

HS-303CEH

Neutron Testing

TR031

Rev.0.00

July 12, 2016

## Introduction

This report summarizes results of 1MeV equivalent neutron testing of the [HS-303CEH](#) dual analog switch. The test was conducted in order to determine the sensitivity of the part to displacement damage (DD) caused by neutron or proton environments. Neutron fluences ranged from  $2 \times 10^{12} \text{ n/cm}^2$  to  $1 \times 10^{14} \text{ n/cm}^2$ . This project was carried out in collaboration with Boeing (El Segundo, CA), whose support is gratefully acknowledged.

## Reference Documents

- MIL-STD-883 test method 1017
- [HS-303CEH](#) datasheet
- Standard Microcircuit Drawing (SMD) [5962-95813](#)

## Part Description

The HS-303CEH is a dual analog switch fabricated using Intersil's dielectrically isolated Radiation Hardened Silicon Gate (RSG) process technology to insure latch-up free operation. It is pinout compatible and functionally equivalent to the HS-303RH. This switch offers low-resistance switching performance for analog voltages up to the supply rails. ON-resistance is low and stays reasonably constant over the full range of operating voltage and current. Break-before-make switching is controlled by 5V digital inputs. The HS-303CEH can operate with rails of  $\pm 15\text{V}$ .

Specifications for Radiation Hardened QML devices are controlled by the Defense Logistics Agency Land and Maritime (DLA). The SMD number listed in the SMD must be used when ordering. Detailed electrical specifications for the HS-303CEH are contained in SMD [5962-95813](#).

The HS-303CEH is acceptance tested to total dose (TID) levels of 100krad(Si) at high dose rate (50-300rad(Si)/s) and 50krad(Si) at low dose rate ( $< 0.01\text{rad(Si)/s}$ ).

TABLE 1. HS-303CEH PIN ASSIGNMENTS

TERMINAL NUMBER	TERMINAL SYMBOL	TERMINAL NUMBER	TERMINAL SYMBOL
1	NC	8	V-
2	S3	9	IN2
3	D3	10	S2
4	D1	11	D2
5	S1	12	D4
6	IN1	13	S4
7	GND	14	V+

## Test Description

### Irradiation Facilities

1MeV equivalent neutron irradiation was performed by the Boeing team at the White Sands Missile Range fast burst reactor. Dosimetry data can be furnished upon request. Parts were tested in an unbiased configuration with all leads shorted together in general accordance with TM 1017 of MIL-STD-883. As neutron irradiation activates many of the heavier elements found in a packaged integrated circuit, the parts exposed at the higher neutron levels required considerable "cooldown" time before being shipped back to Intersil for electrical testing.

### Test Fixturing

No formal irradiation test fixturing was involved. These DD tests are termed "bag tests" in the sense that the parts are irradiated in an electrically inactive state with all leads shorted together.

### Characterization Equipment and Procedures

Electrical testing was performed before and after irradiation using the Intersil Palm Bay, FL Automated Test Equipment (ATE). All electrical testing was performed at room temperature.

### Experimental Matrix

The experimental matrix consisted of 5 samples irradiated at  $2 \times 10^{12} \text{ n/cm}^2$ , 5 irradiated at  $1 \times 10^{13} \text{ n/cm}^2$ , 5 irradiated at  $3 \times 10^{13} \text{ n/cm}^2$  and 5 irradiated at  $1 \times 10^{14} \text{ n/cm}^2$ . Five control units were used. The HS-303CEH samples were drawn from fabrication lot G2J7DFA and were packaged in the standard 14 Ld ceramic production package, code CDFP3-F14. Samples were screened to the SMD limits over temperature before the start of neutron testing.

## Results

Neutron testing of the HS-303CEH is complete and the results are reported in the balance of this report. It should be carefully realized when interpreting the data that each neutron irradiation was performed on a different five-unit sample; this is not total dose testing, where the damage is cumulative over a number of downpoints.

### Attributes Data

TABLE 2. HS-303CEH ATTRIBUTES DATA

PART	SERIAL	SAMPLE SIZE	FLUENCE, n/cm <sup>2</sup>	PASS (Note 1)	FAIL	NOTES
HS-303CEH	1-5	5	2x10 <sup>12</sup>	5	0	All passed
HS-303CEH	6-10	5	1x10 <sup>13</sup>	5	0	All passed
HS-303CEH	11-15	5	3x10 <sup>13</sup>	5	0	All passed
HS-303CEH	16-20	5	1x10 <sup>14</sup>	5	0	All passed

NOTE:

1. "Pass" indicates a sample that passes all SMD limits.

### Variables Data

The plots in [Figures 1](#) through [10](#) show data plots for key parameters before and after irradiation to each level. The reported parameters and their datasheet limits are shown in [Table 3 on page 8](#). We plot the data for Channel 1 in all cases; no measure differences in the responses of the other four channels were seen in the data.

The plots show the population median of each parameter as a function of neutron irradiation as well as population maximum and minimum error bars. We chose to plot the median because of the small sample sizes (five per cell) involved. We also show the applicable post-total dose electrical limits as taken from the SMD; it should be carefully noted that these limits are provided for *guidance only* as the HS-303CEH is not specified or guaranteed for the neutron environment. Intersil does not design, qualify or guarantee its parts for the DD environment, but has performed limited collaborative neutron testing for customer guidance.

## Variables Data Plots

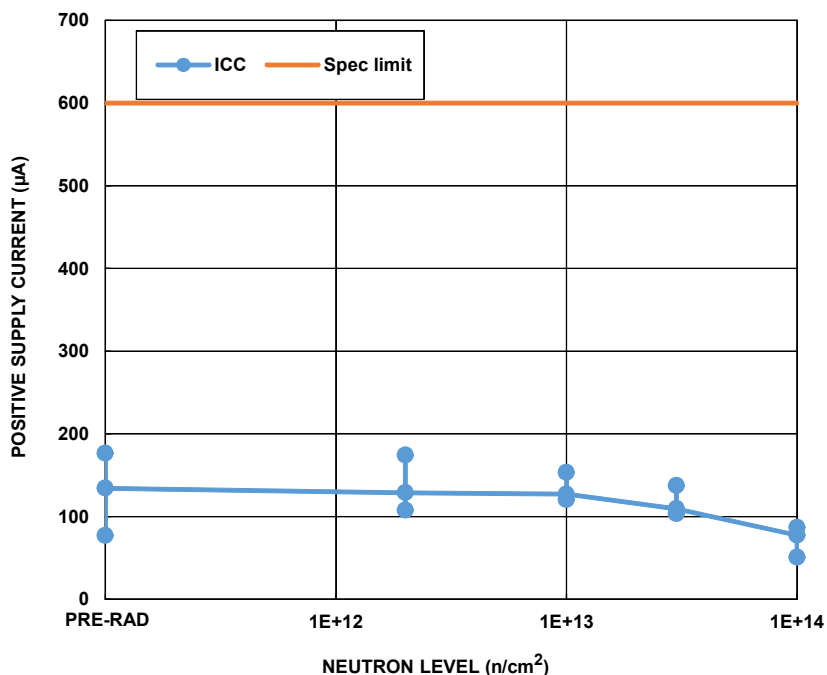
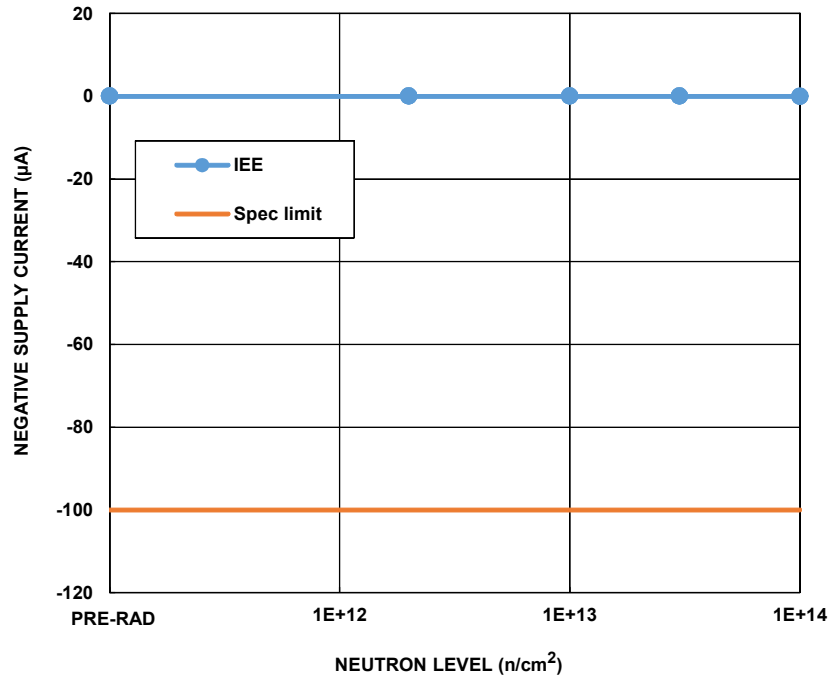
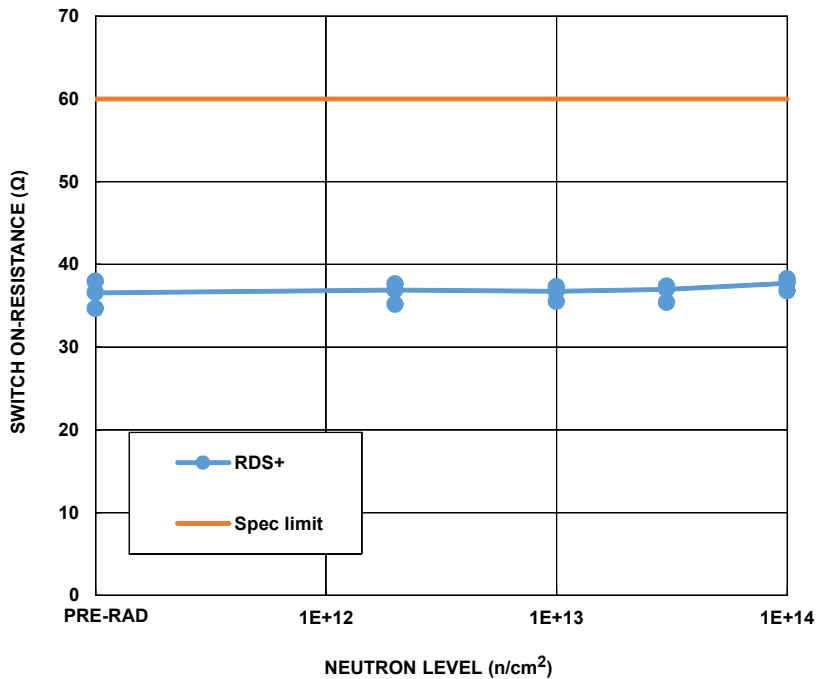


FIGURE 1. HS-303CEH positive supply current, all four channels, as a function of 1MeV equivalent neutron irradiation at 2x10<sup>12</sup>n/cm<sup>2</sup>, 1x10<sup>13</sup>n/cm<sup>2</sup>, 3x10<sup>13</sup>n/cm<sup>2</sup> and 1x10<sup>14</sup>n/cm<sup>2</sup>. The plot shows the population median and minimum and maximum error bars at each downpoint. Sample size for each cell was 5. The post-total dose irradiation SMD limit is 600µA maximum.

**Variables Data Plots (Continued)**

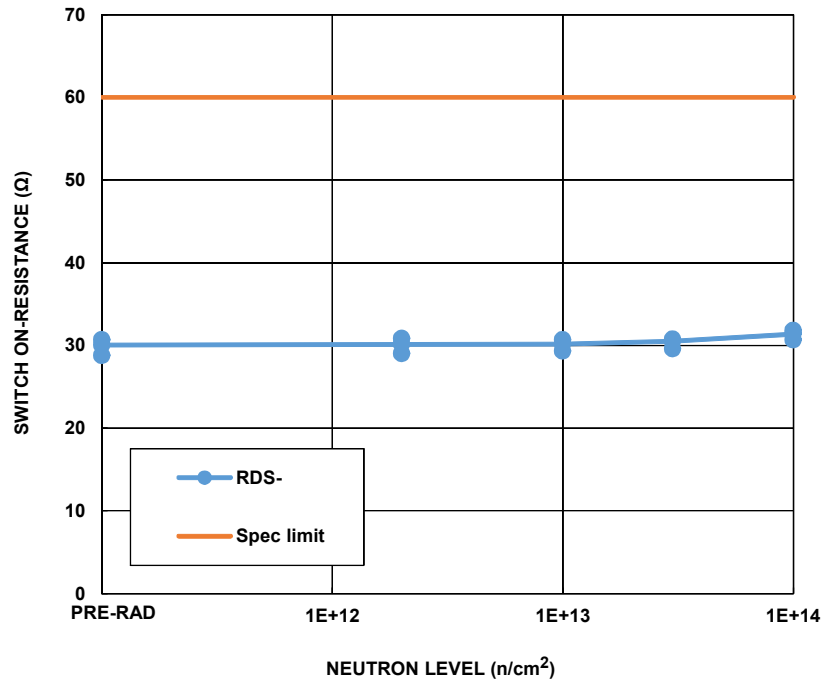


**FIGURE 2.** HS-303CEH negative supply current, all four channels, as a function of 1MeV equivalent neutron irradiation at  $2 \times 10^{12} \text{ n/cm}^2$ ,  $1 \times 10^{13} \text{ n/cm}^2$ ,  $3 \times 10^{13} \text{ n/cm}^2$  and  $1 \times 10^{14} \text{ n/cm}^2$ . The plot shows the population median and minimum and maximum error bars at each datapoint. Sample size for each cell was 5. The post-total dose irradiation SMD limit is  $-100 \mu\text{A}$  minimum.

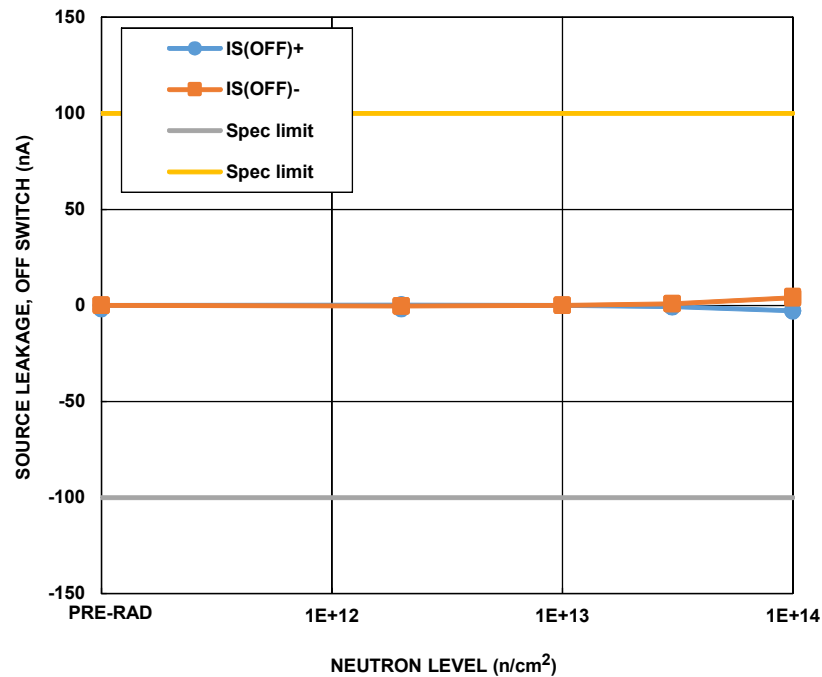


**FIGURE 3.** HS-303CEH switch ON-resistance, Channel 1, drain voltage +10V, as a function of 1MeV equivalent neutron irradiation at  $2 \times 10^{12} \text{ n/cm}^2$ ,  $1 \times 10^{13} \text{ n/cm}^2$ ,  $3 \times 10^{13} \text{ n/cm}^2$  and  $1 \times 10^{14} \text{ n/cm}^2$ . The plot shows the population median and minimum and maximum error bars at each datapoint. Sample size for each cell was 5. The post-total dose irradiation SMD limit is  $60 \Omega$  maximum.

**Variables Data Plots (Continued)**

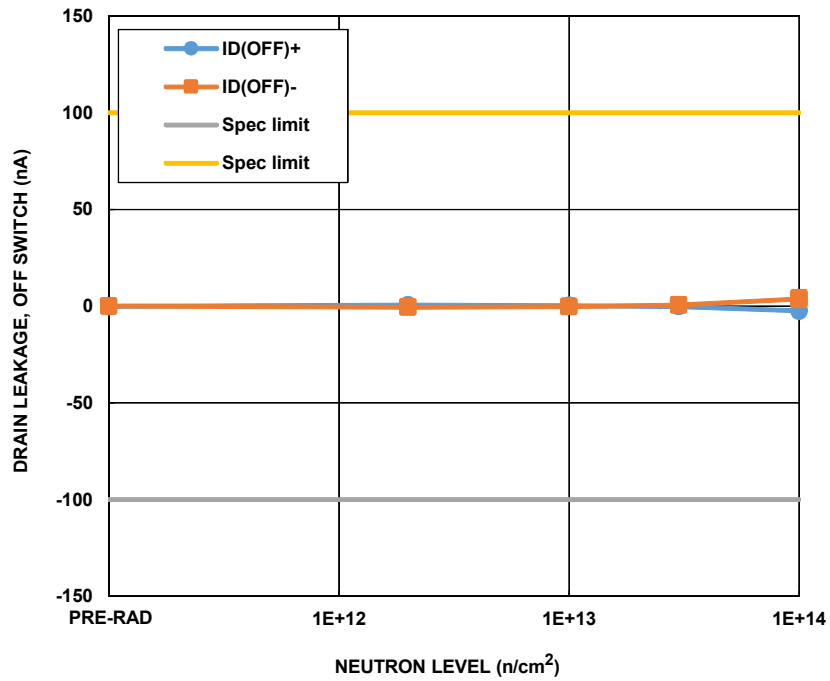


**FIGURE 4.** HS-303CEH switch ON-resistance, Channel 1, drain voltage -10V, as a function of 1MeV equivalent neutron irradiation at  $2 \times 10^{12} \text{ n/cm}^2$ ,  $1 \times 10^{13} \text{ n/cm}^2$ ,  $3 \times 10^{13} \text{ n/cm}^2$  and  $1 \times 10^{14} \text{ n/cm}^2$ . The plot shows the population median and minimum and maximum error bars at each datapoint. Sample size for each cell was 5. The post-total dose irradiation SMD limit is  $60 \Omega$  maximum.

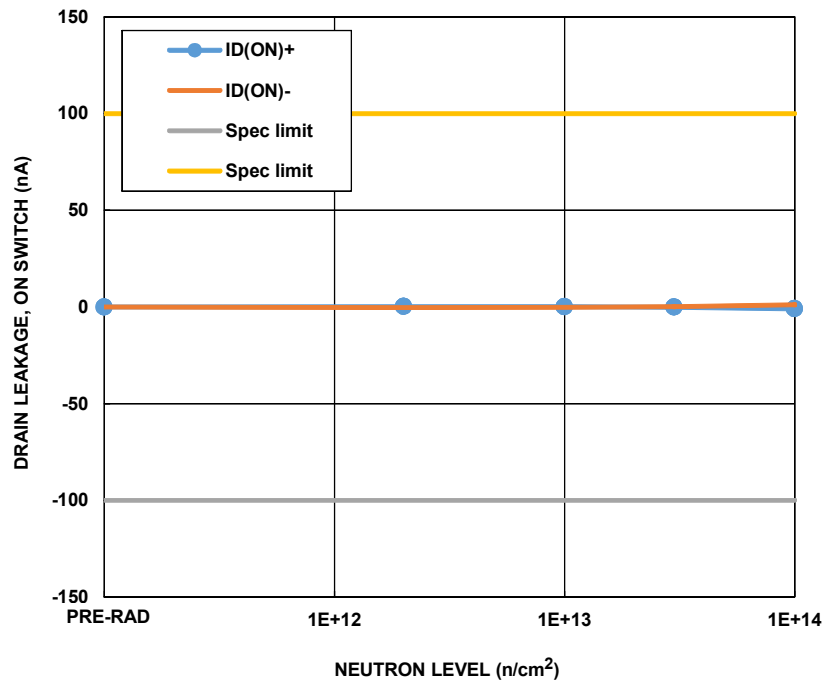


**FIGURE 5.** HS-303CEH leakage current into the source terminal of an OFF switch, Channel 1, as a function of 1MeV equivalent neutron irradiation at  $2 \times 10^{12} \text{ n/cm}^2$ ,  $1 \times 10^{13} \text{ n/cm}^2$ ,  $3 \times 10^{13} \text{ n/cm}^2$  and  $1 \times 10^{14} \text{ n/cm}^2$ . The plot shows the population median and minimum and maximum error bars at each datapoint. Sample size for each cell was 5. The post-total dose irradiation SMD limits are -100nA to 100nA.

**Variables Data Plots (Continued)**

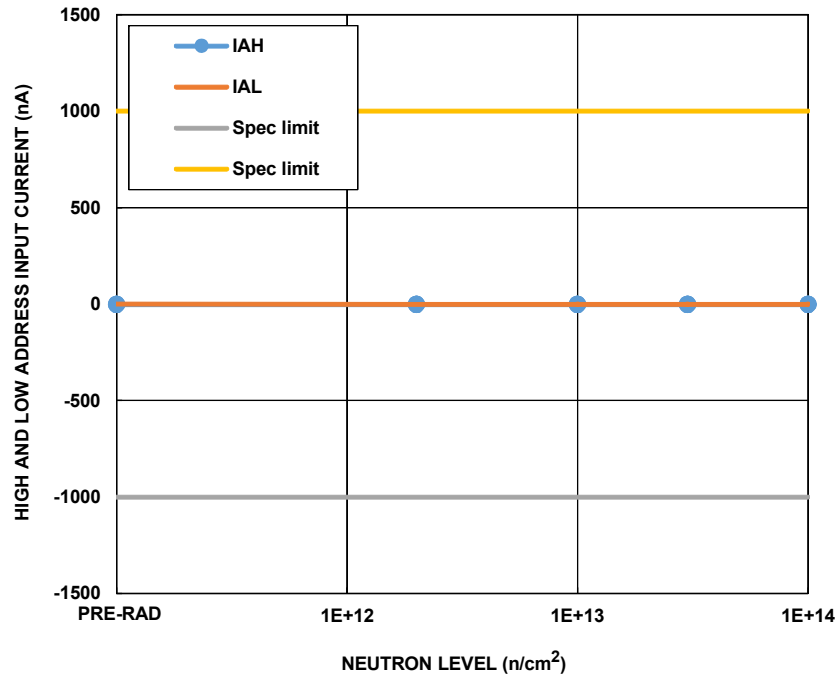


**FIGURE 6.** HS-303CEH leakage current into the drain terminal of an OFF switch, Channel 1, as a function of 1MeV equivalent neutron irradiation at  $2 \times 10^{12} \text{ n/cm}^2$ ,  $1 \times 10^{13} \text{ n/cm}^2$ ,  $3 \times 10^{13} \text{ n/cm}^2$  and  $1 \times 10^{14} \text{ n/cm}^2$ . The plot shows the population median and minimum and maximum error bars at each downpoint. Sample size for each cell was 5. The post-total dose irradiation SMD limits are -100nA to 100nA.

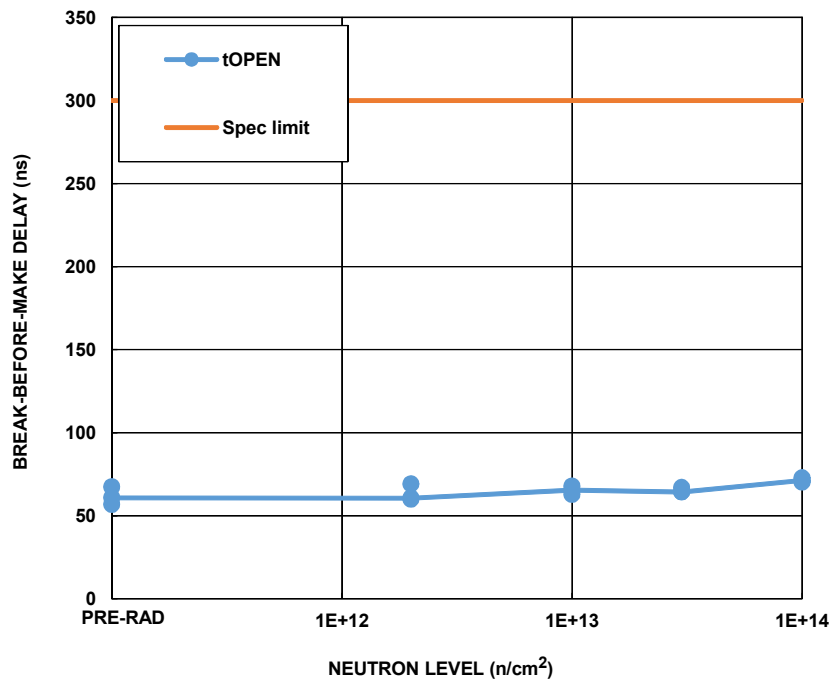


**FIGURE 7.** HS-303CEH leakage current into the drain terminal of an ON switch, Channel 1, as a function of 1MeV equivalent neutron irradiation at  $2 \times 10^{12} \text{ n/cm}^2$ ,  $1 \times 10^{13} \text{ n/cm}^2$ ,  $3 \times 10^{13} \text{ n/cm}^2$  and  $1 \times 10^{14} \text{ n/cm}^2$ . The plot shows the population median and minimum and maximum error bars at each downpoint. Sample size for each cell was 5. The post-total dose irradiation SMD limits are -100nA to 100nA.

**Variables Data Plots (Continued)**

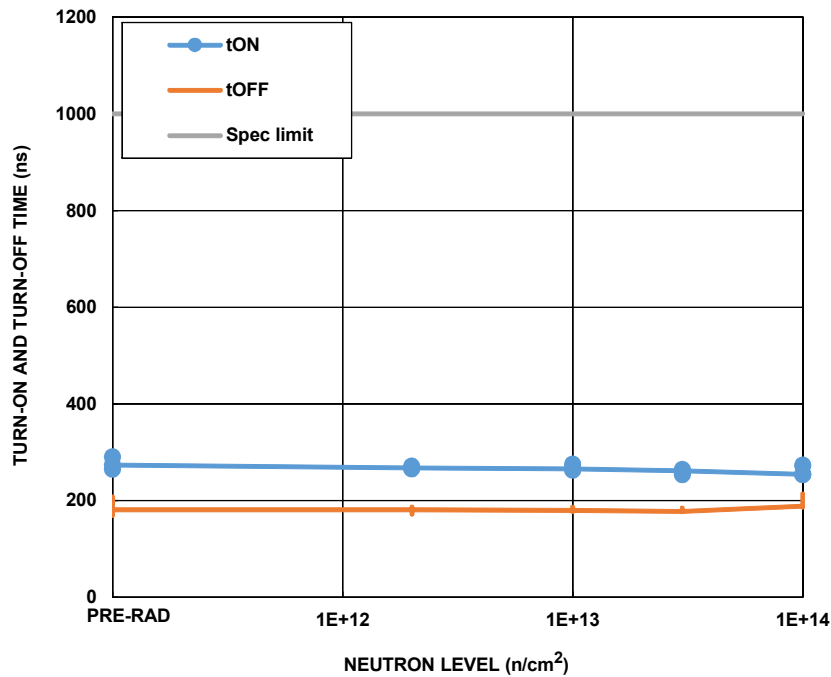


**FIGURE 8.** HS-303CEH HIGH and LOW address input current, Address A1 as a function of 1MeV equivalent neutron irradiation at  $2 \times 10^{12} \text{ n/cm}^2$ ,  $1 \times 10^{13} \text{ n/cm}^2$ ,  $3 \times 10^{13} \text{ n/cm}^2$  and  $1 \times 10^{14} \text{ n/cm}^2$ . The plot shows the population median and minimum and maximum error bars at each datapoint. Sample size for each cell was 5. The post-total dose irradiation SMD limits are -1000nA to 1000nA.



**FIGURE 9.** HS-303CEH break-before-make delay, Channel 1, as a function of 1MeV equivalent neutron irradiation at  $2 \times 10^{12} \text{ n/cm}^2$ ,  $1 \times 10^{13} \text{ n/cm}^2$ ,  $3 \times 10^{13} \text{ n/cm}^2$  and  $1 \times 10^{14} \text{ n/cm}^2$ . The plot shows the population median and minimum and maximum error bars at each datapoint. Sample size for each cell was 5. The post-total dose irradiation SMD limits are 300ns maximum.

**Variables Data Plots (Continued)**



**FIGURE 10.** HS-303CEH switch turn-on and turn-off time, Channel 1, as a function of 1MeV equivalent neutron irradiation at  $2 \times 10^{12} \text{ n/cm}^2$ ,  $1 \times 10^{13} \text{ n/cm}^2$ ,  $3 \times 10^{13} \text{ n/cm}^2$  and  $1 \times 10^{14} \text{ n/cm}^2$ . The plot shows the population median and minimum and maximum error bars at each datapoint. Sample size for each cell was 5. The post-total dose irradiation SMD limits are 1000ns maximum for both parameters.

**Conclusion**

This report summarizes results of 1MeV equivalent neutron testing of the HS-303CEH dual analog switch. The test was conducted in order to determine the sensitivity of the part to Displacement Damage (DD) caused by neutron or proton environments in space. Neutron fluences ranged from  $2 \times 10^{12} \text{ n/cm}^2$  to  $1 \times 10^{14} \text{ n/cm}^2$ . This test was carried out as part of a collaborative project with Boeing (El Segundo, CA), whose support is gratefully acknowledged.

The samples met all specifications (Bin 1) after  $2 \times 10^{14} \text{ n/cm}^2$ ,  $1 \times 10^{13} \text{ n/cm}^2$ ,  $3 \times 10^{13} \text{ n/cm}^2$  and  $1 \times 10^{14} \text{ n/cm}^2$ .

## Appendices

### Reported Parameters

Reported parameters are shown in [Table 3](#). The limits are taken from the applicable SMD and are provided for guidance only as the part is not designed or guaranteed for the neutron environment. The plots show the population median and minimum and maximum error bars at each downpoint.

TABLE 3. REPORTED PARAMETERS

FIGURE	PARAMETER	LIMIT, LOW	LIMIT, HIGH	UNITS	NOTES
<a href="#">1</a>	Positive Supply Current	-	600	μA	All four channels
<a href="#">2</a>	Negative Supply Current	-100	-	μA	All four channels
<a href="#">3</a>	Switch ON-Resistance	-	60	Ω	Channel 1, drain voltage 10V
<a href="#">4</a>	Switch ON-Resistance	-	60	Ω	Channel 1, drain voltage -10V
<a href="#">5</a>	Leakage Current into the Source Terminal of an Off Switch	-100	100	nA	Channel 1
<a href="#">6</a>	Leakage Current into the Drain Terminal of an Off Switch	-100	100	nA	Channel 1
<a href="#">7</a>	Leakage Current into the Drain Terminal of an On Switch	-100	100	nA	Channel 1
<a href="#">8</a>	Address Input HIGH Current	-1000	1000	nA	Address A1
	Address Input LOW Current	-1000	1000	nA	Address A1
<a href="#">9</a>	Break-Before-Make-Delay	-	300	ns	Channel 1
<a href="#">10</a>	Switch Turn-On Time	-	1000	ns	Channel 1
	Switch Turn-Off Time	-	1000	ns	Channel 1

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