CC}, A0-A3 = EN = 2.0V	-250	250	nA
18	Input Low Current	I_{IL}	V_{CC} = 3V, 5.5V, COM = V_{CC}, A0-A3 = EN = 0.8V	-250	250	nA
19	Enable Turn-On Time	t_{EN}	V_{CC} = 3V, 13.2V, COM = 35V, A0-A3 = 0V. CH0 channel under test connected to 97Ω to 34V, other CHx channels connected to 10kΩ to 34V	-	5	µs
20	Disable Turn-Off Time	t_{DIS}		-	15	µs

A.2 Related Information

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

- ISL72814SEH and ISL73814SEH device pages
- MIL-STD-883 test method 1017

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