Neutron testing of the HS-201HSRH quad analog switch

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Revision 0

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1. Introduction

This report summarizes results of 1 MeV equivalent neutron testing of the HS-201HSRH quad analog switch. The test was conducted in order to determine the sensitivity of the part to the displacement damage caused by the neutron environment. Neutron fluences ranged from 5 x 10^{11} n/cm^2 to 1 x 10^{14} n/cm^2 in an approximately logarithmic sequence. This project was carried out in collaboration with Honeywell Aerospace (Clearwater, FL), and their support is gratefully acknowledged.

2: Part Description

The HS-201HSRH, HS-201HSEH are monolithic CMOS analog switches featuring power-off high input impedance, very fast switching speeds and low ON-resistance. Fabrication on the Intersil DI RSG process assures SEL immunity and good low dose rate performance. These Class V/Q devices are acceptance tested to 300krad (Si) at high dose rate and to 50krad(Si) at low dose rate. Power-off high input impedance enables the use of this device in redundant circuits without causing data bus signal degradation. ESD protection, overvoltage protection, fast switching times, low ON resistance and guaranteed radiation hardness make the HS-201HSRH ideal for any space application where improved switching performance is required.

Specifications for Rad Hard QML devices are controlled by the Defense Logistics Agency Land and Maritime (DLA). The SMD numbers listed below must be used when ordering. Detailed Electrical Specifications for these devices are contained in SMD 5962-99618. A “hot-link” is provided on the Intersil homepage for downloading this and other documents.

- QML qualified per MIL-PRF-38535
- Radiation performance:
  - High dose rate (50-300rad(Si)/s) — 300krad(Si)
  - Low dose rate (0.01rad(SI)/s) — 50krad(Si)
  - SEL immune — DI RSG process
- Overvoltage protection (power on, switch off) — ±30V
- Power off high impedance — ±17V
- Fast switching times
  - t_{ON} — 110ns (max)
  - t_{OFF} — 80ns (max)
- Low “ON” resistance — 50Ω (max)
- Pin compatible with industry standard 201 switches
- Operating supply range — ±10V to ±15V
- Wide analog voltage range (±15V supplies) — ±15V

3: Test Description

3.1 Irradiation Facilities

Neutron irradiation was performed by the Honeywell (Clearwater, FL) team at the Fast Burst Reactor facility at White Sands Missile Range (White Sands, NM), which provides a controlled 1MeV equivalent neutron flux. Parts were tested in an unbiased configuration with all leads open. As neutron irradiation activates many of the elements found in a packaged integrated circuit, the parts exposed at the higher neutron levels required (as expected) significant ‘cooldown time’ before being shipped back to the Intersil facility (Palm Bay, FL) for electrical testing.

3.2 Characterization equipment and procedures

Electrical testing was performed before and after irradiation using the Intersil production automated test equipment (ATE). All electrical testing was performed at room temperature.

3.3 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 5×10^{11} n/cm^2, five samples irradiated at 2×10^{12} n/cm^2, five samples irradiated at 1×10^{13} n/cm^2 and five samples irradiated at 1×10^{14} n/cm^2. Two control units were used.

4: Results

4.1 Attributes data

Neutron testing of the HS-201HSRH is complete and the results are reported in the balance of this report. It should be realized when reviewing the data that each neutron irradiation was made on a different 5-unit sample; this is not total dose testing, where the damage is cumulative. Table 1 summarizes the results.

Table 1: Neutron irradiation test results.

Neutron fluence	Sample size	Bin 1	Rejects
5 x 10^{11} n/cm^2	5	5	0
2 x 10^{12} n/cm^2	5	5	0
1 x 10^{13} n/cm^2	5	5	0
1 x 10^{14} n/cm^2	5	5	5

4.2 Variables data

The plots in Figs. 1 through 15 show data plots for key parameters before and after irradiation to each level. The plots show the average, minimum and maximum of each parameter for each of the four channels as a function of neutron irradiation. The exception is Fig. 1 which shows the total power supply current, positive and negative, for the four channels.

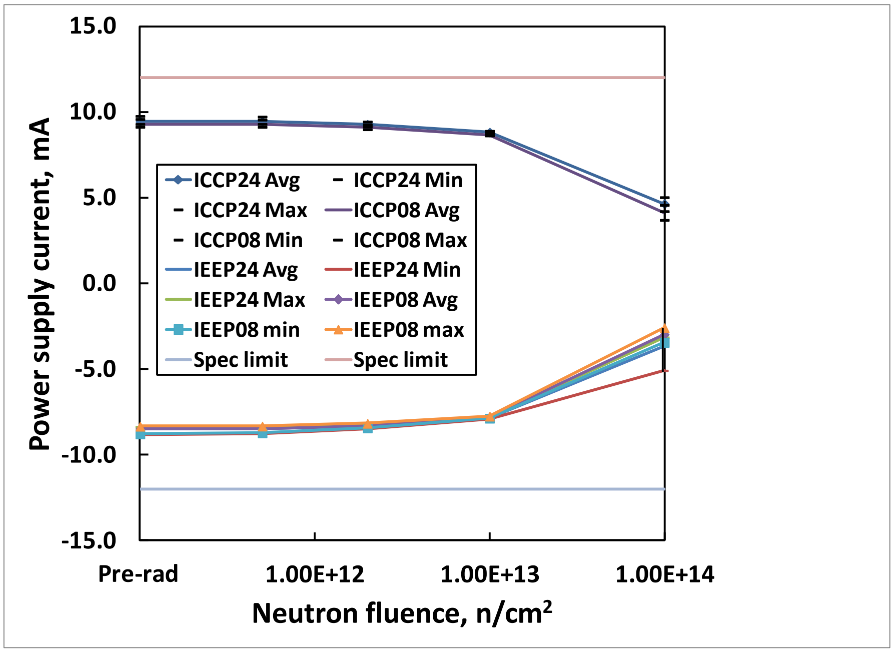

Fig. 1: HS-201HSRH positive and negative power supply current at ±8.0V and ±24V as a function of neutron irradiation, showing the mean, minimum and maximum of the populations at each level. Sample size was 5 for each cell (5 x 10^{11} n/cm^2, 2 x 10^{12} n/cm^2, 1 x 10^{13} n/cm^2 and 1 x 10^{14} n/cm^2), with two control units. The post-irradiation SMD limits are +12mA maximum (ICC) and -12V maximum (IEE).

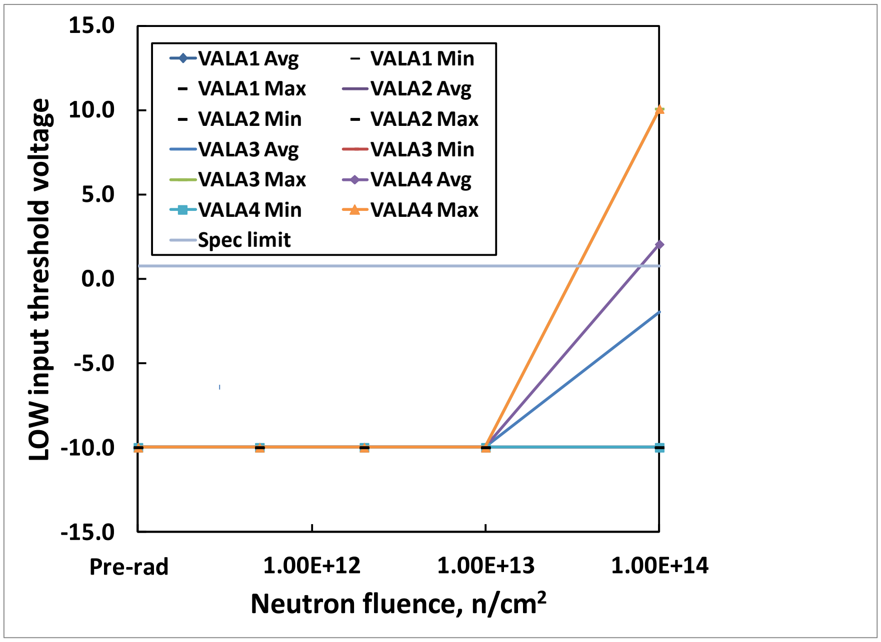

Fig. 2: HS-201HSRH LOW input threshold voltage as a function of neutron irradiation, each channel, showing the mean, minimum and maximum of the populations at each level. Sample size was 5 for each cell (5 x 10^{11} n/cm^2, 2 x 10^{12} n/cm^2, 1 x 10^{13} n/cm^2 and 1 x 10^{14} n/cm^2), with two control units. The post-irradiation SMD limit is 0.8V maximum.

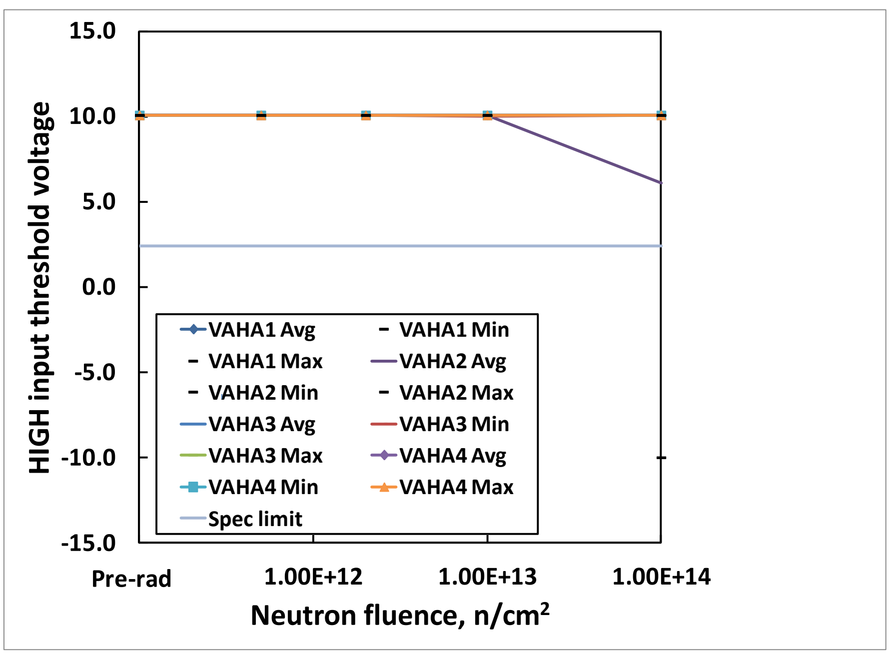

Fig. 3: HS-201HSRH HIGH input threshold voltage as a function of neutron irradiation, each channel, showing the mean, minimum and maximum of the populations at each level. Sample size was 5 for each cell (5 x 10^{11} n/cm^2, 2 x 10^{12} n/cm^2, 1 x 10^{13} n/cm^2 and 1 x 10^{14} n/cm^2), with two control units. The post-irradiation SMD limit is 2.4V minimum.

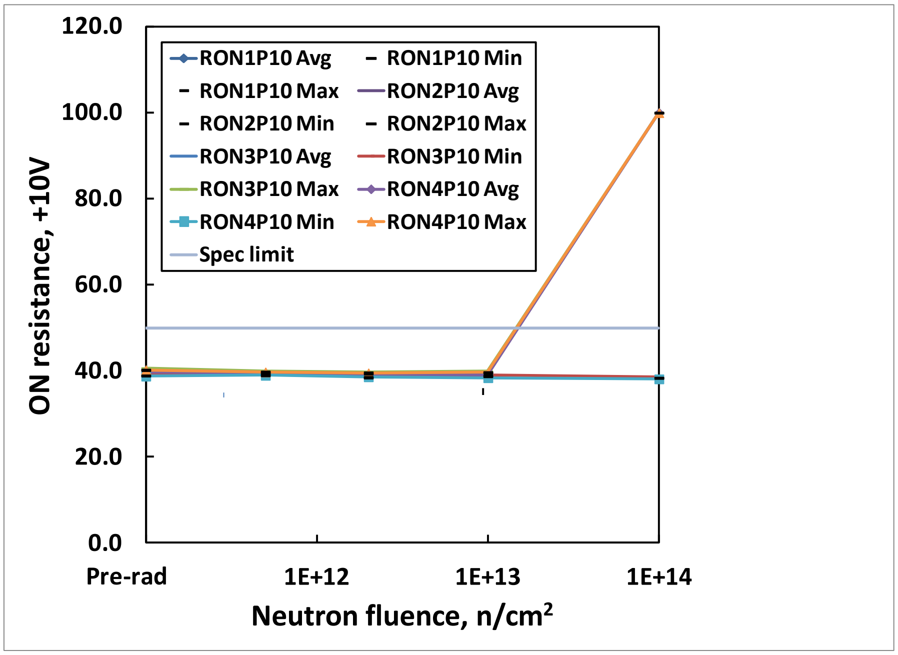

Fig. 4: HS-201HSRH ON resistance at +10.0V as a function of neutron irradiation, each channel, showing the mean, minimum and maximum of the populations at each level. Sample size was 5 for each cell (5 x 10^{11} n/cm^2, 2 x 10^{12} n/cm^2, 1 x 10^{13} n/cm^2 and 1 x 10^{14} n/cm^2), with two control units. The post-irradiation SMD limit is 50.0 ohms maximum.

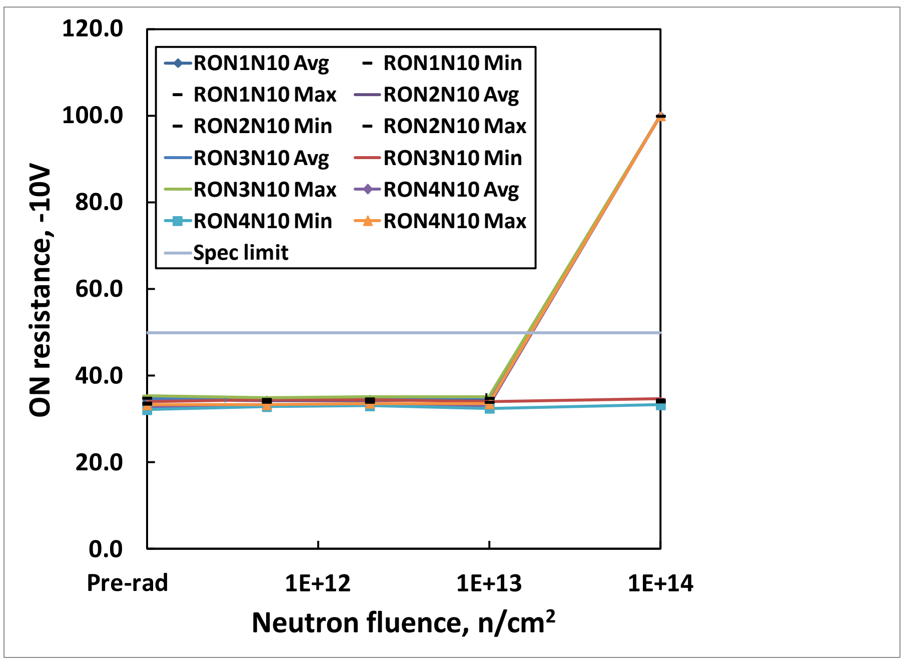

Fig. 5: HS-201HSRH ON resistance at -10.0V as a function of neutron irradiation, each channel, showing the mean, minimum and maximum of the populations at each level. Sample size was 5 for each cell (5 x 10^{11} n/cm^2, 2 x 10^{12} n/cm^2, 1 x 10^{13} n/cm^2 and 1 x 10^{14} n/cm^2), with two control units. The post-irradiation SMD limit is 50.0 ohms maximum.

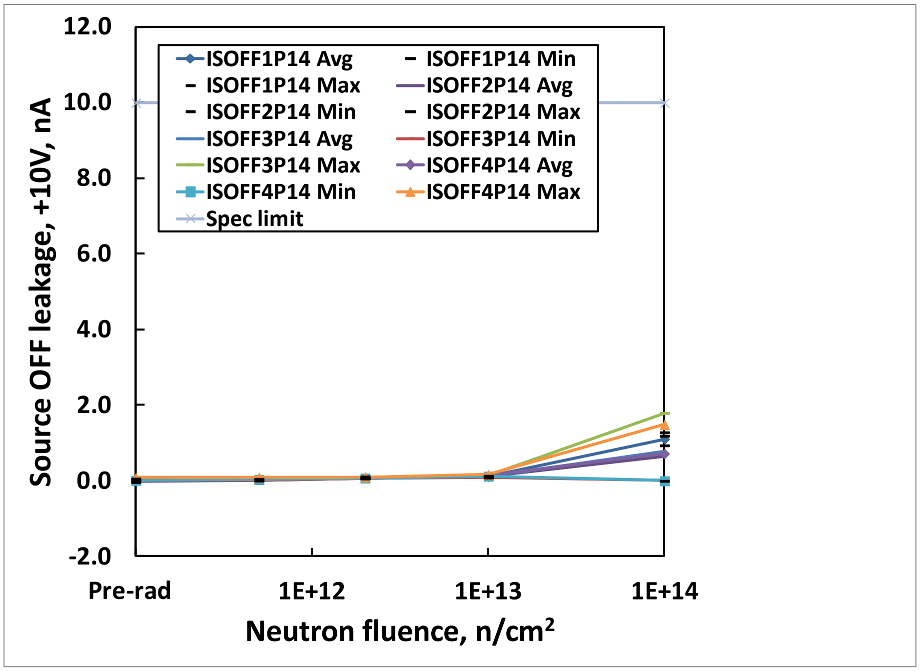

Fig. 6: HS-201HSRH source OFF leakage at +10.0V as a function of neutron irradiation, each channel, showing the mean, minimum and maximum of the populations at each level. Sample size was 5 for each cell (5 x 10^{11} n/cm^2, 2 x 10^{12} n/cm^2, 1 x 10^{13} n/cm^2 and 1 x 10^{14} n/cm^2), with two control units. The post-irradiation SMD limit is +10.0nA maximum.

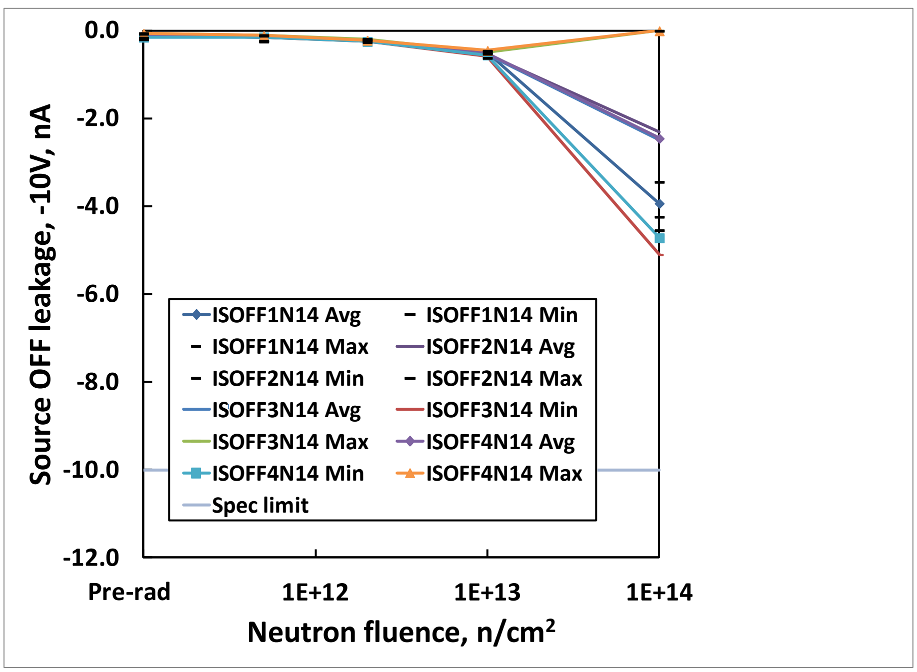

Fig. 7: HS-201HSRH source OFF leakage at -10.0V as a function of neutron irradiation, each channel, showing the mean, minimum and maximum of the populations at each level. Sample size was 5 for each cell (5 x 10^{11} n/cm^2, 2 x 10^{12} n/cm^2, 1 x 10^{13} n/cm^2 and 1 x 10^{14} n/cm^2), with two control units. The post-irradiation SMD limit is +10.0nA maximum

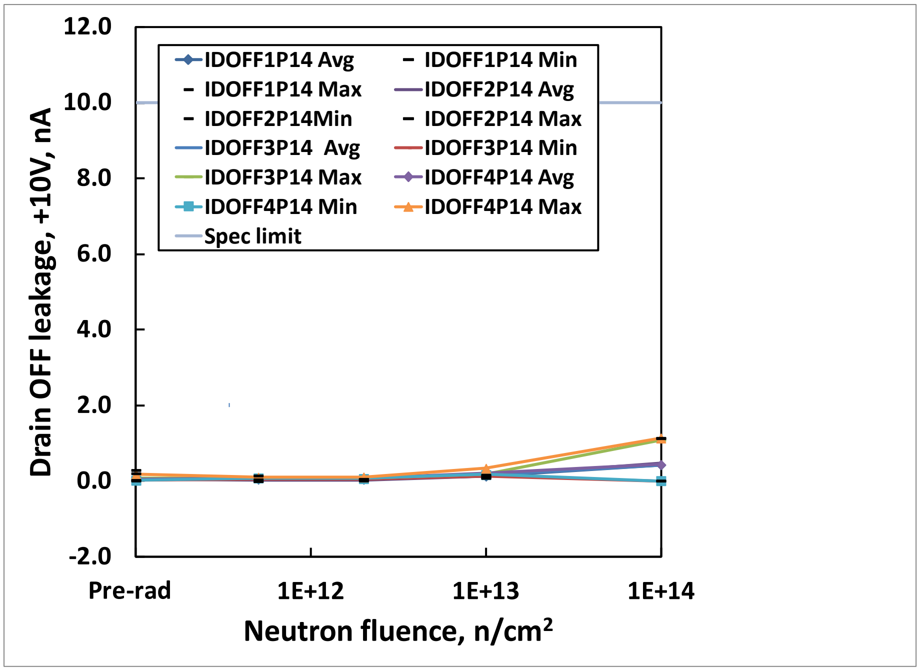

Fig. 8: HS-201HSRH drain OFF leakage at +10.0V as a function of neutron irradiation, each channel, showing the mean, minimum and maximum of the populations at each level. Sample size was 5 for each cell (5 x 10^{11} n/cm^2, 2 x 10^{12} n/cm^2, 1 x 10^{13} n/cm^2 and 1 x 10^{14} n/cm^2), with two control units. The post-irradiation SMD limit is +10.0nA maximum.

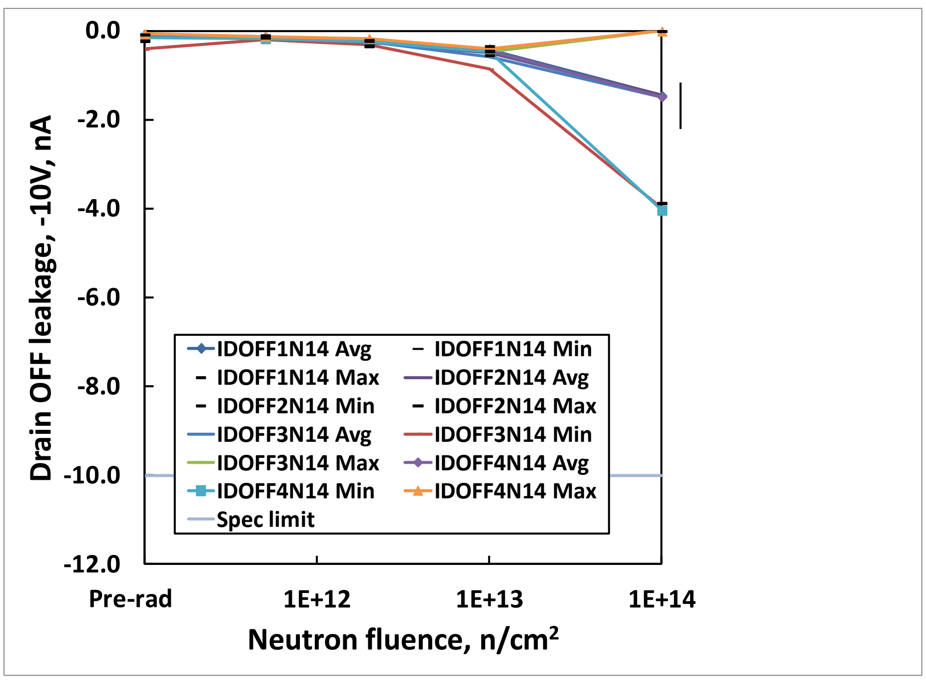

Fig. 9: HS-201HSRH drain OFF leakage at -10.0V as a function of neutron irradiation, each channel, showing the mean, minimum and maximum of the populations at each level. Sample size was 5 for each cell (5 x 10^{11} n/cm^2, 2 x 10^{12} n/cm^2, 1 x 10^{13} n/cm^2 and 1 x 10^{14} n/cm^2), with two control units. The post-irradiation SMD limit is -10.0nA maximum.

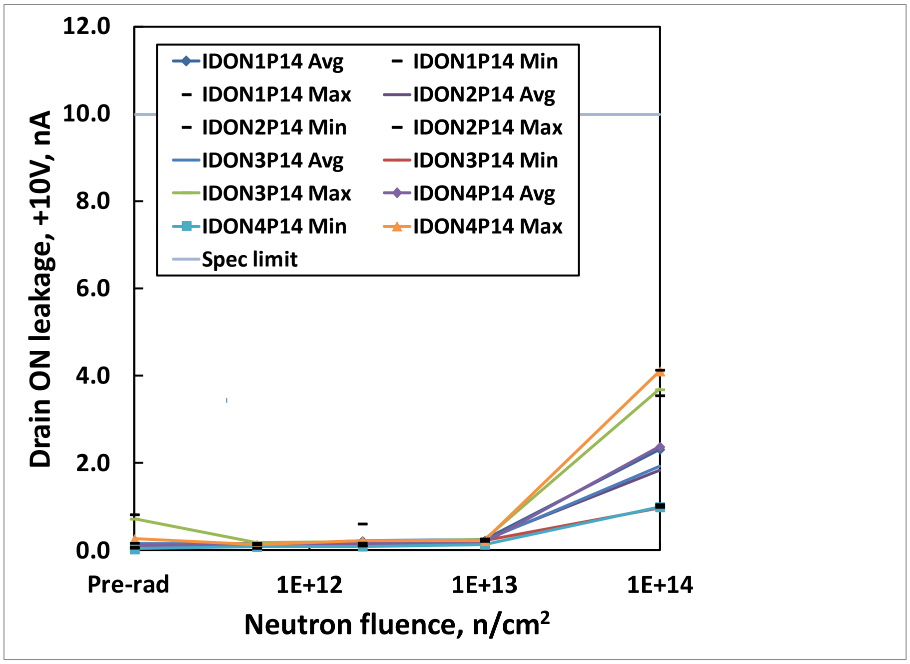

Fig. 10: HS-201HSRH drain ON leakage at +10.0V as a function of neutron irradiation, each channel, showing the mean, minimum and maximum of the populations at each level. Sample size was 5 for each cell (5 x 10^{11} n/cm^2, 2 x 10^{12} n/cm^2, 1 x 10^{13} n/cm^2 and 1 x 10^{14} n/cm^2), with two control units. The post-irradiation SMD limit is +10.0nA maximum.

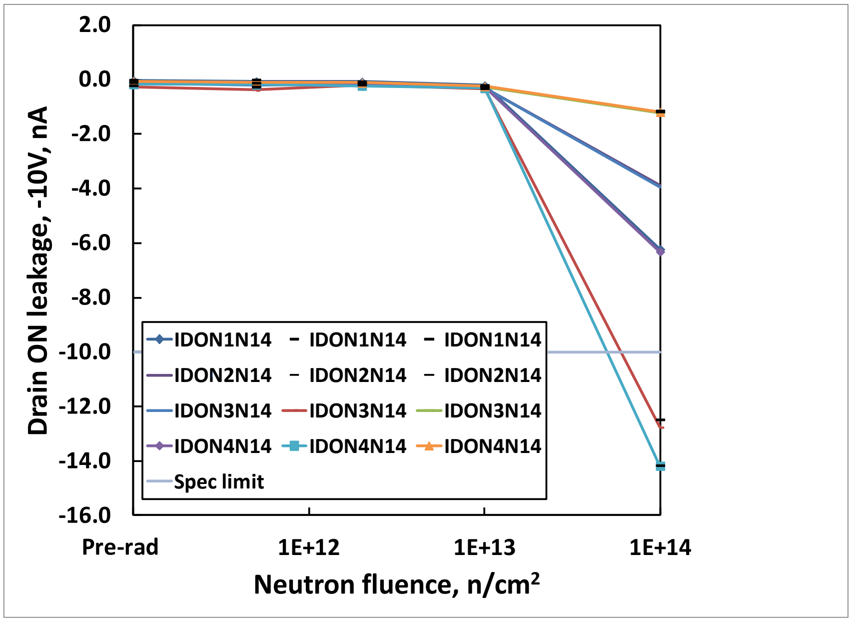

Fig. 11: HS-201HSRH drain ON leakage at -10.0V as a function of neutron irradiation, each channel, showing the mean, minimum and maximum of the populations at each level. Sample size was 5 for each cell (5 x 10^{11} n/cm^2, 2 x 10^{12} n/cm^2, 1 x 10^{13} n/cm^2 and 1 x 10^{14} n/cm^2), with two control units. The post-irradiation SMD limit is -10.0nA maximum.

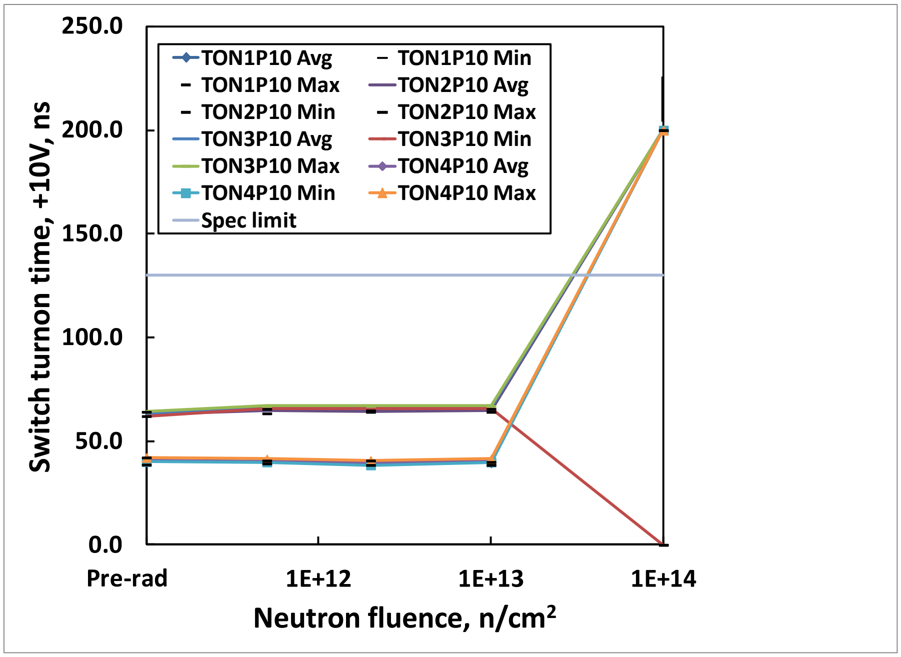

Fig. 12: HS-201HSRH switch turnon time at +10.0V as a function of neutron irradiation, each channel, showing the mean, minimum and maximum of the populations at each level. Sample size was 5 for each cell (5 x 10^{11} n/cm^2, 2 x 10^{12} n/cm^2, 1 x 10^{13} n/cm^2 and 1 x 10^{14} n/cm^2), with two control units. The post-irradiation SMD limit is 130.0ns maximum.

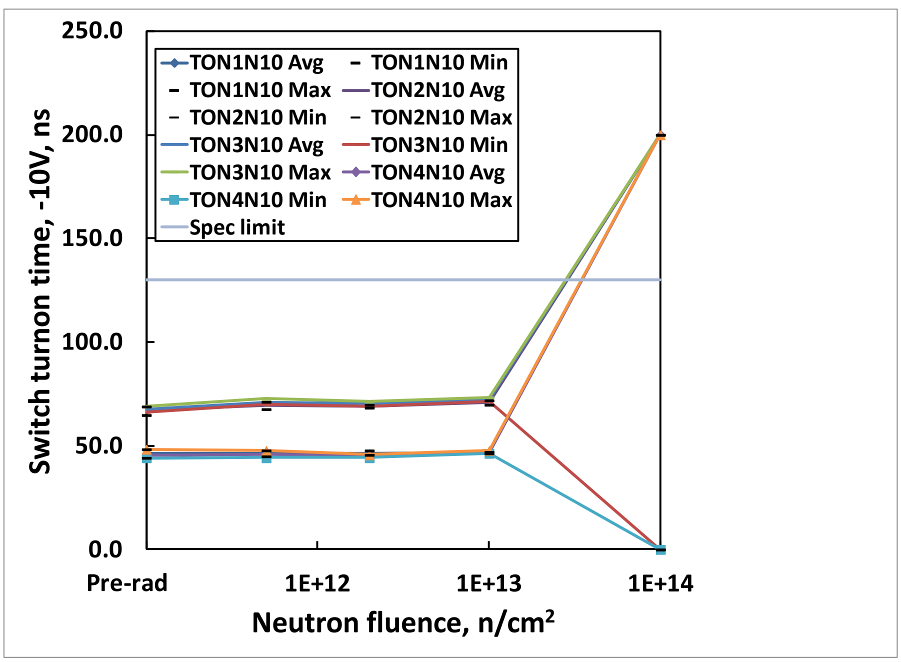

Fig. 13: HS-201HSRH switch turnon time at -10.0V as a function of neutron irradiation, each channel, showing the mean, minimum and maximum of the populations at each level. Sample size was 5 for each cell (5 x 10^{11} n/cm^2, 2 x 10^{12} n/cm^2, 1 x 10^{13} n/cm^2 and 1 x 10^{14} n/cm^2), with two control units. The post-irradiation SMD limit is 130.0ns maximum.

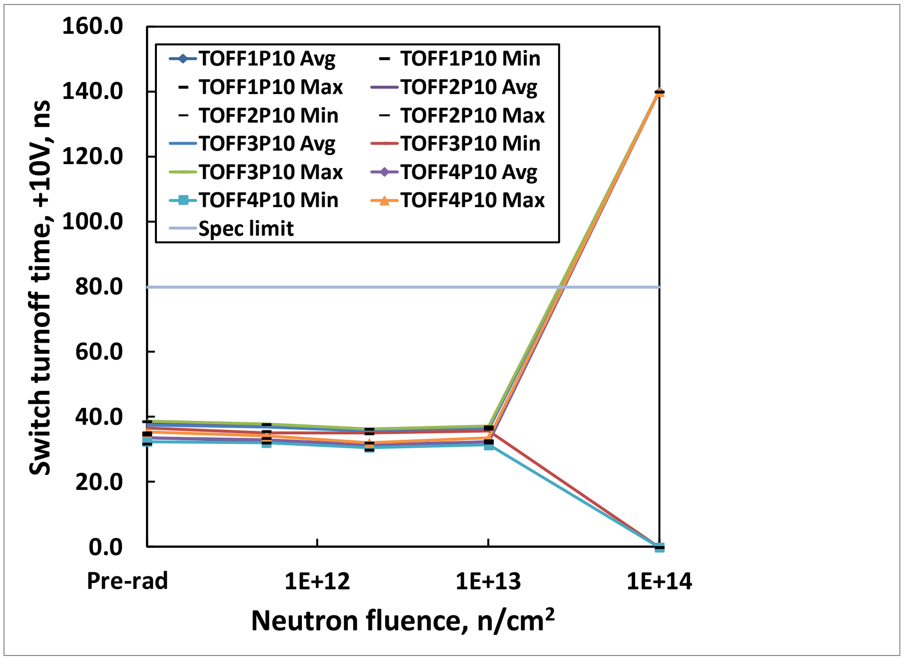

Fig. 14: HS-201HSRH switch turnoff time at +10.0V as a function of neutron irradiation, each channel, showing the mean, minimum and maximum of the populations at each level. Sample size was 5 for each cell (5 x 10^{11} n/cm^2, 2 x 10^{12} n/cm^2, 1 x 10^{13} n/cm^2 and 1 x 10^{14} n/cm^2), with two control units. The post-irradiation SMD limit is 80.0ns maximum.

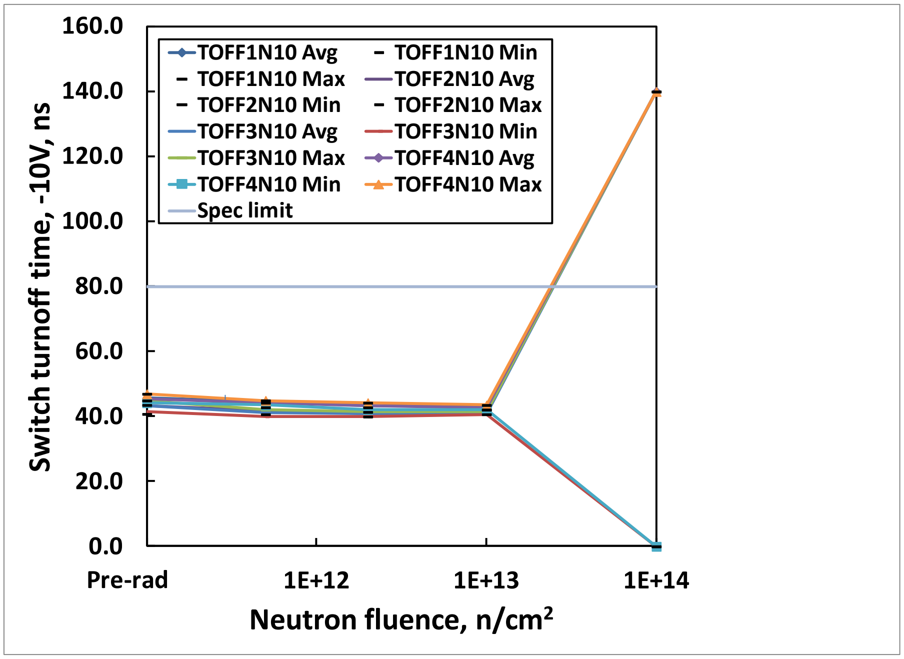

Fig. 15: HS-201HSRH switch turnoff time at -10.0V as a function of neutron irradiation, each channel, showing the mean, minimum and maximum of the populations at each level. Sample size was 5 for each cell (5 x 10^{11} n/cm^2, 2 x 10^{12} n/cm^2, 1 x 10^{13} n/cm^2 and 1 x 10^{14} n/cm^2), with two control units. The post-irradiation SMD limit is 80.0ns maximum.

5: Discussion and conclusion

This document reports the results of neutron testing of the HS-201HSRH quad analog switch. Samples were irradiated to levels of 5 x 10^{11} n/cm^2, 2 x 10^{12} n/cm^2, 1 x 10^{13} n/cm^2 and 1 x 10^{14} n/cm^2 with a sample size of five parts per cell. It should again be realized when reviewing the data that each neutron irradiation was made on a different 5-unit sample; this is not total dose testing, where the damage is cumulative. ATE characterization testing was performed before and after the irradiations, and three control units were used to insure repeatable data. Variables data for monitored parameters is presented in Figs. 1 through 15. The 2 x 10^{12} n/cm^2 level is of some interest in the context of recent developments in the JEDEC community, where the discrete component vendor community have signed up for characterization testing (but not for acceptance testing) at this level.

The HS-201HSRH is not formally designed for neutron hardness. The part is built in a DI BiCMOS process. There are some bipolar transistors in the design; these are minority carrier devices may be expected to be sensitive to displacement damage (DD) at the higher levels. This expectation turned out to be correct. We will discuss the results on a parameter by parameter basis and then draw some conclusions.

The positive and negative power supply current (Fig. 1) showed good stability after 5 x 10^{11} n/cm^2 and 2 x 10^{12} n/cm^2, a slight decrease after 1 x 10^{13} n/cm^2 irradiation and a further decrease after 1 x 10^{14} n/cm^2 irradiation.

The switch turnon time at +10.0V and HIGH input threshold voltage (Figs. 2 and 3) showed good stability after 5 x 10^{11} n/cm^2, 2 x 10^{12} n/cm^2 and 1 x 10^{13} n/cm^2 irradiation but was basically nonfunctional after 1 x 10^{14} n/cm^2 irradiation.

The switch ON resistance at +10.0V and -10.0V (Figs. 4 and 5) showed good stability after 5 x 10^{11} n/cm^2, 2 x 10^{12} n/cm^2 and 1 x 10^{13} n/cm^2 irradiation but was also nonfunctional after 1 x 10^{14} n/cm^2 irradiation. At this point the reader will note that the samples were nonfunctional after irradiation to 1 x 10^{14} n/cm^2, and the data taken at this level do not carry a great deal of meaning.

The source OFF leakage at +10.0V and -10.0V (Figs. 6 and 7), the drain OFF leakage at +10.0V and -10.0V (Figs. 8 and 9) and the drain ON leakage at +10.0V and -10.0V (Figs. 10 and 11) showed good stability after 5 x 10^{11} n/cm^2, 2 x 10^{12} n/cm^2 and 1 x 10^{13} n/cm^2 irradiation but were nonfunctional after 1 x 10^{14} n/cm^2 irradiation.

The switch turnon time at +10.0V and -10.0V (Figs. 12 and 13) and the switch turnoff time at +10.0V and -10.0V (Figs. 14 and 15) showed good stability after 5 x 10^{11} n/cm^2, 2 x 10^{12} n/cm^2 and 1 x 10^{13} n/cm^2 irradiation but were nonfunctional after 1 x 10^{14} n/cm^2 irradiation.

We conclude that the HS-201HSRH is capable of post 1 x 10^{13} n/cm^2 operation within the SMD post-total dose parameters. The part is not capable of post 1 x 10^{14} n/cm^2 operation as it was found to be nonfunctional after irradiation to this level.

6: Appendices

6.1: Reported parameters.

Fig.	Parameter	Limit, low	Limit, high	Units	Notes
1	Positive and negative supply current	-	±12.0	mA	
2	ON input threshold	-	0.8	V	
3	OFF input threshold	2.4	-	V	
4	ON resistance, +10.0V	-	50	ohms	
5	ON resistance, +10.0V	-	50	ohms	
6	Source OFF leakage, +10.0V	-	+10.0	nA	
7	Source OFF leakage, -10.0V	-	-10.0	nA	
8	Drain OFF leakage, +10.0V	-	+10.0	nA	
9	Drain OFF leakage, -10.0V	-	-10.0	nA	
10	Drain ON leakage, +10.0V	-	+10.0	nA	
11	Drain ON leakage, -10.0V	-	-10.0	nA	
12	Switch turnon time, +10.0V	-	130.0	ns	
13	Switch turnon time, -10.0V	-	130.0	ns	
14	Switch turnoff time, +10.0V	-	80.0	ns	
15	Switch turnoff time, -10.0V	-	80.0	ns	

7: Document revision history

Revision	Date	Pages	Comments
0	11 October 2013	All	Original issue