

IS-1845ASRH

Neutron Testing

TR036

Rev 0.00

August 25, 2016

## Introduction

This report summarizes results of 1MeV equivalent neutron testing of the IS-1845ASRH current mode Pulse Width Modulator (PWM). 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
- [IS-1845ASRH](#) datasheet
- DSCC Standard Microcircuit Drawing (SMD) [5962-01509](#)

## Part Description

The IS-1845ASRH and IS-1845ASEH pulse width modulators are designed to be used in switching power supplies operating in current mode. The rising edge of the on-chip oscillator turns on the output. Turn-off is controlled by the current sense comparator and occurs when the sensed current reaches a peak controlled by the error amplifier. Fabricated using Intersil's Radiation Hardened Silicon Gate (RSG) dielectrically isolated BiCMOS process, these devices are immune to single event latch-up and provide excellent Single-Event Transient (SET) performance. The part is available in an 18 Ld hermetic flatpack or in an 8 Ld CERDIP.

Detailed Electrical Specifications for these devices are contained in SMD [5962-01509](#). Specifications for radiation hardened QML devices are controlled by the Defense Logistics Agency Land and Maritime (DLA).

The IS-1845ASRH is acceptance tested on a wafer-by-wafer basis to a total dose level of 300krad(Si) at high dose rate (50-300rad(Si)/s) only. The IS-1845ASEH is acceptance tested to 300krad(Si) at high dose rate (50-300rad(Si)/s) and to 50krad(Si) at low dose rate ( $< 0.01 \text{ rad(Si)/s}$ ). The parts are identical except for these acceptance testing flows.

TABLE 1. IS-1845ASRH PIN ASSIGNMENTS, 18 LD FLATPACK VERSION

TERMINAL NUMBER	TERMINAL SYMBOL	TERMINAL NUMBER	TERMINAL SYMBOL
1	NC	10	NC
2	COMP	11	VREF
3	VFB	12	VCC
4	NC	13	VC
5	NC	14	OUT
6	NC	15	NC
7	ISENSE	16	GND

TABLE 1. IS-1845ASRH PIN ASSIGNMENTS, 18 LD FLATPACK VERSION (Continued)

TERMINAL NUMBER	TERMINAL SYMBOL	TERMINAL NUMBER	TERMINAL SYMBOL
8	RTCT	17	OSC_GND
9	NC	18	NC

## Test Description

### Irradiation Facilities

1MeV equivalent neutron irradiation was performed at the White Sands Missile Range Fast Burst Reactor (FBR). 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 informally termed 'bag tests' indicating that the parts are irradiated in an 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. IS-1845ASRH samples were drawn from fabrication lot DCNJLEBA and were packaged in the standard 18 Ld hermetic package. Samples were screened to the SMD limits over temperature before the start of neutron testing.

## Results

Neutron testing of the IS-1845ASRH 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. IS-1845ASRH ATTRIBUTES DATA

PART	SAMPLE SIZE	FLUENCE, (n/cm <sup>2</sup> )	PASS (Note 1)	FAIL	NOTES
IS-1845ASRH	5	2x10 <sup>12</sup>	5	0	All passed
IS-1845ASRH	5	1x10 <sup>13</sup>	0	5	All failed, sink current and minimum pulse width
IS-1845ASRH	5	3x10 <sup>13</sup>	0	5	All failed, input bias current and reference voltage
IS-1845ASRH	5	1x10 <sup>14</sup>	0	5	All failed, nonfunctional

NOTE:

- 'Pass' indicates a sample that passes all SMD limits.

### Variables Data

The plots in [Figures 1](#) through [15](#) show data plots for key parameters before and after irradiation to each level. The reported parameters and their SMD post-total dose limits are shown in ["Appendices" on page 10](#). As indicated in [Table 2](#), all samples failed parametrically after exposure to 1x10<sup>13</sup>n/cm<sup>2</sup> and 3x10<sup>13</sup>n/cm<sup>2</sup> and were nonfunctional after exposure to 1x10<sup>14</sup>n/cm<sup>2</sup>. For several of the figures, we elected to not plot the 1x10<sup>14</sup>n/cm<sup>2</sup> data as it has little meaning (being no more than an ATE overrange) and makes the data at the other three levels more difficult to interpret.

The plots show the population median of each parameter as a function of neutron irradiation as well as the population maximum and minimum. 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 IS-1845ASRH 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

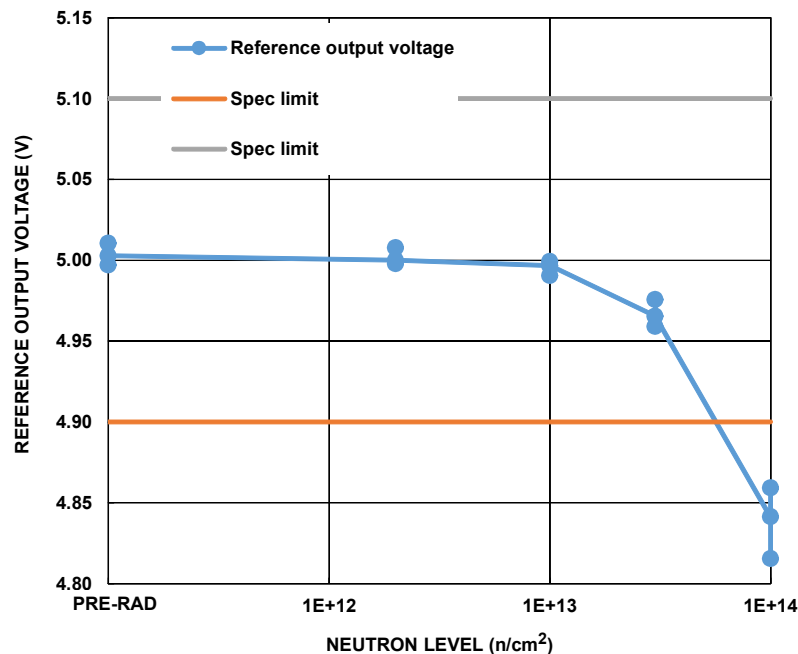


FIGURE 1. IS-1845ASRH reference output voltage as a function of 1MeV equivalent neutron irradiation at 2x10<sup>12</sup>n/cm<sup>2</sup>, 1x10<sup>13</sup>n/cm<sup>2</sup>, 3x10<sup>13</sup>n/cm<sup>2</sup> and 1x10<sup>14</sup>n/cm<sup>2</sup>. The plot shows the population median, minimum and maximum at each downpoint. The sample size for each cell was 5. The post-total dose irradiation SMD limits are 4.90V to 5.10V.

Variables Data Plots (Continued)

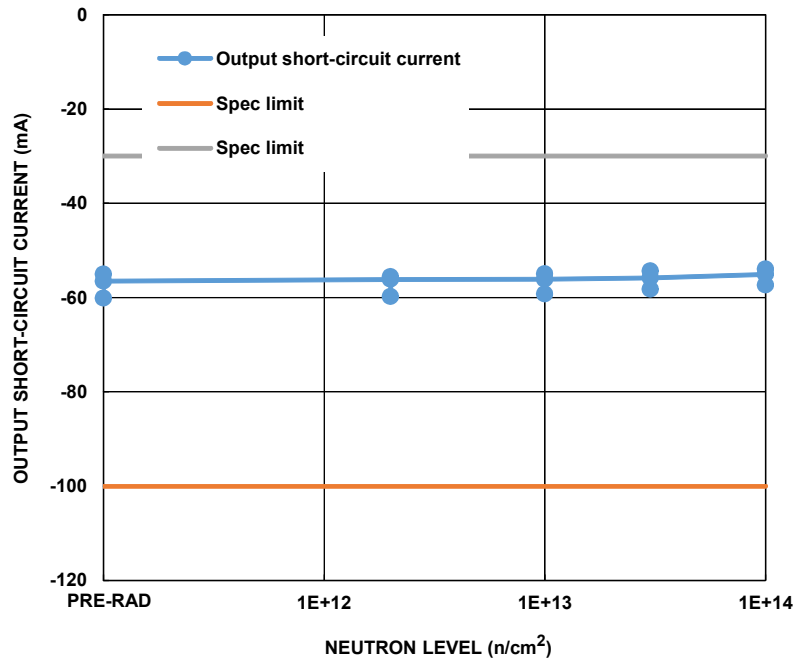


FIGURE 2. IS-1845ASRH reference section output short-circuit current as a function of 1MeV equivalent neutron irradiation at  $2 \times 10^{12} \text{ n/cm}^2$ ,  $1 \times 10^{13} \text{ n/cm}^2$ ,  $3 \times 10^{13} \text{ n/cm}^2$  and  $1 \times 10^{14} \text{ n/cm}^2$ . The plot shows the population median, minimum and maximum at each datapoint. The sample size for each cell was 5. The post-total dose irradiation SMD limits are -100mA to -30mA.

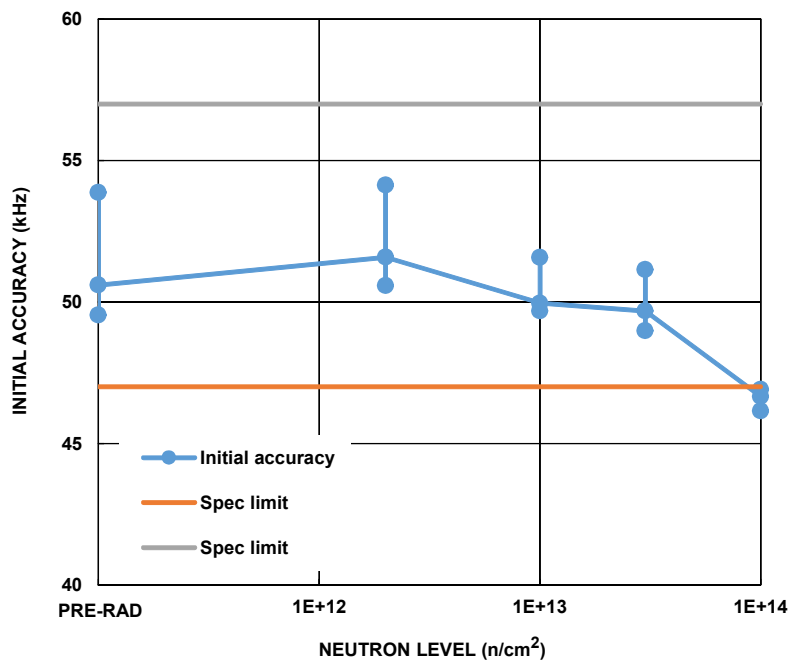


FIGURE 3. IS-1845ASRH oscillator section initial accuracy as a function of 1MeV equivalent neutron irradiation at  $2 \times 10^{12} \text{ n/cm}^2$ ,  $1 \times 10^{13} \text{ n/cm}^2$ ,  $3 \times 10^{13} \text{ n/cm}^2$  and  $1 \times 10^{14} \text{ n/cm}^2$ . The plot shows the population median, minimum and maximum at each datapoint. The sample size for each cell was 5. The post-total dose irradiation SMD limits are 47kHz to 57kHz.

Variables Data Plots (Continued)

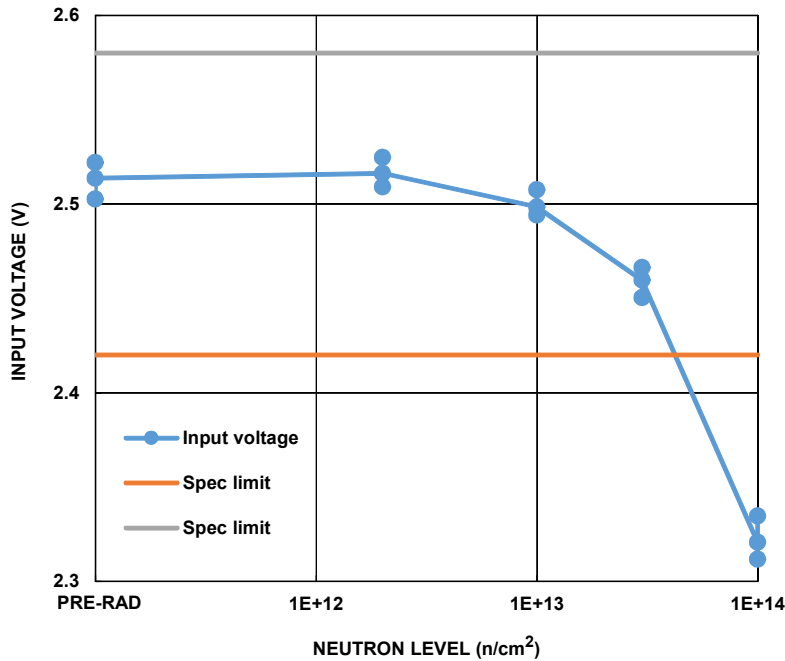


FIGURE 4. IS-1845ASRH error amplifier input voltage as a function of 1MeV equivalent neutron irradiation at  $2 \times 10^{12} \text{ n/cm}^2$ ,  $1 \times 10^{13} \text{ n/cm}^2$ ,  $3 \times 10^{13} \text{ n/cm}^2$  and  $1 \times 10^{14} \text{ n/cm}^2$ . The plot shows the population median, minimum and maximum at each datapoint. The sample size for each cell was 5. The post-total dose irradiation SMD limits are 2.42V to 2.58V.

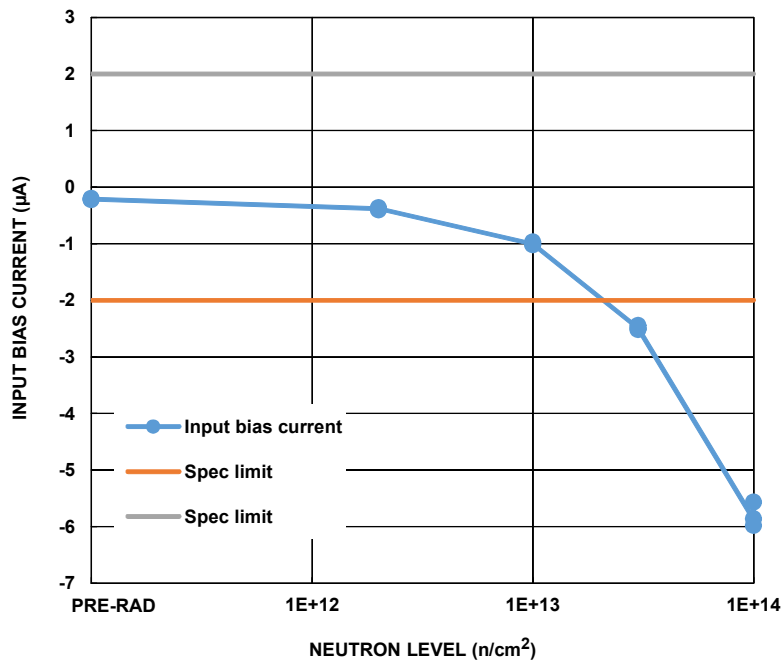


FIGURE 5. IS-1845ASRH error amplifier input bias current as a function of 1MeV equivalent neutron irradiation at  $2 \times 10^{12} \text{ n/cm}^2$ ,  $1 \times 10^{13} \text{ n/cm}^2$ ,  $3 \times 10^{13} \text{ n/cm}^2$  and  $1 \times 10^{14} \text{ n/cm}^2$ . The plot shows the population median, minimum and maximum at each datapoint. The sample size for each cell was 5. The post-total dose irradiation SMD limits are  $-2 \mu\text{A}$  to  $2 \mu\text{A}$ .

Variables Data Plots (Continued)

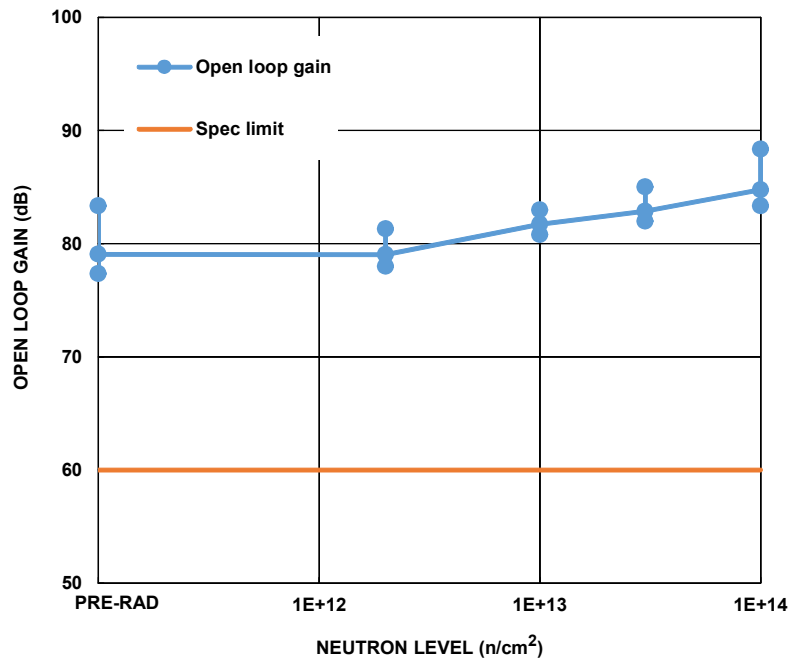


FIGURE 6. IS-1845ASRH error amplifier open loop gain as a function of 1MeV equivalent neutron irradiation at  $2 \times 10^{12} \text{ n/cm}^2$ ,  $1 \times 10^{13} \text{ n/cm}^2$ ,  $3 \times 10^{13} \text{ n/cm}^2$  and  $1 \times 10^{14} \text{ n/cm}^2$ . The plot shows the population median, minimum and maximum at each downpoint. The sample size for each cell was 5. The post-total dose irradiation SMD limit is 60dB minimum.

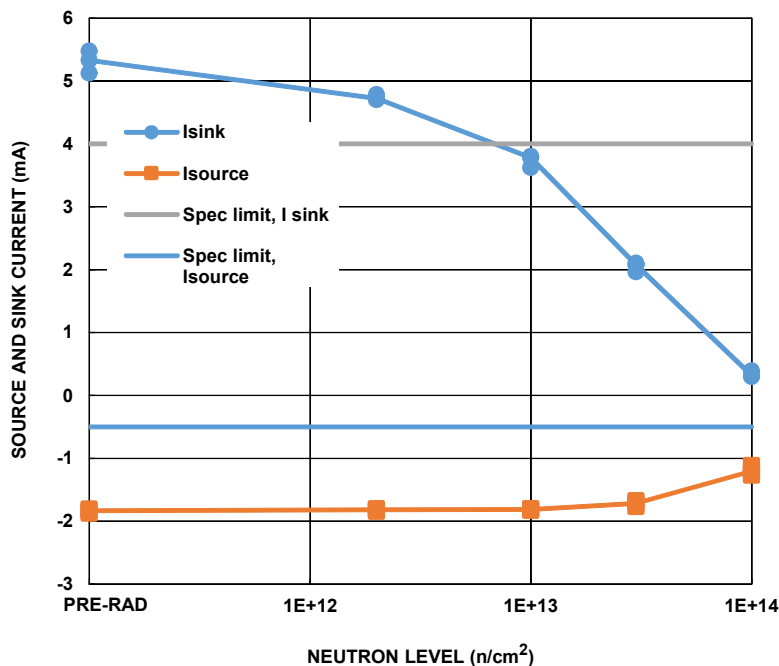
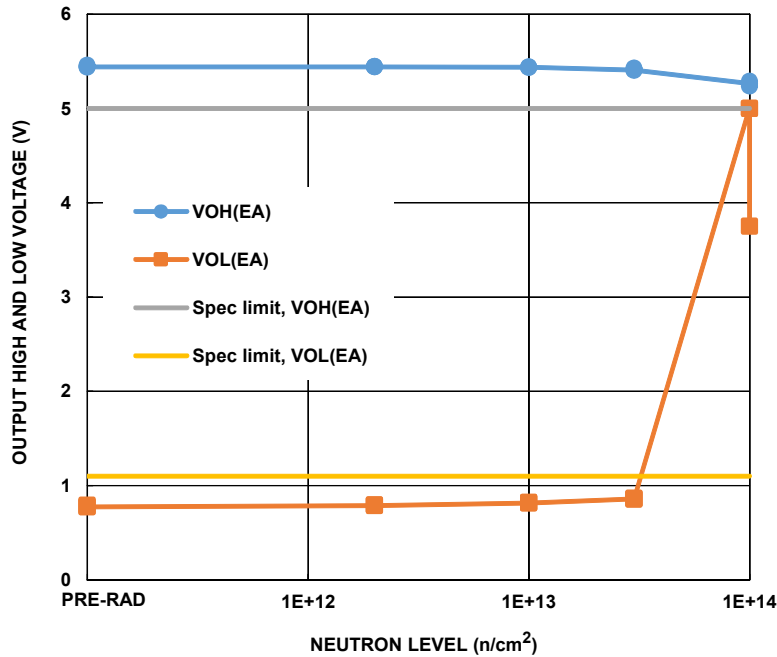
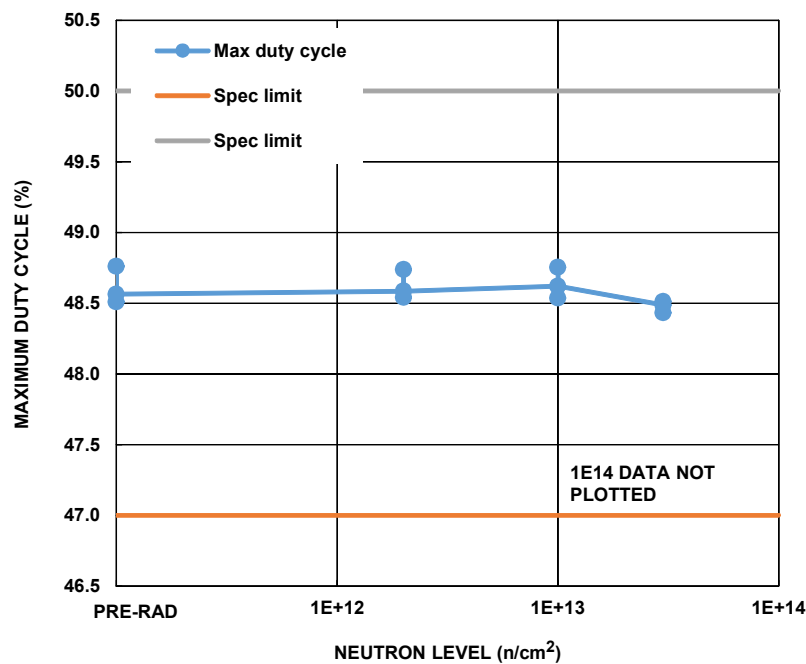


FIGURE 7. IS-1845ASRH error amplifier output source and sink current as a function of 1MeV equivalent neutron irradiation at  $2 \times 10^{12} \text{ n/cm}^2$ ,  $1 \times 10^{13} \text{ n/cm}^2$ ,  $3 \times 10^{13} \text{ n/cm}^2$  and  $1 \times 10^{14} \text{ n/cm}^2$ . The plot shows the population median, minimum and maximum at each downpoint. The sample size for each cell was 5. The post-total dose irradiation SMD limits are 4mA minimum (sinking) and -0.5mA maximum (sourcing).

**Variables Data Plots (Continued)**



**FIGURE 8.** IS-1845ASRH error amplifier output HIGH and LOW voltage 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, minimum and maximum at each datapoint. The sample size for each cell was 5. The post-total dose irradiation SMD limits are 5V minimum ( $V_{OH}$ ) and 1.1V maximum ( $V_{OL}$ ).



**FIGURE 9.** IS-1845ASRH output section maximum duty cycle 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, minimum and maximum at each datapoint. The sample size for each cell was 5. The  $1 \times 10^{14} \text{ n/cm}^2$  data was an ATE overrange and is not plotted. The post-total dose irradiation SMD limits are 47% to 50%.

Variables Data Plots (Continued)

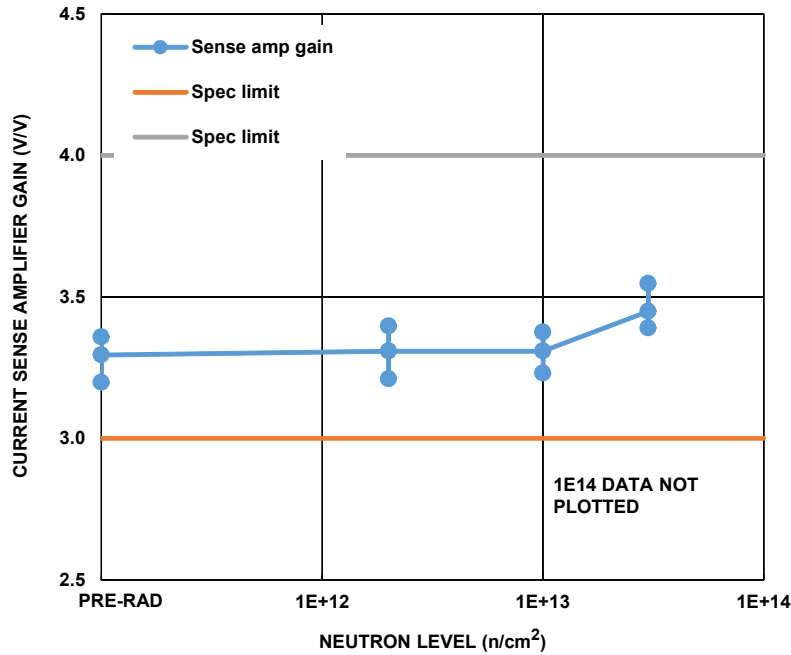


FIGURE 10. IS-1845ASRH current sense amplifier gain as a function of 1MeV equivalent neutron irradiation at  $2 \times 10^{12} \text{ n/cm}^2$ ,  $1 \times 10^{13} \text{ n/cm}^2$ ,  $3 \times 10^{13} \text{ n/cm}^2$  and  $1 \times 10^{14} \text{ n/cm}^2$ . The plot shows the population median, minimum and maximum at each datapoint. The sample size for each cell was 5. The  $1 \times 10^{14} \text{ n/cm}^2$  data was an ATE overrange and is not plotted. The post-total dose irradiation SMD limits are 3V/V to 4V/V.

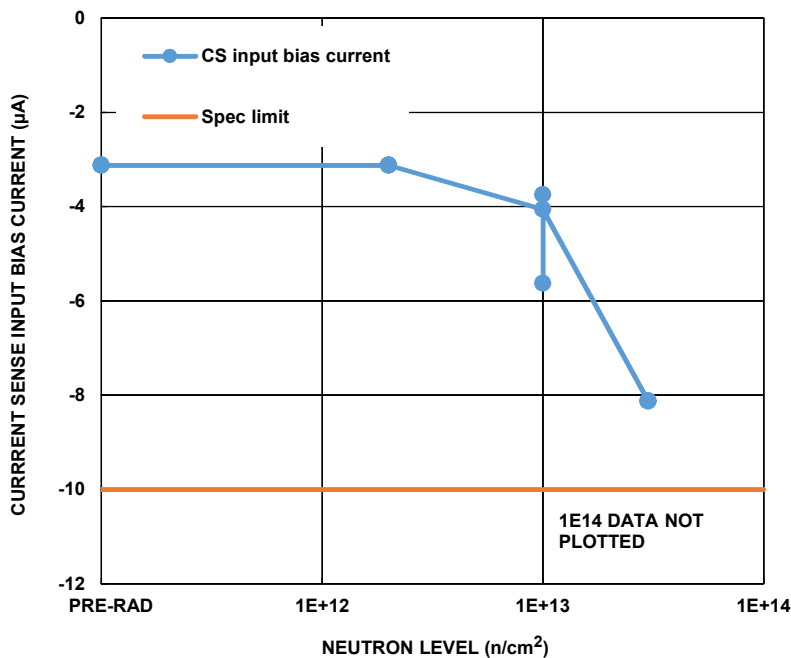
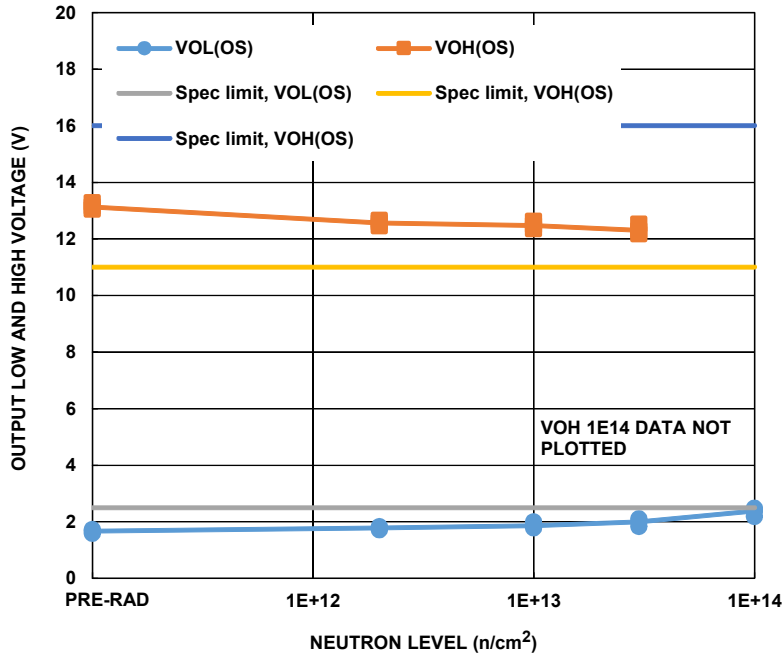
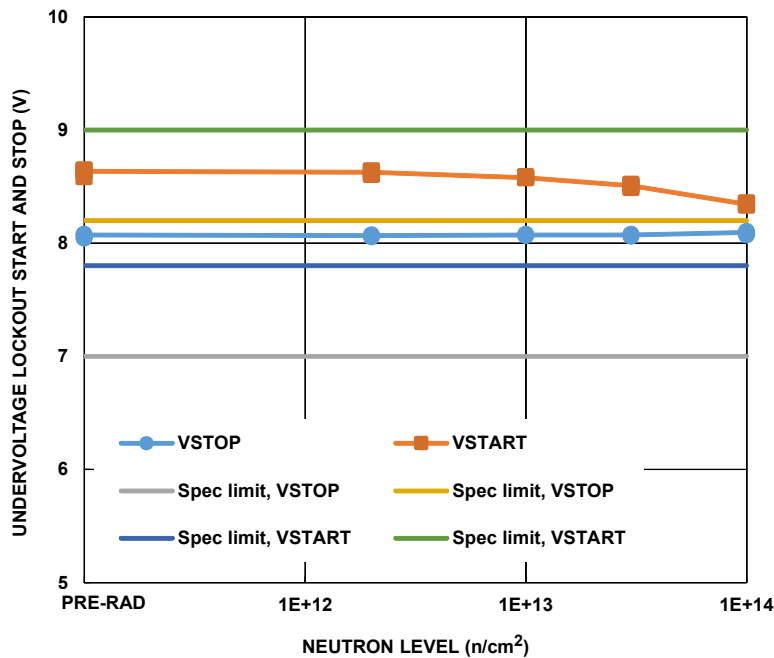


FIGURE 11. IIS-1845ASRH current sense amplifier input bias current as a function of 1MeV equivalent neutron irradiation at  $2 \times 10^{12} \text{ n/cm}^2$ ,  $1 \times 10^{13} \text{ n/cm}^2$ ,  $3 \times 10^{13} \text{ n/cm}^2$  and  $1 \times 10^{14} \text{ n/cm}^2$ . The plot shows the population median, minimum and maximum at each datapoint. The sample size for each cell was 5. The  $1 \times 10^{14} \text{ n/cm}^2$  data was an ATE overrange and is not plotted. The post-total dose irradiation SMD limit is -10µA minimum.

**Variables Data Plots (Continued)**

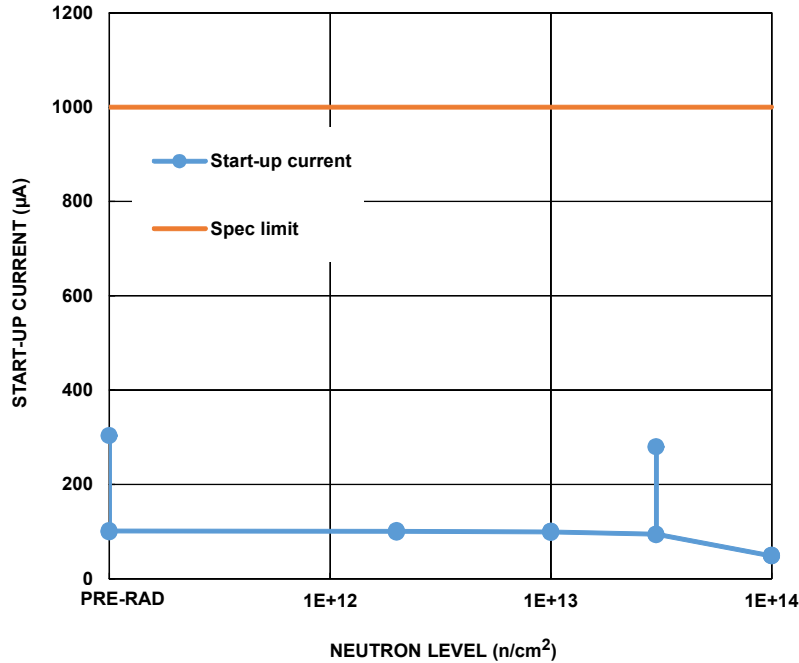


**FIGURE 12.** IS-1845ASRH output section LOW and HIGH output voltage at 200mA as a function of 1MeV equivalent neutron irradiation at  $2 \times 10^{12} \text{ n/cm}^2$ ,  $1 \times 10^{13} \text{ n/cm}^2$ ,  $3 \times 10^{13} \text{ n/cm}^2$  and  $1 \times 10^{14} \text{ n/cm}^2$ . The plot shows the population median, minimum and maximum at each datapoint. The sample size for each cell was 5. The  $1 \times 10^{14} \text{ n/cm}^2$  data was an ATE overrange and is not plotted. The post-total dose irradiation SMD limits are 2.5V maximum ( $V_{OL}$ ) and 11V to 16V ( $V_{OH}$ ).

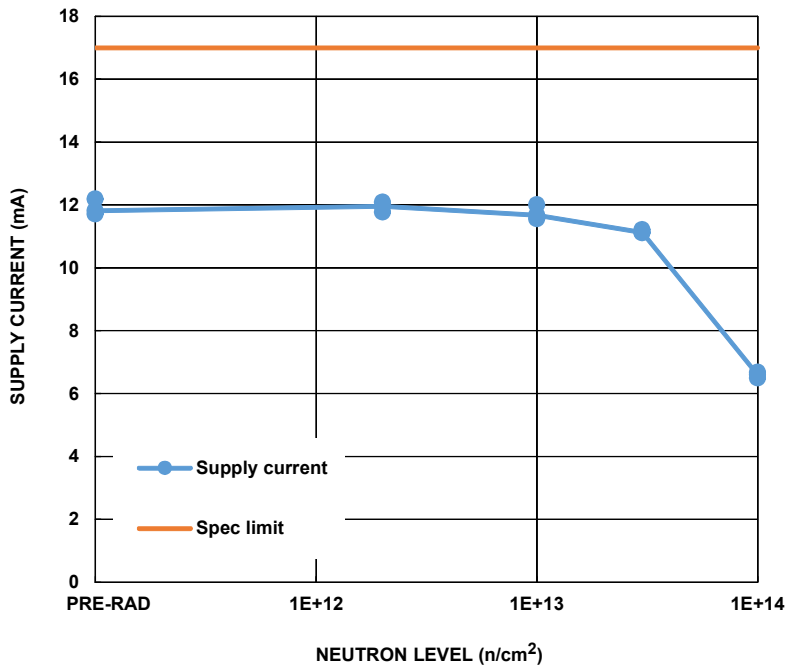


**FIGURE 13.** IS-1845ASRH Undervoltage Lockout (UVLO) START and STOP levels as a function of 1MeV equivalent neutron irradiation at  $2 \times 10^{12} \text{ n/cm}^2$ ,  $1 \times 10^{13} \text{ n/cm}^2$ ,  $3 \times 10^{13} \text{ n/cm}^2$  and  $1 \times 10^{14} \text{ n/cm}^2$ . The plot shows the population median, minimum and maximum at each datapoint. The sample size for each cell was 5. The post-total dose irradiation SMD limits are 7V to 8.2V (STOP) and 7.8V to 9.0V (START).

**Variables Data Plots (Continued)**



**FIGURE 14.** IS-1845ASRH start-up current 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, minimum and maximum at each downpoint. The sample size for each cell was 5. The post-total dose irradiation SMD limit is 1000µA maximum.



**FIGURE 15.** IS-1845ASRH supply current 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, minimum and maximum at each downpoint. The sample size for each cell was 5. The post-total dose irradiation SMD limit is 17mA maximum.

## Conclusion

This report summarizes results of 1MeV equivalent neutron testing of the IS-1845ASRH current mode Pulse Width Modulator (PWM). 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  $2 \times 10^{11} \text{ n/cm}^2$ .

The samples showed parametric degradation after  $1 \times 10^{13} \text{ n/cm}^2$  and  $3 \times 10^{13} \text{ n/cm}^2$ . All samples were nonfunctional after the  $1 \times 10^{14} \text{ n/cm}^2$  irradiation.

## 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.

TABLE 3. REPORTED PARAMETERS

FIGURE	PARAMETER	LIMIT, LOW	LIMIT, HIGH	UNITS	NOTES
<a href="#">1</a>	Reference Output Voltage	4.90	5.10	V	
<a href="#">2</a>	Reference Output Short-Circuit Current	-100	-30	mA	
<a href="#">3</a>	Oscillator Initial Accuracy	47	57	kHz	
<a href="#">4</a>	Error Amplifier Input Voltage	2.42	2.58	V	
<a href="#">5</a>	Error Amplifier Input Bias Current	-2	2	$\mu\text{A}$	
<a href="#">6</a>	Error Amplifier Open Loop Gain	60	-	dB	
<a href="#">7</a>	Error Amplifier Output Current	4	-	mA	Sourcing
	Error Amplifier Output Current	-	-0.5	mA	Sinking
<a href="#">8</a>	Error Amplifier Output Voltage	5	-	V	High
	Error Amplifier Output Voltage	-	1.1	V	Low
<a href="#">9</a>	Output Maximum Duty Cycle	47	50	%	
<a href="#">10</a>	Current Sense Amplifier Gain	3	4	V/V	
<a href="#">11</a>	Sense Amplifier Input Bias Current	-10	-	$\mu\text{A}$	
<a href="#">12</a>	Output LOW Voltage	-	2.5	V	$V_{OL}$
	Output HIGH Voltage	11	16	V	$V_{OH}$
<a href="#">13</a>	UVLO Start Level	7.8	9	V	
	UVLO Stop Level	7	8.2	V	
<a href="#">14</a>	Start-Up Current	-	1000	$\mu\text{A}$	
<a href="#">15</a>	Supply Current	-	17	mA	

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