HS-26CLV31xH

Neutron Testing of the HS-26CLV31xH 3.3V Radiation Tolerant Quad Differential Line Driver

Introduction

This report summarizes the results of 1MeV equivalent neutron testing of the HS-26CLV31RH quad differential line driver. 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. Although these results were obtained on the HS-26CLV31RH, because neutron damage is more process than design dependent, they also apply to the HS-26CLV31EH, HS-26C31RH, HS-26C31EH, HS-26CT31RH, and HS-26CT31EH.

Product Description

The HS-26CLV31RH, HS-26CLV31EH are radiation hardened 3.3V quad differential line drivers designed for digital data transmission over balanced lines in low-voltage RS-422 protocol applications. CMOS processing assures low power consumption, high speed, and reliable operation in the most severe radiation environments.

The HS-26CLV31RH and HS-26CLV31EH accept CMOS-level inputs and convert them to differential outputs. The Enable pins allow several devices to be connected to the same data source and addressed independently. These devices have unique outputs that become high impedance when the driver is disabled or powered down (VDD = 0V), maintaining signal integrity in multi-driver applications. Detailed Electrical Specifications for these devices are contained in SMD 5962-96663.

The block diagram for the HS-26CLV31xH is shown in Figure 1, with the package and pinout configuration used for this testing shown in Figure 2.

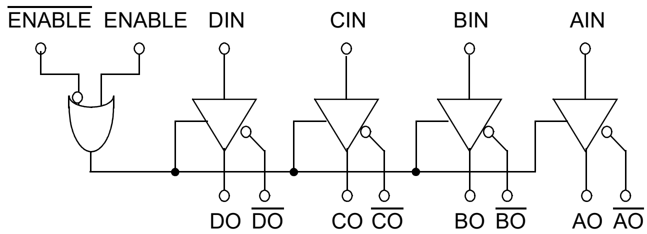

Figure 1. HS-26CLV31xH Block Diagram

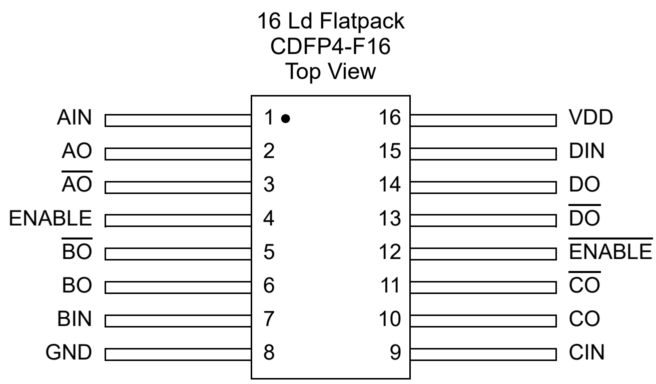

Figure 2. HS-26CLV31xH Pin Assignments

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. HS-26CLV31xH 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 five samples to be irradiated at 5×10^{11}n/cm^2, five at 2×10^{12}n/cm^2, and five at 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 15 HS-26CLV31xH samples were drawn from Lot G5M7TECA. Samples were packaged in the standard 16 Lead FLATPACK (package drawing K16.A). Samples were processed through burn-in before irradiation and screened to the SMD limits at room, low, and high temperatures before the neutron testing.

2. Results

Neutron testing of the HS-26CLV31xH 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. HS-26CLV31xH Attributes Data

1MeV Fluence, (n/cm^2)		Sample Size	Pass[1]	Fail	Notes
Planned	Actual				
5×10^{11}	5.30×10^{11}	5	5	0	All passed
2×10^{12}	2.33×10^{12}	5	5	0	All passed
1×10^{13}	1.04×10^{13}	5	5	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 5 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, although in some plots the error bars might not be visible due to their values compared to the scale of the graph. The applicable electrical limits taken from the SMD are also shown.

All samples passed the post-irradiation SMD limits after all three exposures up to and including $1.04\times10^{13}n/cm^2$.

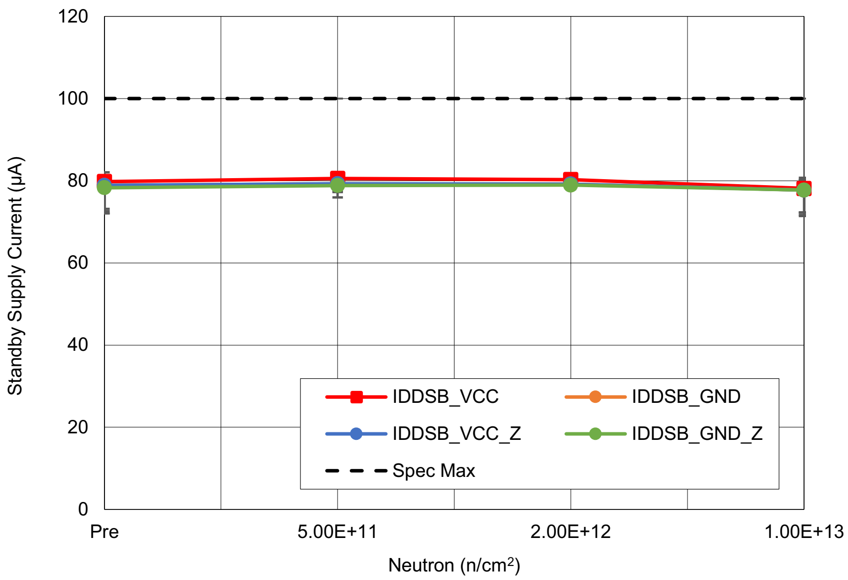

Figure 3. HS-26CLV31xH average standby supply current (I_{DDSB}), at V_{DD} = 3.6V, with inputs at V_{DD}, grounded or tri-stated, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The SMD limit is 100µA maximum.

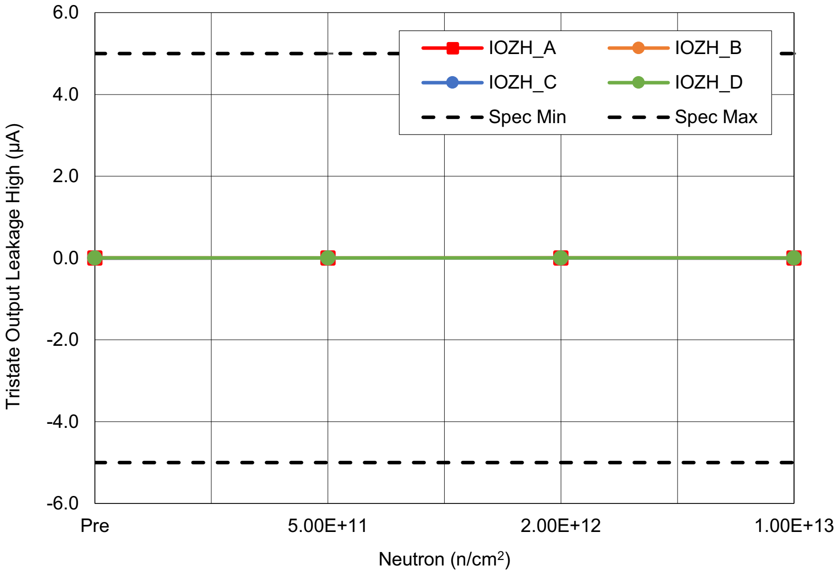

Figure 4. HS-26CLV31xH average tri-state output leakage current high (I_{OZH}), with V_{DD} = 3.6V, with outputs grounded or at V_{DD}, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The SMD limits are -5µA minimum and 5µA maximum.

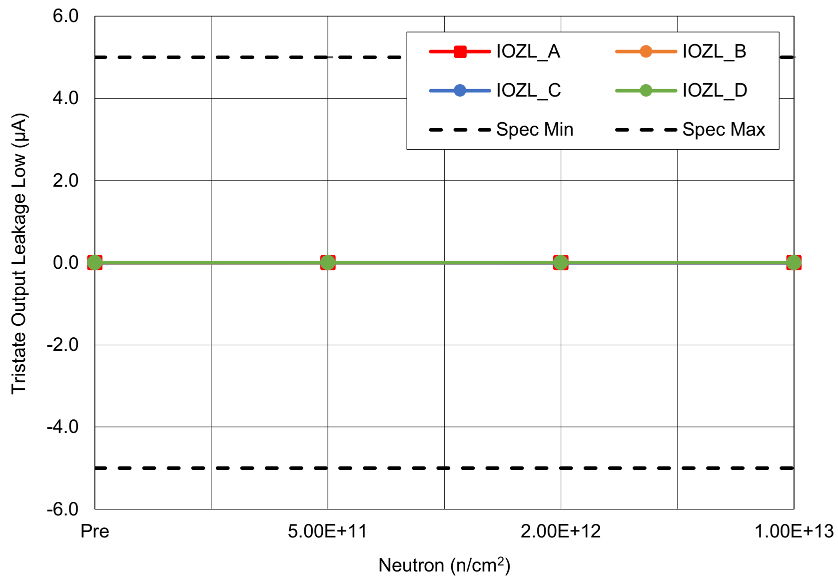

Figure 5. HS-26CLV31xH average tri-state output leakage current low (I_{OZL}), with V_{DD} = 3.6V, with outputs grounded or at V_{DD}, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The SMD limits are -5µA minimum and 5µA maximum.

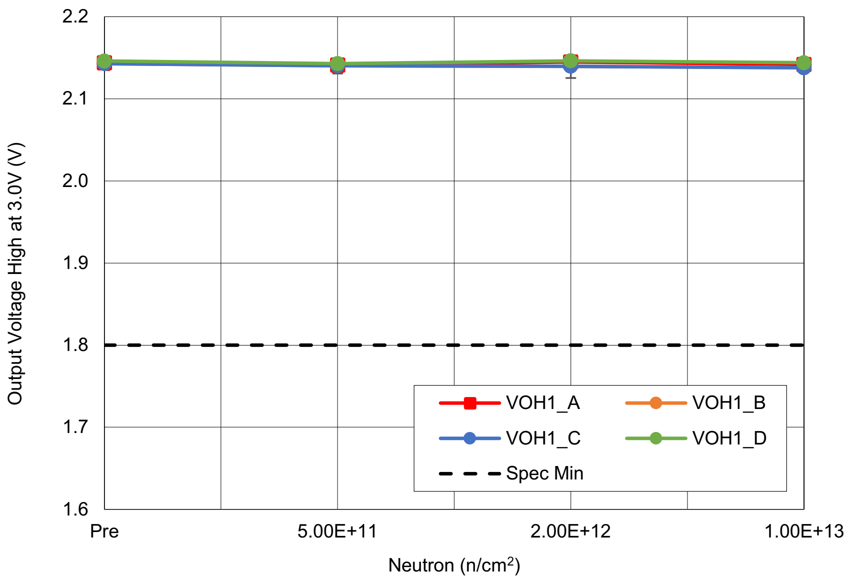

Figure 6. HS-26CLV31xH average high output voltage (V_{OH}), with V_{DD} = 3V and I_{OUT} = -20mA, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The SMD limit is 1.8V minimum.

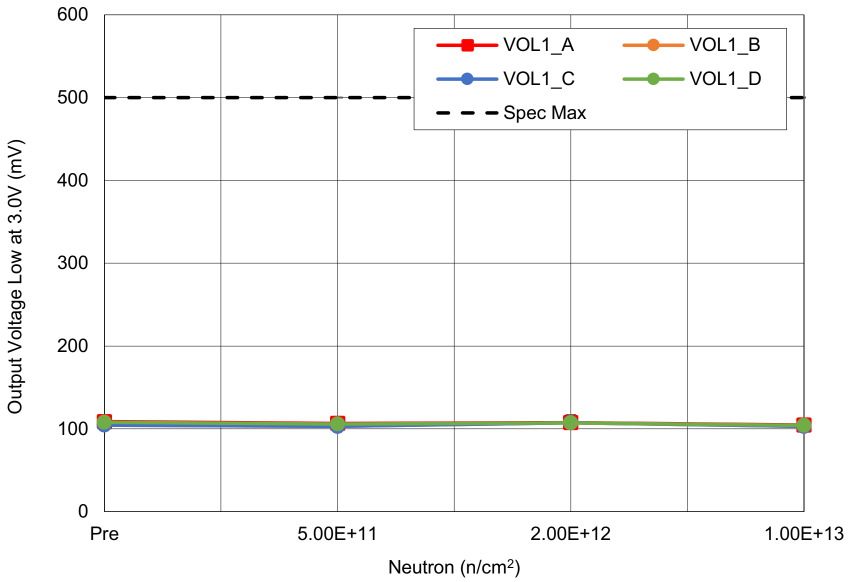

Figure 7. HS-26CLV31xH average low output voltage (V_{OL}), with V_{DD} = 3V and I_{OUT} = 20mA, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The SMD limit is 500mV maximum.

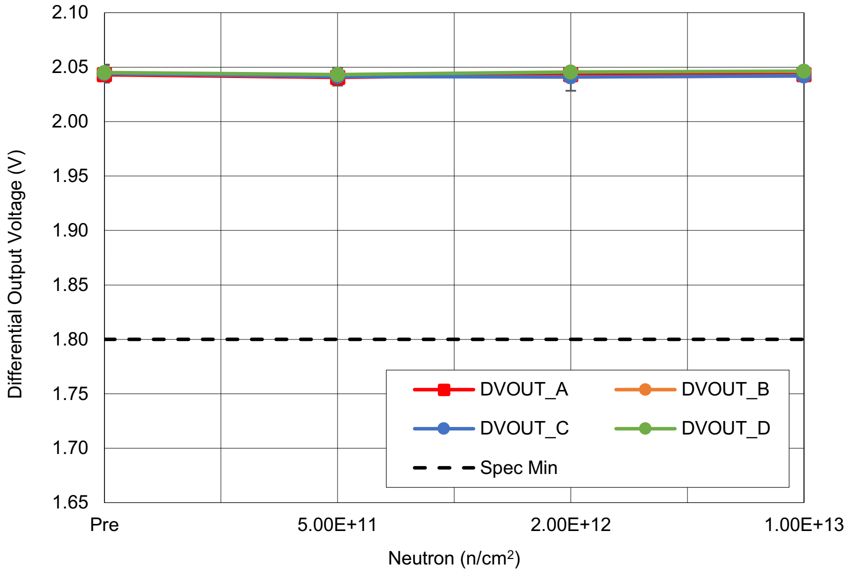

Figure 8. HS-26CLV31xH average differential output voltage (V_T), with $V_{DD} = V_{IH} = 3V$, $V_{IL} = 0V$ and $R_L = 100\Omega$, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The SMD limit is 1.8V minimum.

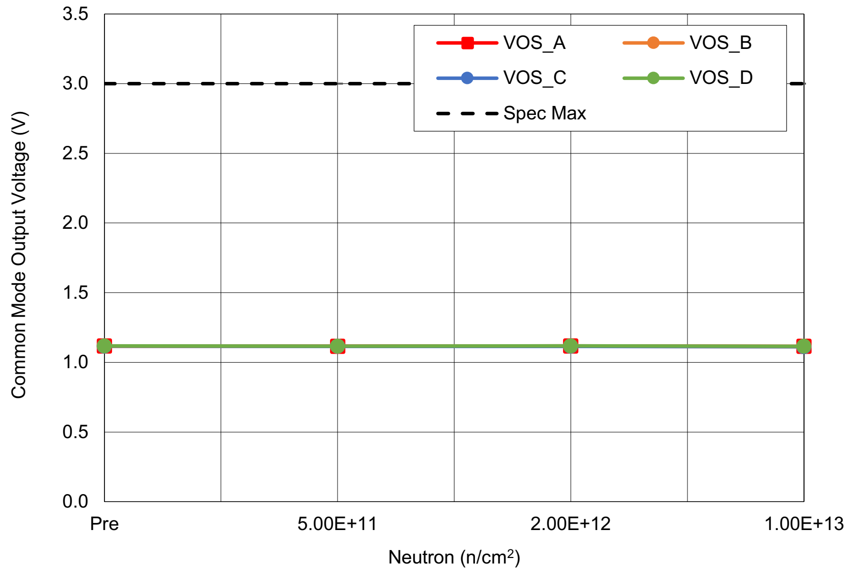

Figure 9. HS-26CLV31xH average common mode output voltage (V_{OS}), with $V_{DD} = V_{IH} = 3V$, $V_{IL} = 0V$ and $R_L = 100\Omega$, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The SMD limit is 3V maximum.

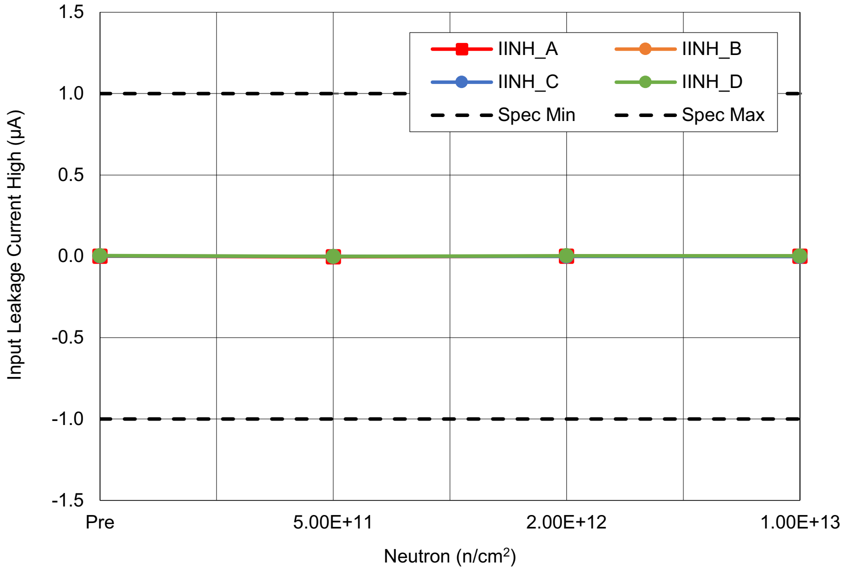

Figure 10. HS-26CLV31xH average input leakage current high (I_{IH}), with V_{DD} = 3.6V and inputs at V_{DD}, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The SMD limits are -1µA minimum and 1µA maximum.

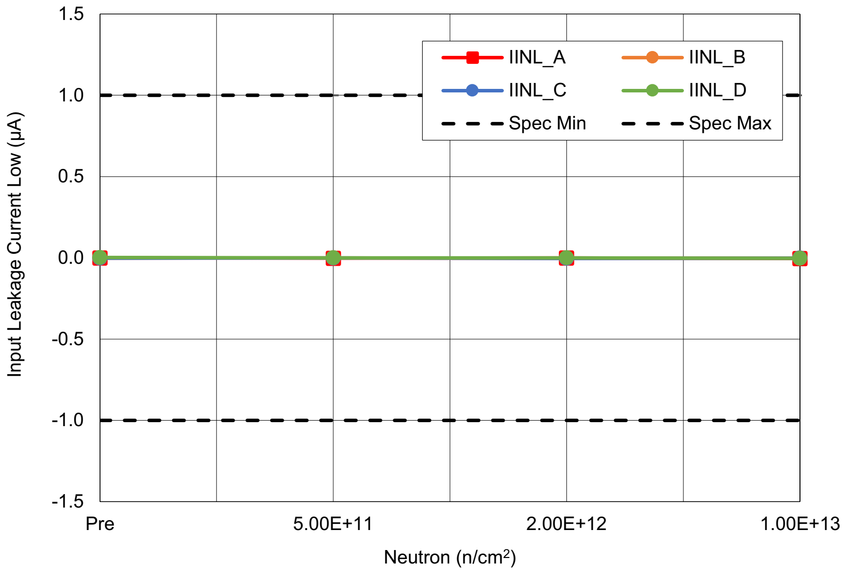

Figure 11. HS-26CLV31xH average input leakage current low (I_{IL}), with V_{DD} = 3.6V and inputs grounded, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The SMD limits are -1µA minimum and 1µA maximum.

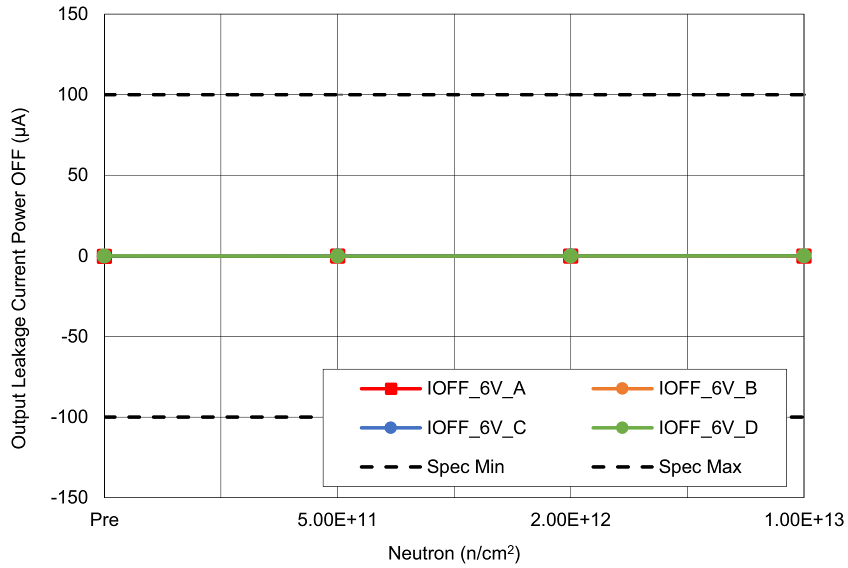

Figure 12. HS-26CLV31xH average output leakage current power off (I_{OFF}), with V_{DD} = 0V, V_{OUT} = 6V and inputs grounded, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The SMD limits are -100µA minimum and 100µA maximum.

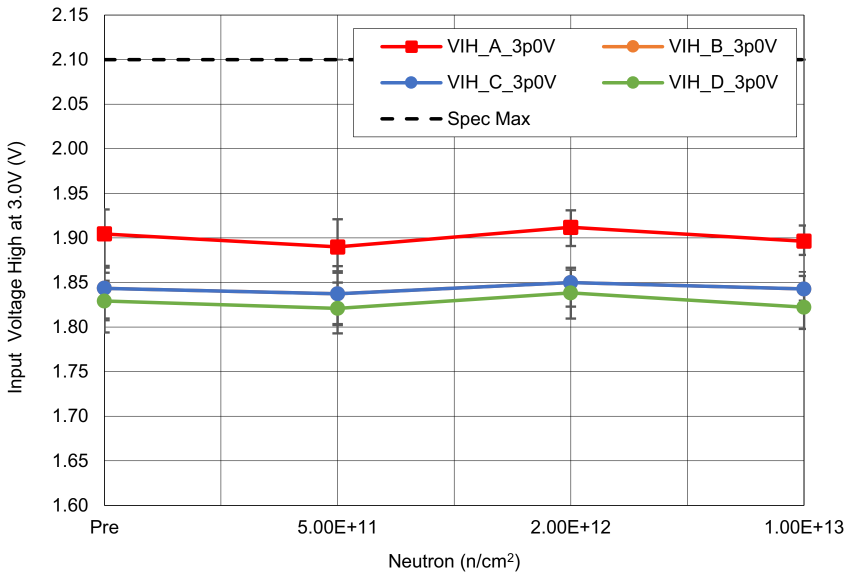

Figure 13. HS-26CLV31xH average input voltage high (V_{IH}), with V_{DD} = 3V, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The SMD limit is 2.1V maximum.

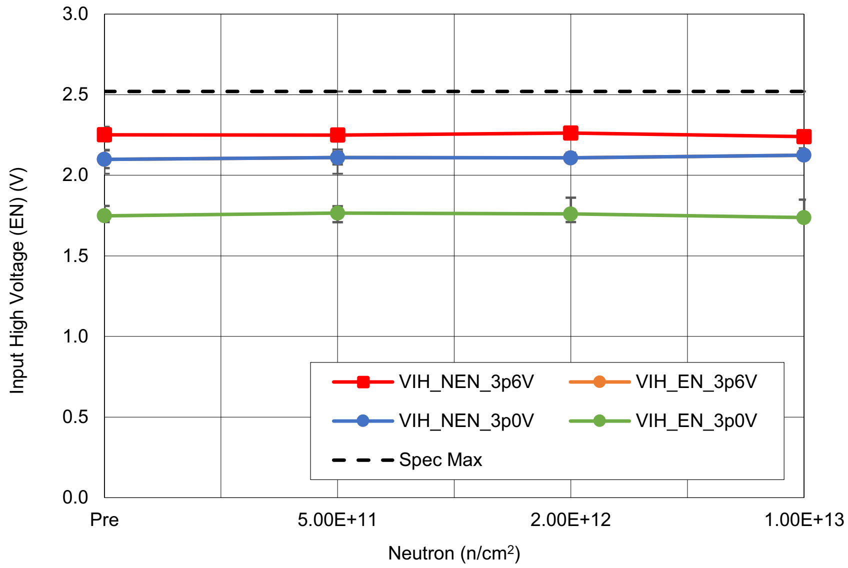

Figure 14. HS-26CLV31xH average enable input voltage high (V_{IH-EN}), with V_{DD} = 3V and 3.6V, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The SMD limit is 2.52V maximum.

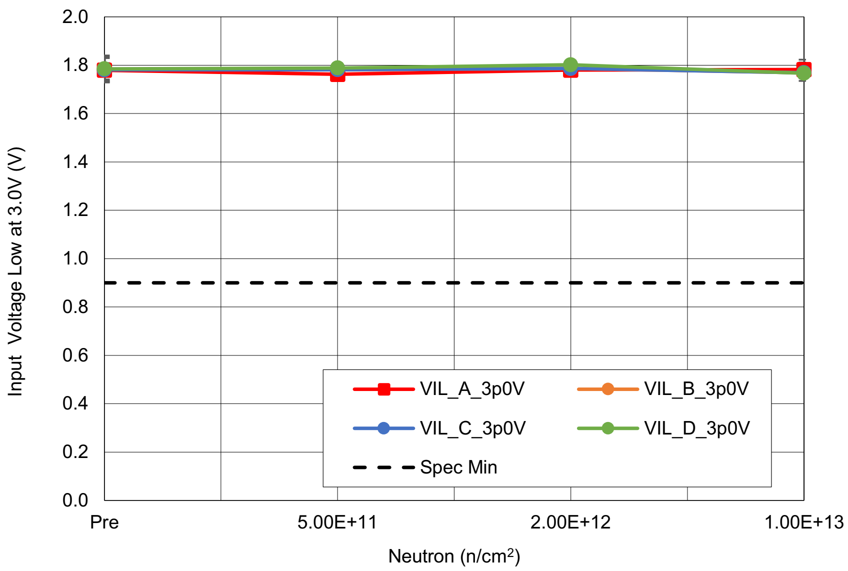

Figure 15. HS-26CLV31xH average input voltage low (V_{IL}), with V_{DD} = 3V, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The SMD limit is 0.9V minimum.

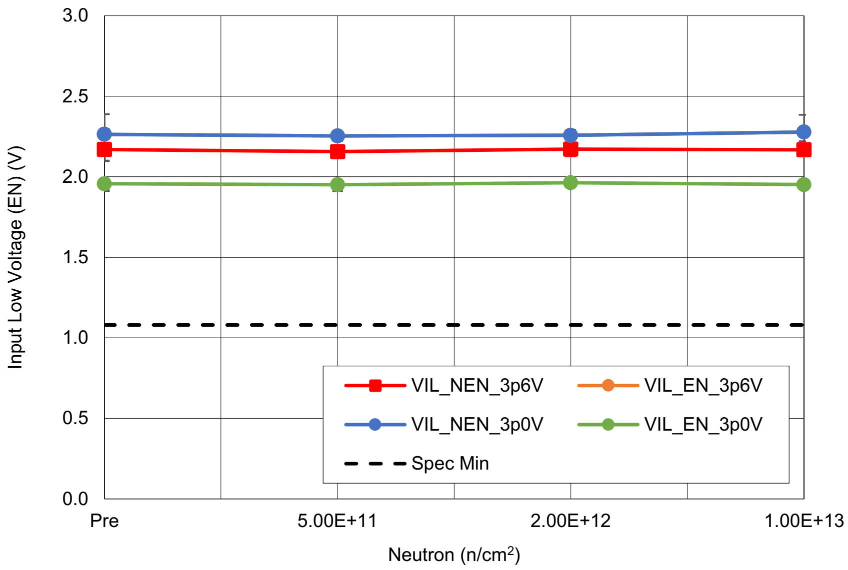

Figure 16. HS-26CLV31xH average enable input voltage low (V_{IL-EN}), with V_{DD} = 3V and 3.6V, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The SMD limit is 1.08V minimum.

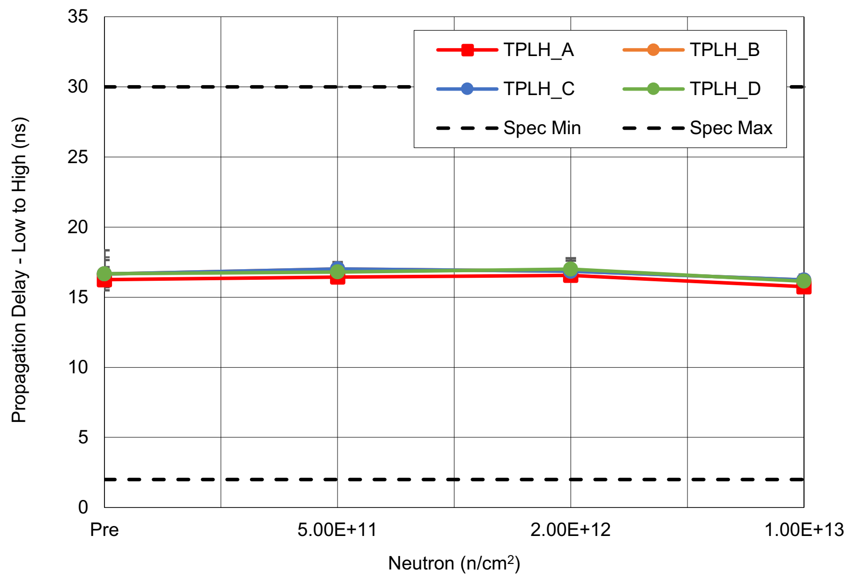

Figure 17. HS-26CLV31xH average low to high propagation delay (t_{PLH}) at V_{DD} = 3V, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The SMD limits are 2ns minimum and 30ns maximum.

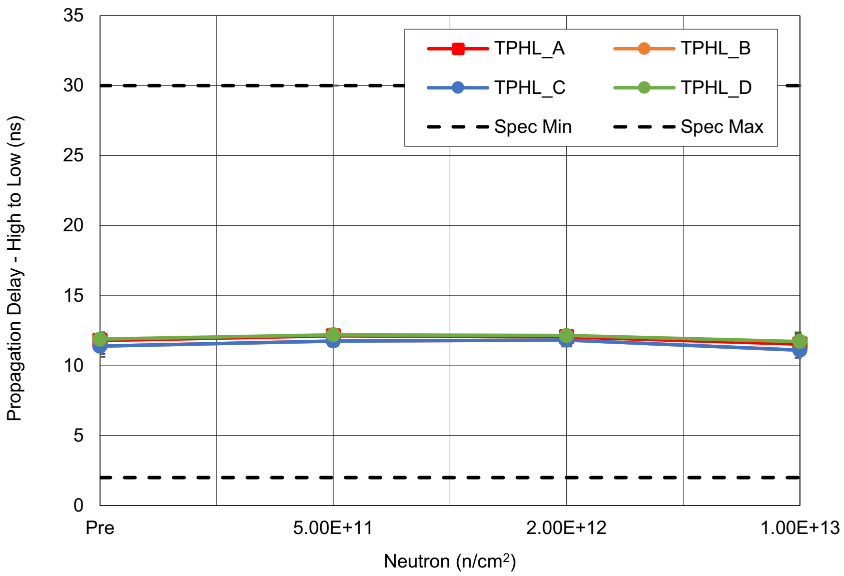

Figure 18. HS-26CLV31xH average high to low propagation delay (t_{PHL}) at V_{DD} = 3V, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The SMD limits are 2ns minimum and 30ns maximum.

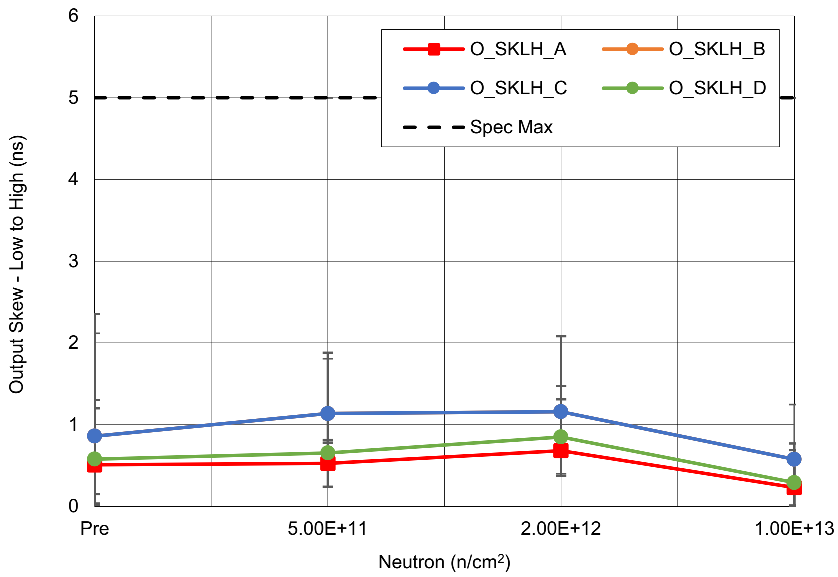

Figure 19. HS-26CLV31xH average low to high output skew (t_{SKEW}) at V_{DD} = 3V, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The SMD limit is 5ns maximum.

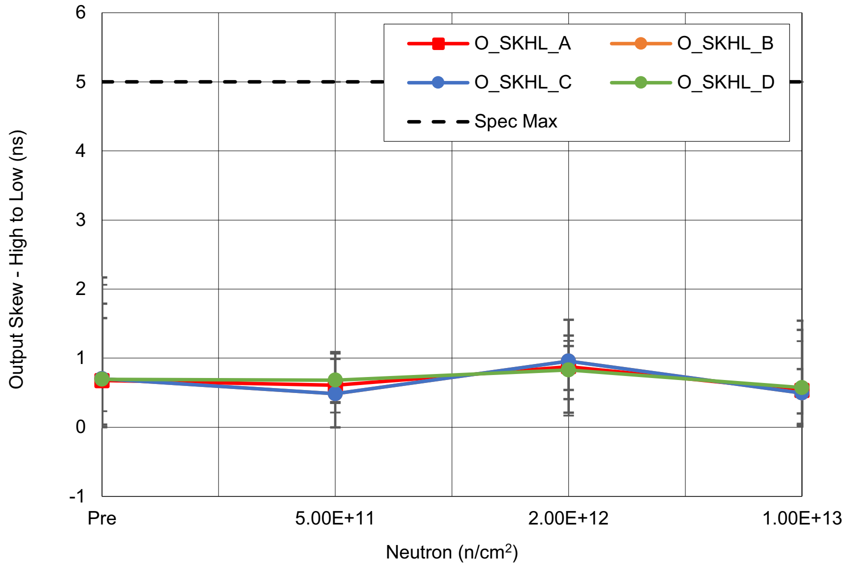

Figure 20. HS-26CLV31xH average high to low output skew (t_{SKEW}) at V_{DD} = 3V, as a function of neutron fluence. The error bars represent the minimum and maximum measured values. The SMD limit is 5ns maximum.

3. Discussion and Conclusion

The 1MeV equivalent neutron testing results of the HS-26CLV31xH radiation-hardened quad differential line 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 Figure 3 through Figure 20. 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 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	May 15, 2025	Updated Key Parameter Variables Data section. Updated Discussion and Conclusion section.
1.00	Jul 3, 2023	Initial release.

A. Appendix

A.1 Reported Parameters

Table 3. HS-26CLV31xH Key Parameters (T_A = 25°C)

Fig	Parameter	Symbol	Conditions	Low Limit	High Limit	Unit
3	Standby Supply Current	I_{DDSB}	V_{DD} = 3.6V, Output = OPEN, V_{IN} = V_{DD} or GND	-	100	µA
4	Tri-state Output Leakage Current High	I_{OZH}	V_{DD} = 3.6V, force V_{OUT} = 0V	-5	5	µA
5	Tri-state Output Leakage Current Low	I_{OZL}	V_{DD} = 3.6V, force V_{OUT} = V_{DD}	-5	5	µA
6	High-Level Output Voltage	V_{OH}	V_{DD} = 3V, I_{OUT} = -20mA	1.8	-	V
7	Low-Level Output Voltage	V_{OL}	V_{DD} = 3V, I_{OUT} = 20mA	-	500	mV
8	Differential Output Voltage	V_T	V_{DD} = V_{IH} = 3V, V_{IL} = 0V, R_L = 100Ω	1.8	-	V
9	Common Mode Output Voltage	V_{OS}	V_{DD} = V_{IH} = 3V, V_{IL} = 0V, R_L = 100Ω	-	3	V
10	Input Leakage Current High	I_{IH}	V_{DD} = 3.6V and inputs = V_{DD}	-1	1	µA
11	Input Leakage Current Low	I_{IL}	V_{DD} = 3.6V and inputs grounded	-1	1	µA
12	Power Off Output Leakage	I_{OFF}	V_{DD} = 0V, V_{OUT} = 6V and inputs grounded	-100	100	µA
13	High-Level Input Voltage (IN)	V_{IH}	V_{DD} = 3V	-	2.1	V
14	High-Level Input Voltage (EN)	V_{IH-EN}	V_{DD} = 3V, 3.6V	-	2.52	V
15	Low-Level Input Voltage (IN)	V_{IL}	V_{DD} = 3V	0.9	-	V
16	Low-Level Input Voltage (EN)	V_{IL-EN}	V_{DD} = 3V, 3.6V	1.08	-	V
17	Low-to-High Propagation Delay	t_{PLH}	V_{DD} = 3V	2	30	ns
18	High-to-Low Propagation Delay	t_{PHL}	V_{DD} = 3V	2	30	ns
19	Low-to-High Output Skew	t_{SKEW}	V_{DD} = 3V	-	5	ns
20	High-to-Low Output Skew	t_{SKEW}	V_{DD} = 3V	-	5	ns

A.2 Related Information

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

- HS-26CLV31RH, HS-26CLV31EH, HS-26C31RH, HS-26C31EH, HS-26CT31RH, and HS-26CT31EH device pages
- MIL-STD-883 test method 1017

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