ISL74422ARH

Neutron Test Report

TR064
Rev.0.00
Mar 27, 2018

Introduction

This report summarizes results of 1MeV equivalent neutron testing of the ISL74422ARH power MOSFET 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 $5x10^{11}n/cm^2$ to $1x10^{14}n/cm^2$. This project was carried out in collaboration with Honeywell Aerospace (Clearwater, FL) and their support is gratefully acknowledged.

Product Description

The ISL74422ARH is a non-inverting, monolithic high-speed MOSFET driver designed to convert a CMOS level input signal into a high current output at voltages up to 18V. Its fast rise times and high current output allow control of even the largest power MOSFET devices in high frequency applications. The input of the ISL74422ARH can be directly driven by the Renesas HS-1825ARH and IS-1845ASRH PWM devices. The 9A high current output minimizes power losses in MOSFET devices by rapidly charging and discharging high gate capacitances.

The part is fabricated using the Renesas dielectrically isolated Radiation Hardened Silicon Gate (RSG) BiCMOS process. It is resistant to single event latch-up and provides highly reliable performance in harsh radiation environments.

Specifications for radiation hardened QML devices are controlled by the Defense Logistics Agency, Land and Maritime, in Columbus, OH. Detailed electrical specifications for the ISL74422ARH are contained in the SMD.

Related Literature

For a full list of related documents, visit our website

- ISL74422ARH product page
- MIL-STD-883 test method 1017
- DSCC Standard Microcircuit Drawing (SMD) 5962–03248

1. Test Description

1.1 Irradiation Facility

Neutron fluence irradiations were performed on the test samples on June 25, 2015, at the WSMR Fast Burst Reactor (FBR) which provides a controlled 1MeV equivalent neutron flux. The tests were carried out per MIL-STD-883G, Method 1017.2, with each part unpowered during irradiation and all leads shorted. Because 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 cool-down time before being shipped back to Renesas (Palm Bay, FL) for electrical testing.

1.2 Test Fixturing

No formal irradiation test fixturing is involved. These DD tests are bag tests, meaning that the parts are irradiated with all leads shorted together.

1.3 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.

1.4 Experimental Matrix

Testing proceeded in general accordance with the guidelines of MIL-STD-883 Test Method 1017. The experimental matrix consisted of five samples irradiated at $5x10^{11}n/cm^2$, five samples irradiated at $2x10^{12}n/cm^2$, five samples irradiated at $1x10^{13}n/cm^2$, and five samples irradiated at $1x10^{14}n/cm^2$. Two control units were used to ensure repeatability. ISL74422ARH samples were drawn from production inventory.

2. Results

ISL74422ARH neutron test results are reported in this report. Each neutron irradiation was performed on a different set of samples; this is *not* total dose testing, in which the damage is cumulative.

2.1 Attributes Data

Table 1. Attributes Data

Fluence, (n/cm^2)	Sample Size	Pass (Note 1)	Fail	Notes
$5x10^{11}$	5	5	0	All passed
$2x10^{12}$	5	5	0	All passed
$1x10^{13}$	5	5	0	All passed
$1x10^{14}$	5	5	5	All failed parametrically, LOW output ON-resistance; all samples were functional

Note:
1. “Pass” indicates a sample that passes all SMD limits.

2.2 Variables Data Plots

The plots in Figures 1 through 6 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 downpoint, 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. Although the applicable electrical limits taken from the SMD are also shown, note that these limits are provided for guidance only because the ISL74422ARH is not specified for the neutron environment.

All samples passed the post-irradiation SMD limits after all exposures up to and including $1x10^{13}n/cm^2$, but failed the SMD post-irradiation limit for low output ON-resistance (R_{ONL}) after $1x10^{14}n/cm^2$.

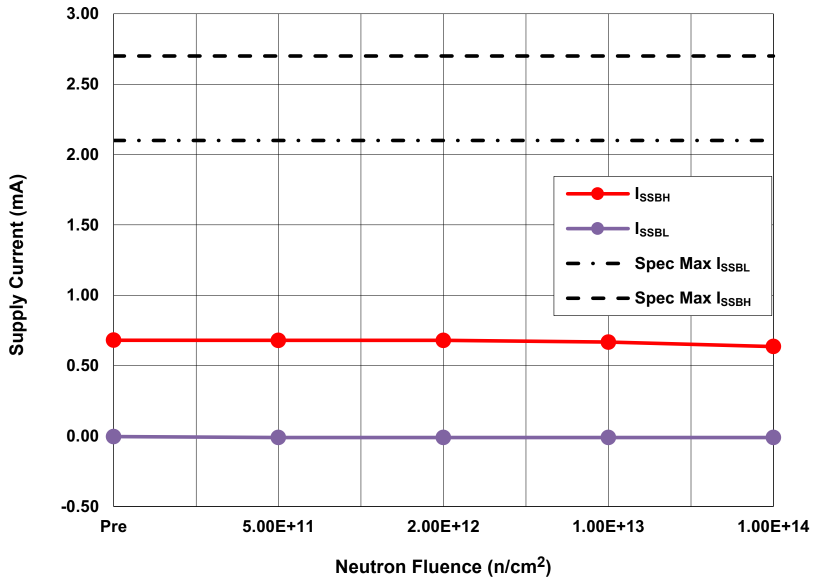

Figure 1. ISL74422ARH low (I_{SSBL}) and high (I_{SSBH}) power supply current following irradiation to each level with V_S = 18V; V_{IN} = 0.8V (I_{SSBL}) and V_{IN} = 10.0V (I_{SSBH}). The error bars represent the minimum and maximum measured values. The SMD limits are 2.1mA maximum (I_{SSBL}) and 2.7mA maximum (I_{SSBH}).

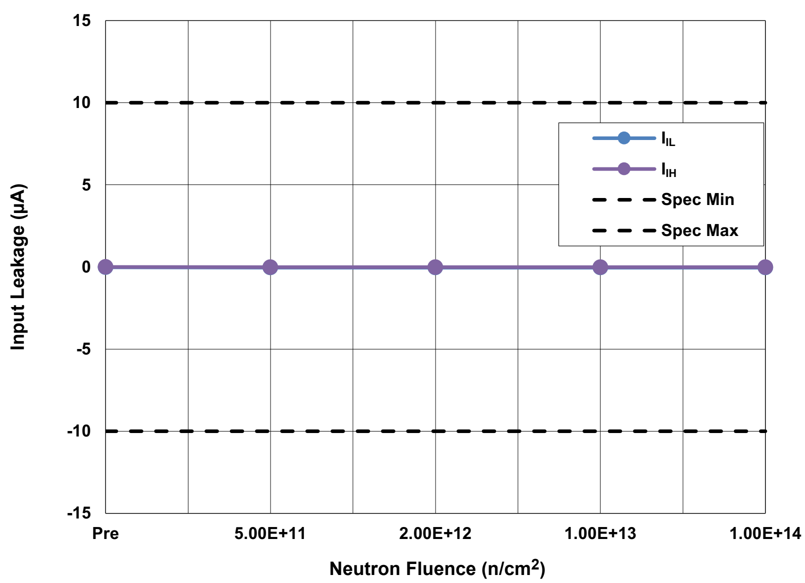

Figure 2. ISL74422ARH low (I_{IL}) and high (I_{IH}) input leakage current following irradiation to each level with V_S = 18V; V_{IN} = 0V (I_{IL}) and V_{IN} = 18V (I_{IH}). The error bars represent the minimum and maximum measured values. The SMD limits are -10µA minimum and +10µA maximum for both parameters.

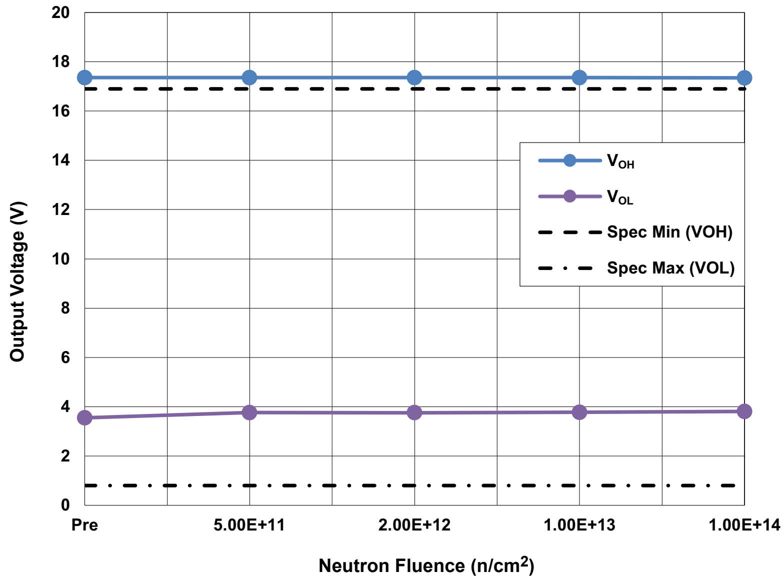

Figure 3. ISL74422ARH low (V_{OL}) and high (V_{OH}) output voltage following irradiation to each level with V_S = 18V; V_{IN} = 0.8V (V_{OL}) and V_{IN} = 10.0V (V_{OH}). The error bars represent the minimum and maximum measured values. The SMD limits are 16.9V minimum (V_{OH}) and 0.8V maximum (V_{OL}).

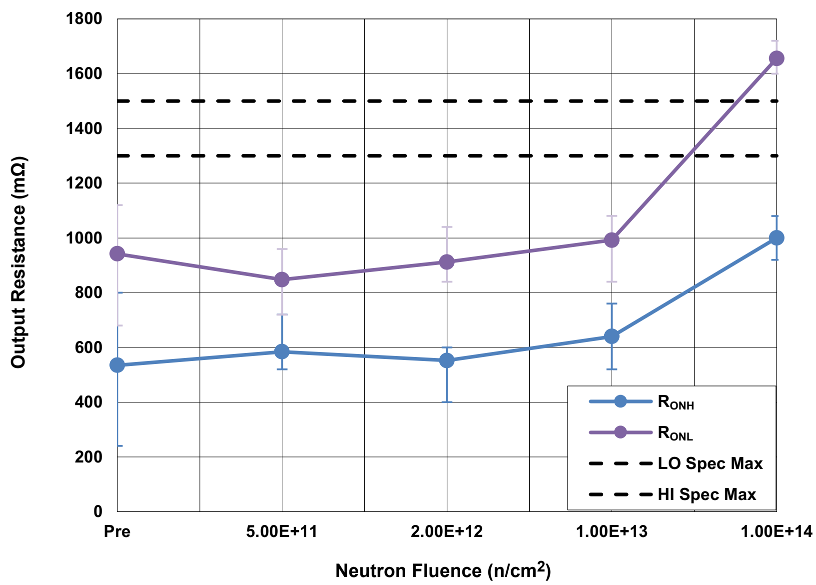

Figure 4. ISL74422ARH low (R_{ONL}) and high (R_{ONH}) output ON-resistance following irradiation to each level with V_S = 18V; V_{IN} = 0.8V (R_{ONL}) and V_{IN} = 5.0V (R_{ONH}). The error bars represent the minimum and maximum measured values. The SMD limits are 1500mΩ maximum (R_{ONL}) and 1300mΩ maximum (R_{ONH}).

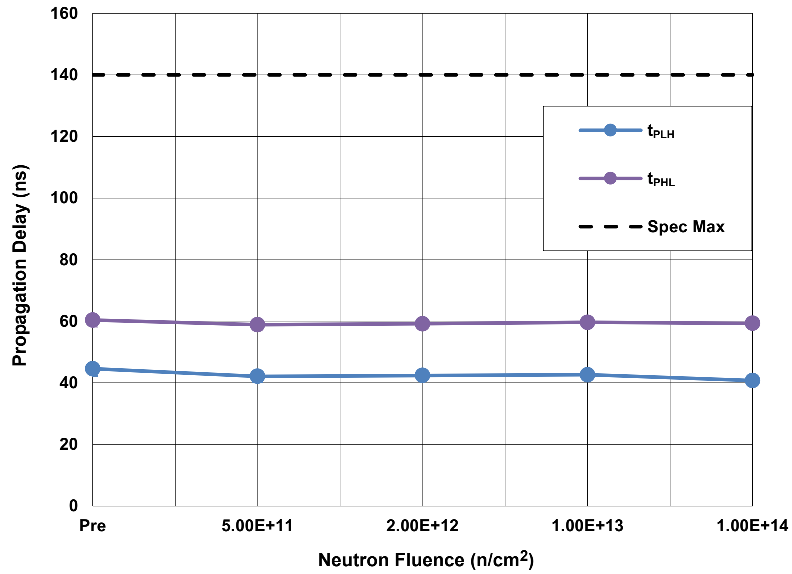

Figure 5. ISL74422ARH low to high (t_{PLH}) and high to low (t_{PHL}) propagation delay following irradiation to each level with V_S = 18V, C_L = 10nF. The error bars represent the minimum and maximum measured values. The SMD limit is 140ns maximum for both parameters.

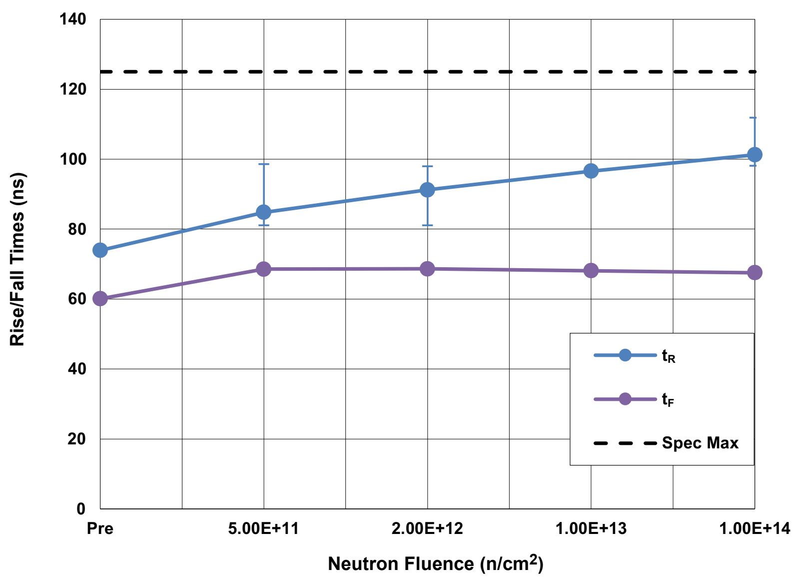

Figure 6. ISL74422ARH rise (t_R) and fall (t_F) time following irradiation to each level with V_S = 15V, C_L = 10nF. The error bars represent the minimum and maximum measured values. The SMD limit is 125ns maximum for both parameters.

3. Discussion and Conclusion

This document reports the results of neutron testing of the ISL74422ARH power MOSFET driver. Samples were irradiated to fluences of $5x10^{11}n/cm^2$, $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$ and $1x10^{14}n/cm^2$. Each neutron irradiation was performed on a different set of samples, in contrast to total dose testing, in which 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 Figures 1 through 6.

The ISL74422ARH is not formally designed, specified, or guaranteed for neutron hardness. The part is built in a dielectrically-isolated BiCMOS process; the bipolar transistors were expected to be sensitive to Displacement Damage (DD) at the higher neutron levels. The following sections analyze the results on a parameter by parameter basis and draw conclusions.

3.1 Reported Parameters

Figure	Parameter	Limit, Low	Limit, High	Units	Notes
1	Supply current	-	2.1	mA	Output LOW
	Supply current	-	2.7	mA	Output HIGH
2	Input current	-10	+10	µA	Output LOW
	Input current	-10	+10	µA	Output HIGH
3	Output voltage	-	0.8	V	Output LOW
	Output voltage	16.9	-	V	Output HIGH
4	Output ON-resistance	-	1300	mΩ	Output HIGH
	Output ON-resistance	-	1500	mΩ	Output LOW
5	Propagation delay	-	140	ns	LOW to HIGH
	Propagation delay	-	140	ns	HIGH to LOW
6	Rise time	-	125	ns	LOW to HIGH
	Fall time	-	125	ns	HIGH to LOW

The low and high output supply current (Figure 1), low and high input current (Figure 2) and low and high output voltage (Figure 3) showed good stability after all neutron levels.

The low and high output ON-resistance (Figure 4) showed a gradual increase through the $1x10^{13}n/cm^2$ level and a marked increase at the $1x10^{14}n/cm^2$ level. At the $1x10^{14}n/cm^2$ level the high ON-resistance remained within the SMD limits but the low ON-resistance was out of specification.

The low to high and high to low propagation delay (Figure 5) and rise and fall time (Figure 6) showed good stability after all neutron levels.

We conclude that the ISL74422ARH remained within the post total dose SMD limits following the $5x10^{11}n/cm^2$, $2x10^{12}$ n/cm^2 and $1x10^{13}n/cm^2$ neutron irradiations. The part failed parametrically following $1x10^{14}n/cm^2$ irradiation, with the low state ON-resistance out of specification but with the high state ON-resistance remaining within the SMD limits.

4. Revision History

Date	Rev.	Description
Mar 27, 2018	0.00	Initial release.

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