Total dose testing of the IS-1845ASRH single event radiation hardened current mode pulse width modulator (PWM)

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1. Introduction

This report provides the results of a low and high dose rate total dose test of the IS-1845ASRH SEE hardened current mode pulse width modulator (PWM). The test was conducted in order to determine the sensitivity of the part to the total dose environment and to determine if dose rate and bias sensitivity exist.

2. Reference Documents

MIL-STD-883G test method 1019.7
IS-1845ASRH data sheet
DSCC Standard Microcircuit Drawing (SMD) 5962-01509

3: Part Description

The IS-1845ASRH is 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. Constructed with Intersil's radiation hardened silicon gate (RSG) dielectrically isolated BiCMOS process, these devices are immune to single event latch-up and have been specifically designed to provide a high level of immunity to single event transients. All specified parameters are guaranteed and tested for 300krad(Si) high dose rate total dose performance.

Specifications for Rad Hard QML devices are controlled by the Defense Supply Center in Columbus (DSCC). Detailed electrical specifications for the IS-1845ASRH are contained in SMD 5962-01509. The document may be downloaded from the Intersil website at www.intersil.com. The SMD number must be used when ordering.

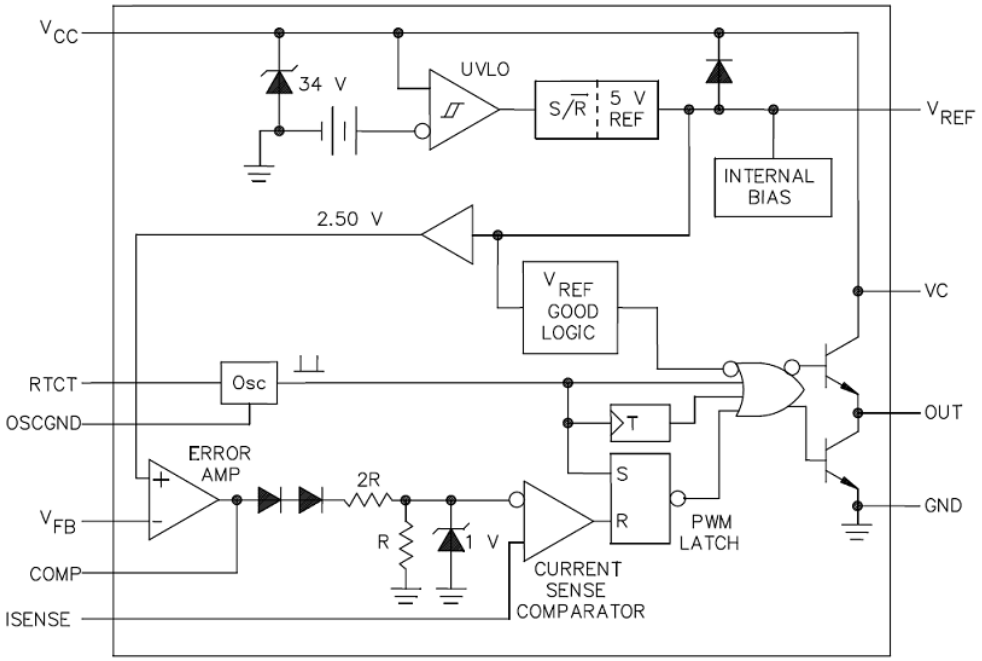

Figure 1: IS-1845ASRH block diagram.

4: Test Description

4.1 Irradiation Facilities

High dose rate testing was performed using a Gammacell 220 ^{60}Co irradiator located in the Palm Bay, Florida Intersil facility. Low dose rate testing was performed on a subcontract basis at White Sands Missile Range (WSMR) Survivability, Vulnerability and Assessment Directorate (SVAD), White Sands, NM, using a vault-type ^{60}Co irradiator. The high dose rate irradiations were done at 55rad(Si)/s and the low dose rate work was performed at 0.010rad(Si)/s, both per MIL-STD-883 Method 1019.7. Dosimetry for both tests was performed using Far West Technology radiochromic dosimeters and readout equipment.

4.2 Test Fixturing

Figure 2 shows the configuration used for biased irradiation in conformance with Standard Microcircuit Drawing (SMD) 5962-01509.

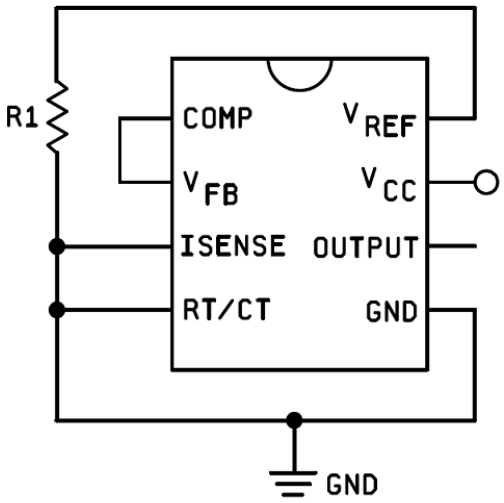

Figure 2: Irradiation bias configuration for the IS-1845ASRH per Standard Microcircuit Drawing (SMD) 5962-01509. VCC = 15V +/- 0.5V, R1 = 10 kΩ, ¼ W ±1%.

4.3 Characterization equipment and procedures

All electrical testing was performed outside the irradiator using the production automated test equipment (ATE) with datalogging at each downpoint. Downpoint electrical testing was performed at room temperature. Performing low dose rate testing at a remote site introduces some challenges, and shipping was performed in a foam container with a frozen Gelpack™ along with a strip chart temperature recorder in order to remain well within the temperature limits imposed by MIL-STD-883 Test Method 1019.7. Close coordination between the two organizations is required, and support by WSMR is gratefully acknowledged.

4.4 Experimental matrix

Total dose irradiation proceeded in accordance with the guidelines of MIL-STD-883 Test Method 1019.7. The experimental matrix consisted of five samples irradiated at high dose rate with all pins grounded, five samples irradiated at high dose rate under bias, five samples irradiated at low dose rate with all pins grounded and five samples irradiated at low dose rate under bias. One control unit was used.

Samples of the IS-1845ASRH die were drawn from production lot DCNJLED, date code X0812ABB3, and were packaged in the standard hermetic 18-pin solder-sealed flatpack (CDFP4-F18) production package. Samples were processed through the standard burnin cycle before irradiation, as required by MIL-STD-883, and were screened to the SMD 5962-01509 limits at room, low and high temperatures prior to the test.

4.5 Downpoints

Downpoints for the tests were 0, 10, 15, 20 and 25krad(Si) for the high dose rate test and 0, 10, 14, 20, 25, 35, 50, 75, 100, 125 and 150krad(Si) for the low dose rate test.

5: Results

5.1 Test results

Parts were tested at low and high dose rate under biased and unbiased conditions as outlined in MIL-STD-883 Test Method 1019.7. Five samples each were irradiated at low and high dose rate under biased and unbiased conditions. The high dose rate samples were exposed through 25krad(Si) and stopped. Intersil elected to reduce the radiation level and to increase the down points to 4 up to 25krad(Si). The high dose rate test focused on an increased number of down points up to 25krad(Si) in the event the data was needed in understanding ELDRS data taken at similar radiation levels. The low dose rate samples were exposed to multiple down points (10, 14, 20, 25krad(Si) to reach 25krad(Si) and then were continued to 150krad(Si). Six more down points (35, 50, 75, 100, 125 and 150krad(Si)) were completed in reaching the 150krad(Si) level.

All samples passed the SMD limits through 25krad(Si) at high dose rate and 150krad(Si) at low dose rate. The part was found to display no discernible dose rate sensitivity or bias sensitivity, with very stable performance out to the maximum total dose level. Nonetheless the part must be considered low dose rate sensitive as the maximum high dose rate baseline test proceeded to 25krad(Si) while the low dose rate test was run out to 150krad(Si). The demonstration of true low dose rate insensitivity will require a high dose rate test to the 150krad(Si) level.

5.2 Variables data

The plots in Figures 3 through 33 show data at all downpoints. The plots show the median of key parameters as a function of total dose for each of the four irradiation conditions. We chose to plot the median for these parameters due to the relatively small sample sizes.

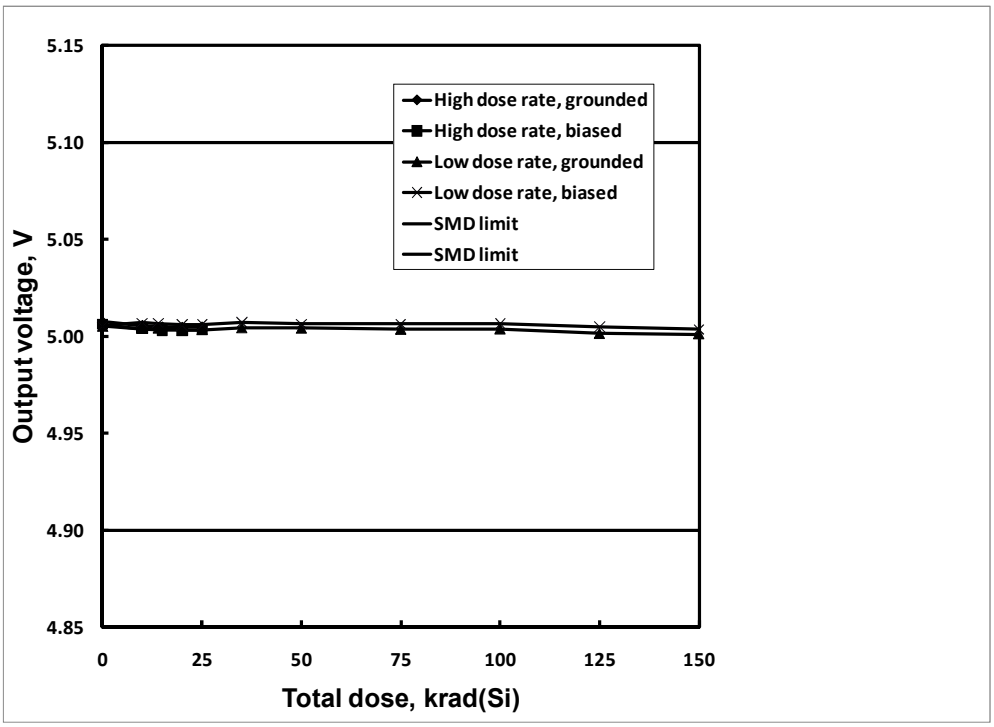

Figure 3: IS-1845ASRH median reference output voltage as a function of total dose irradiation at low and high dose rate for the unbiased (all pins grounded) and the biased (per Figure 2) cases. The low dose rate was 0.01rad(Si)/s and the high dose rate 50rad(Si)/s. Sample size for each cell was 5. The SMD limits for this parameter are 4.90V to 5.10V.

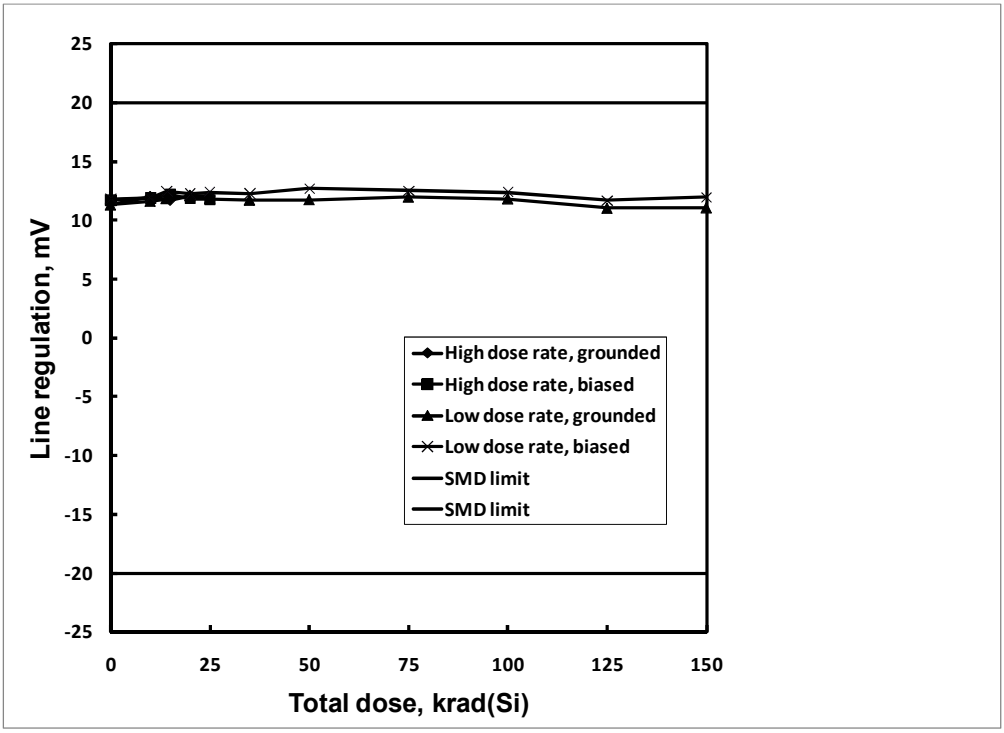

Figure 4: IS-1845ASRH median line regulation as a function of total dose irradiation at low and high dose rate for the unbiased (all pins grounded) and the biased (per Figure 2) cases. The low dose rate was 0.01rad(Si)/s and the high dose rate 55rad(Si)/s. Sample size for each cell was 5. The SMD limits for this parameter are -20mV to +20mV.

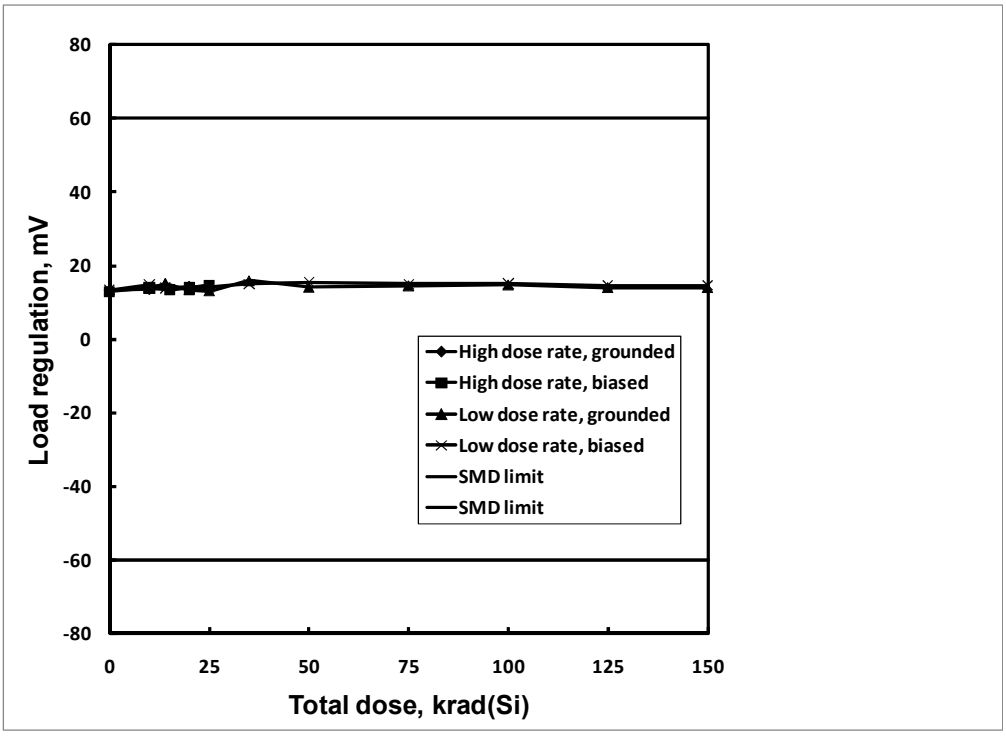

Figure 5: IS-1845ASRH median load regulation as a function of total dose irradiation at low and high dose rate for the unbiased and biased cases. The post-irradiation SMD limits for this parameter are -60mV to +60mV.

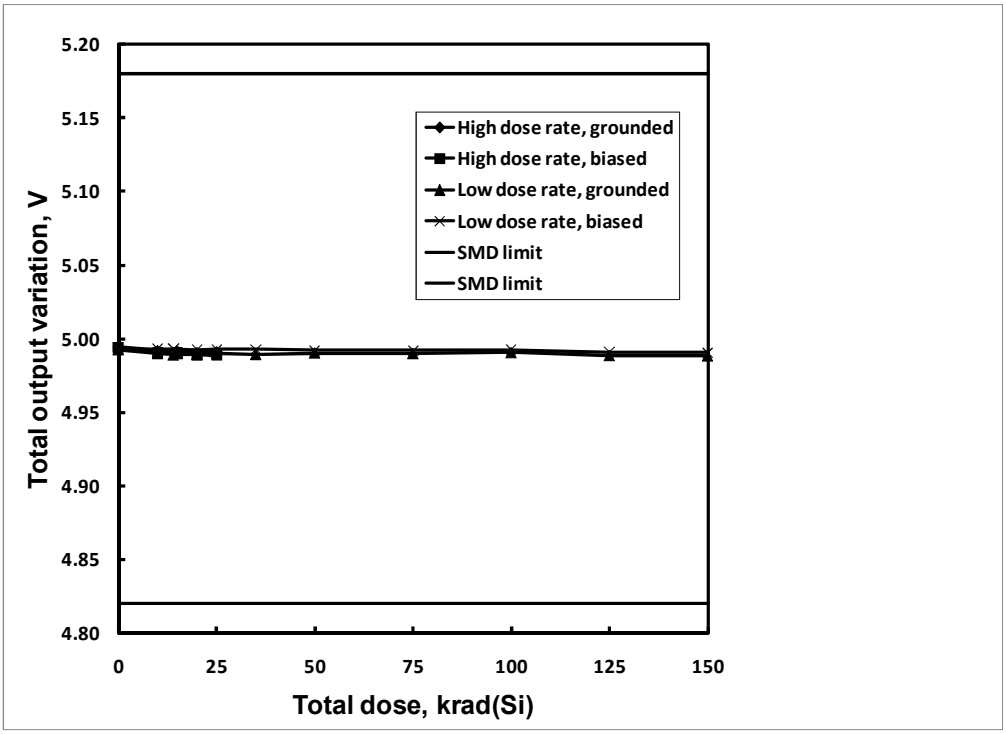

Figure 6: IS-1845ASRH median total reference output voltage variation over line, load and temperature as a function of total dose irradiation at low and high dose rate for the unbiased and biased cases. The SMD limits for this parameter are 4.82V to 5.18V.

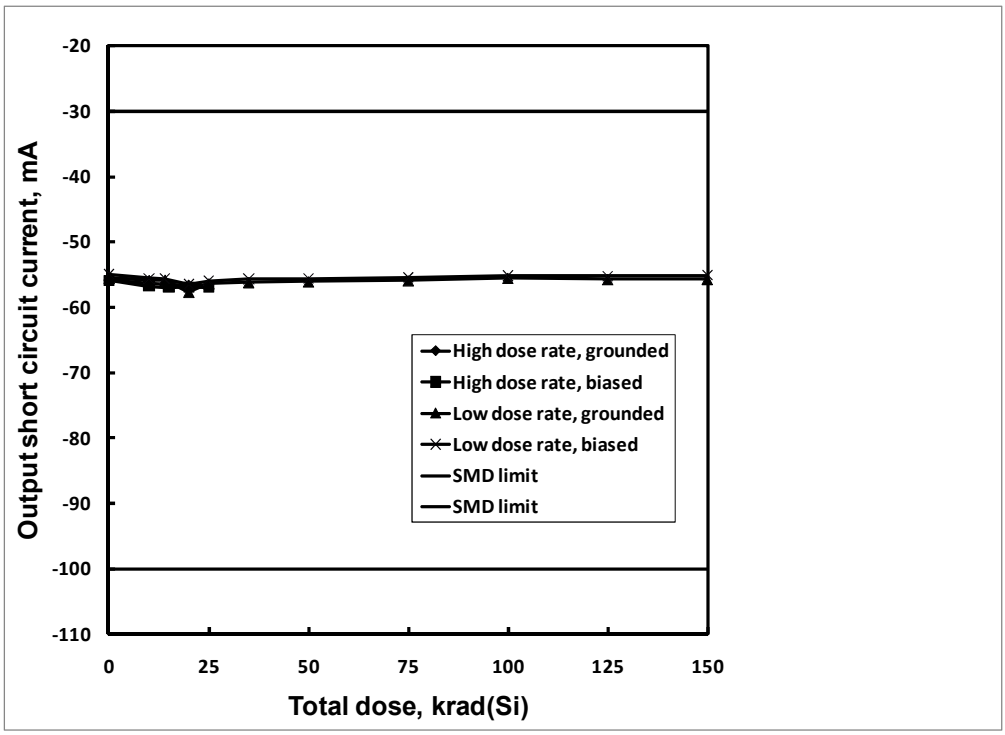

Figure 7: IS-1845ASRH median reference output short circuit current as a function of total dose irradiation at low and high dose rate for the unbiased and biased cases. The SMD limits for this parameter are -30mA to -100mA.

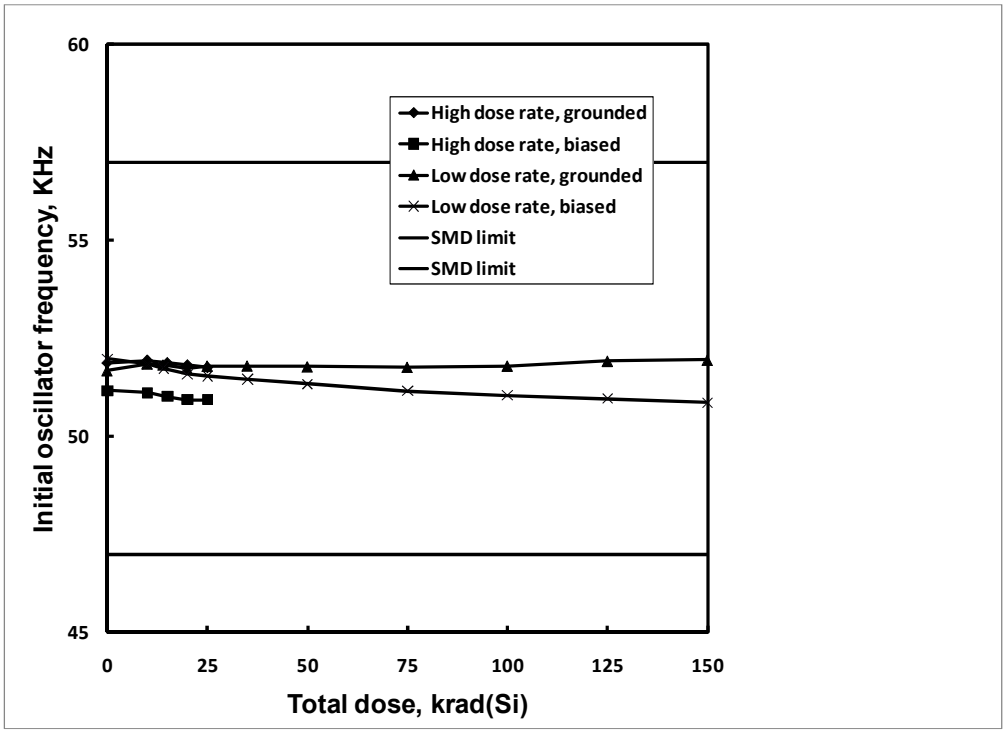

Figure 8: IS-1845ASRH median oscillator frequency as a function of total dose irradiation at low and high dose rate for the unbiased and biased cases. The SMD limits for this parameter are 47 kHz to 57 kHz.

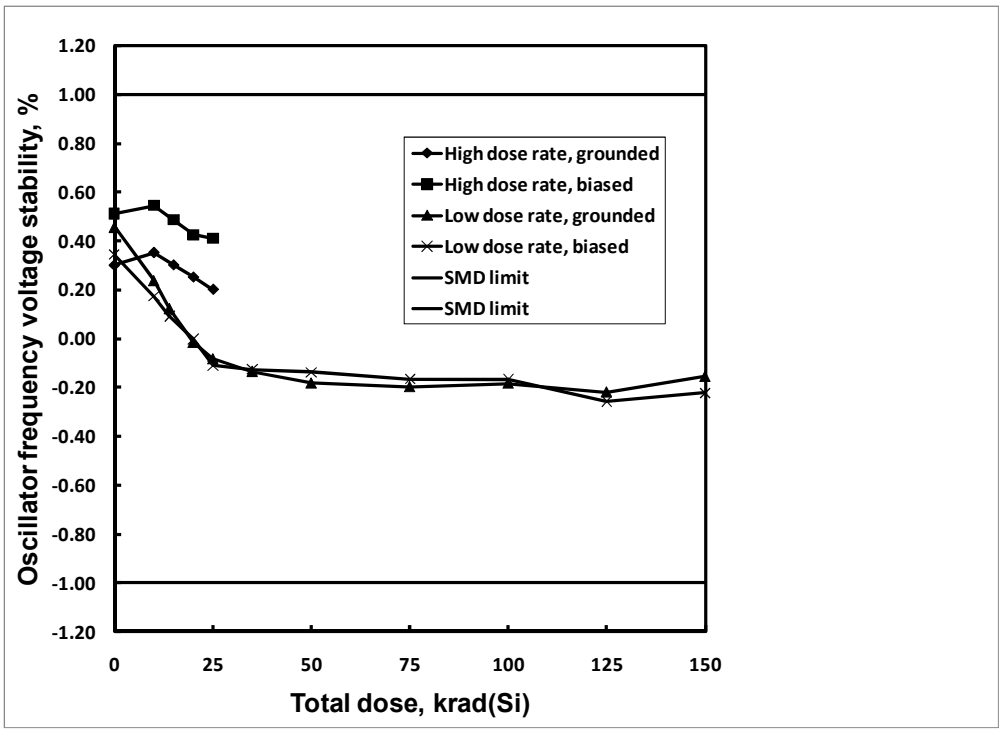

Figure 9: IS-1845ASRH median oscillator supply voltage stability as a function of total dose irradiation at low and high dose rate for the unbiased and biased cases. The SMD limits for this parameter are -1.0% to 1.0%.

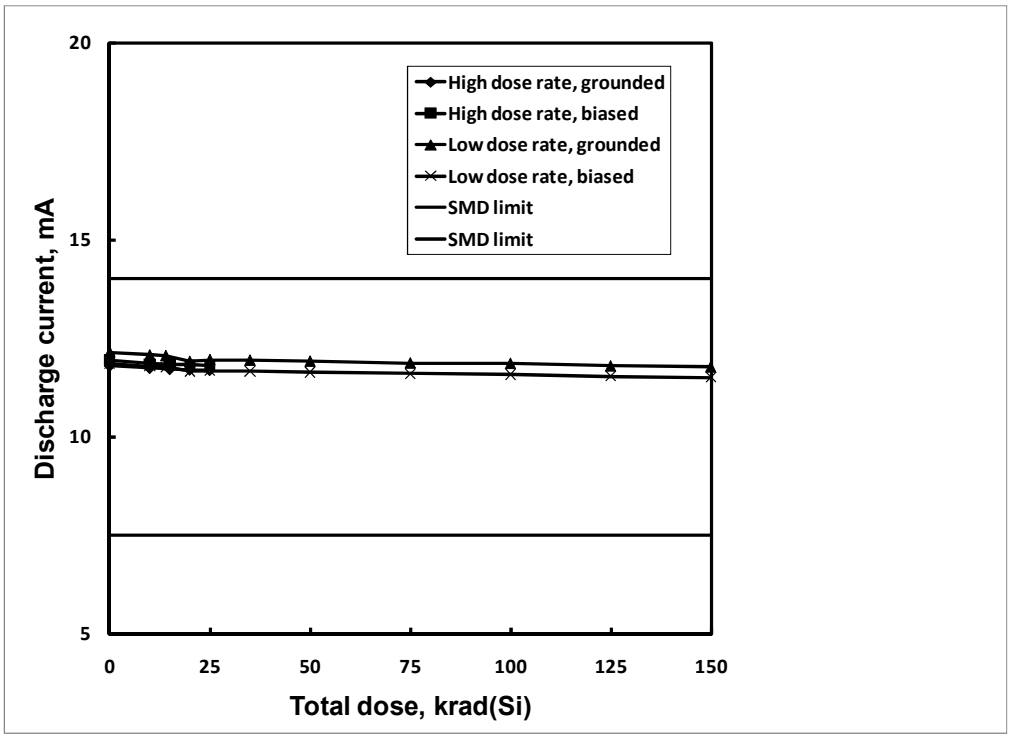

Figure 10: IS-1845ASRH median oscillator discharge current as a function of total dose irradiation at low and high dose rate for the unbiased and biased cases. The SMD limits for this parameter are 7.5mA to 14mA.

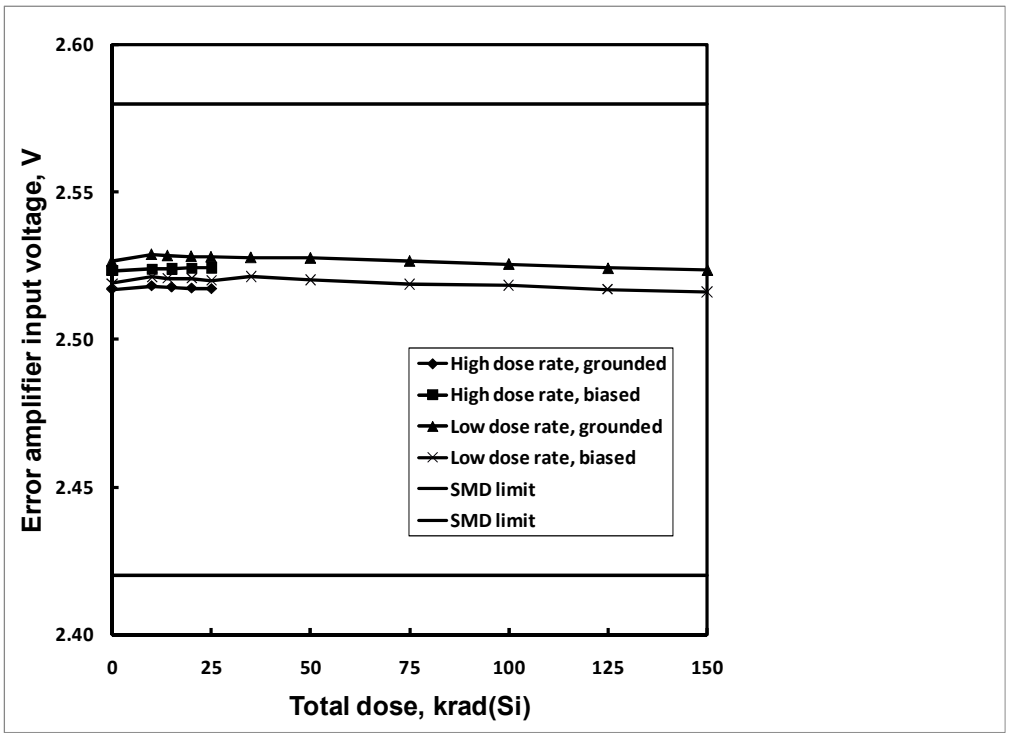

Figure 11: IS-1845ASRH median error amplifier input voltage as a function of total dose irradiation at low and high dose rate for the unbiased and biased cases. The SMD limits for this parameter are 2.42V to 2.58V.

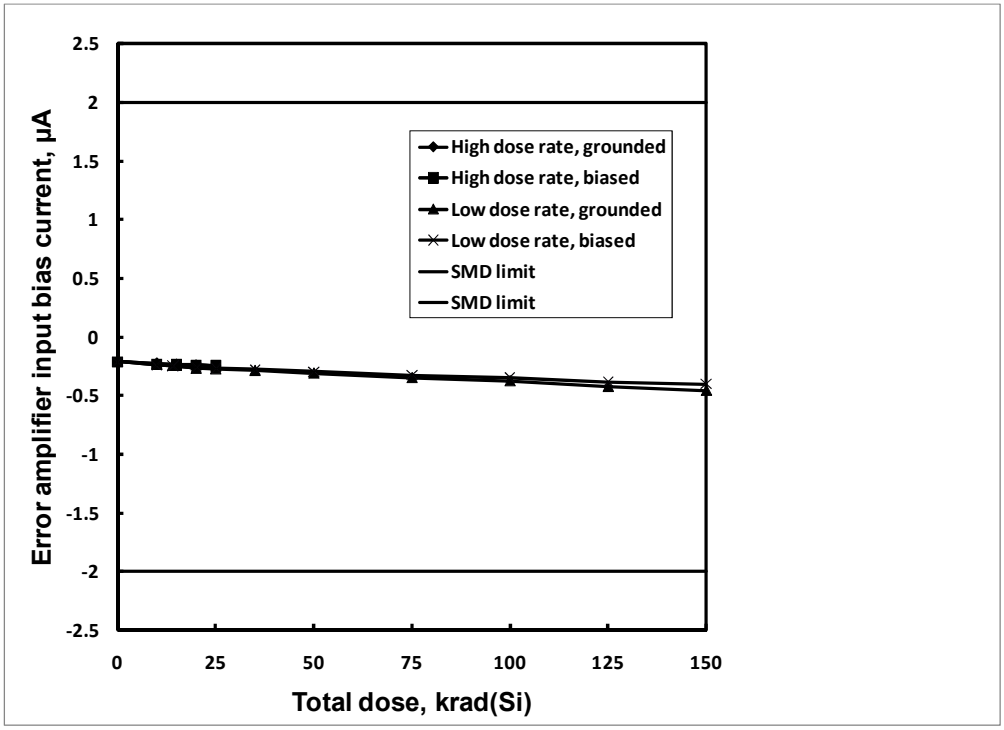

Figure 12: IS-1845ASRH median error amplifier input bias current as a function of total dose irradiation at low and high dose rate for the unbiased and biased cases. The SMD limits for this parameter are -2.0µA to 2.0µA.

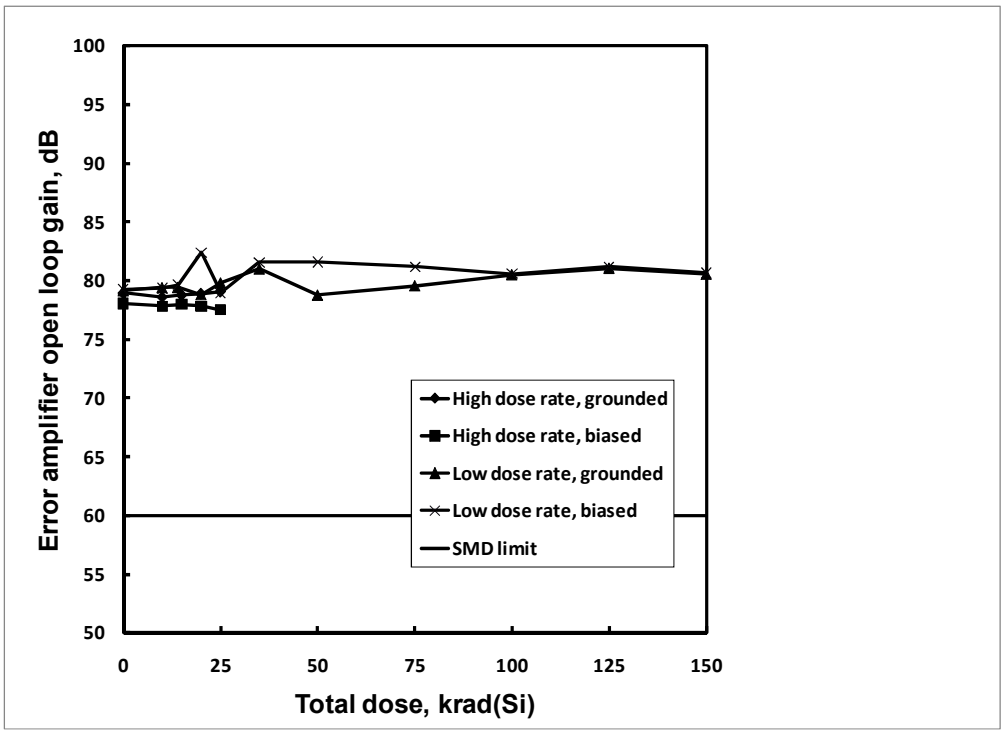

Figure 13: IS-1845ASRH median error amplifier open-loop voltage gain as a function of total dose irradiation at low and high dose rate for the unbiased and biased cases. The SMD limit for this parameter is 60dB minimum.

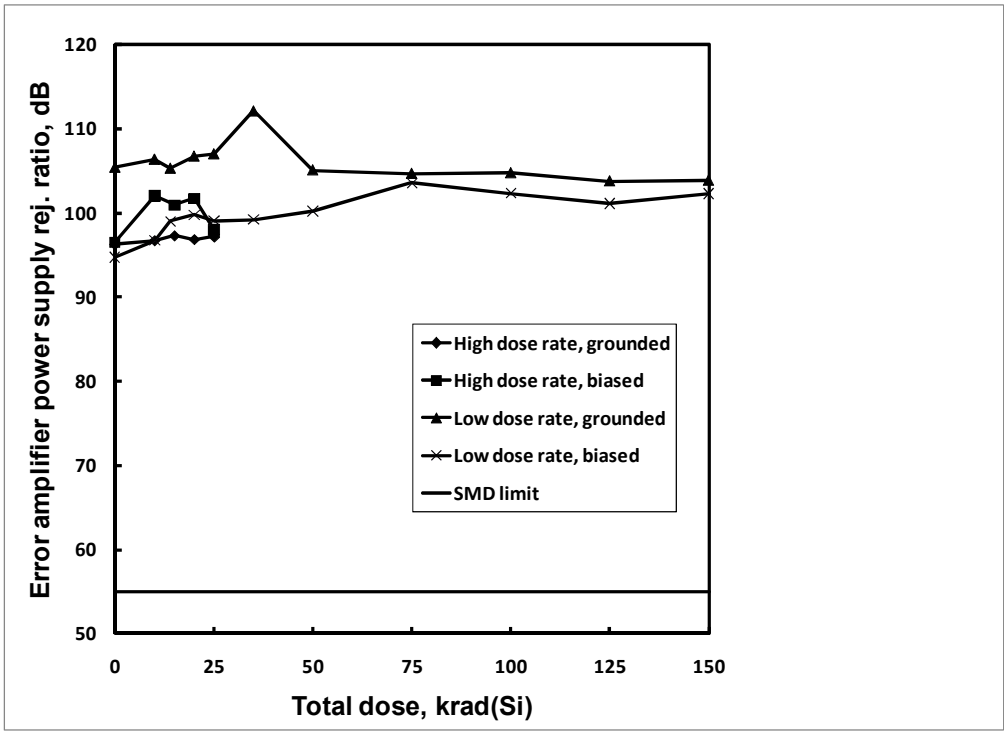

Figure 14: IS-1845ASRH median error amplifier power supply rejection ratio as a function of total dose irradiation at low and high dose rate for the unbiased and biased cases. The post-irradiation SMD limit for this parameter is 55dB minimum.

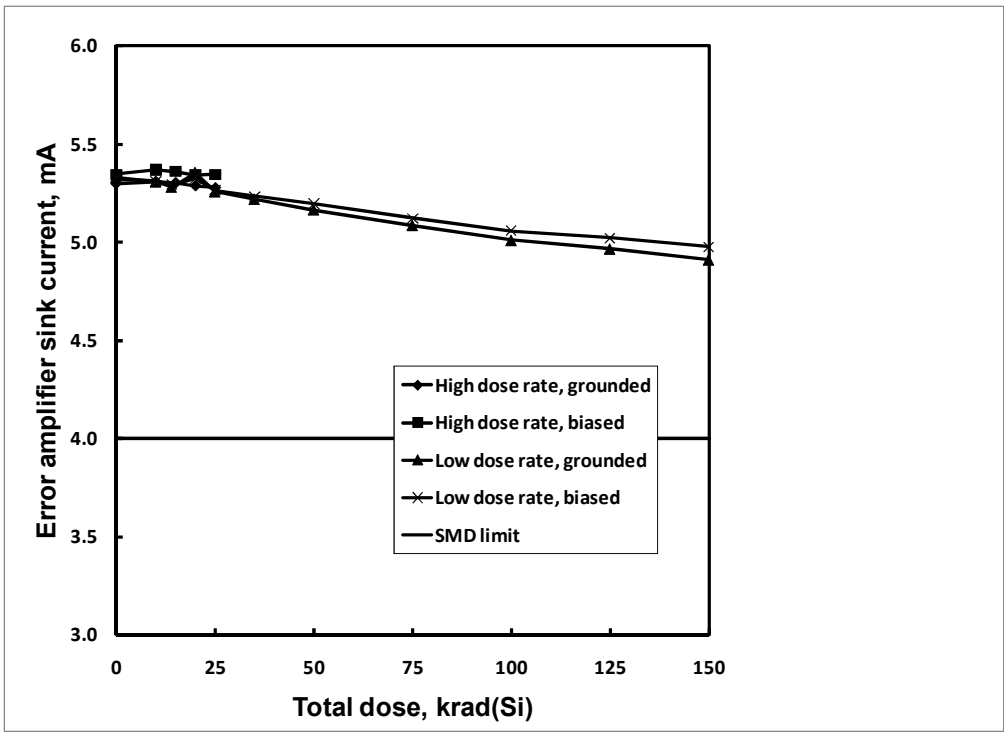

Figure 15: IS-1845ASRH median error amplifier output sink current as a function of total dose irradiation at low and high dose rate for the unbiased and biased cases. The SMD limit for this parameter is 4.0mA minimum.

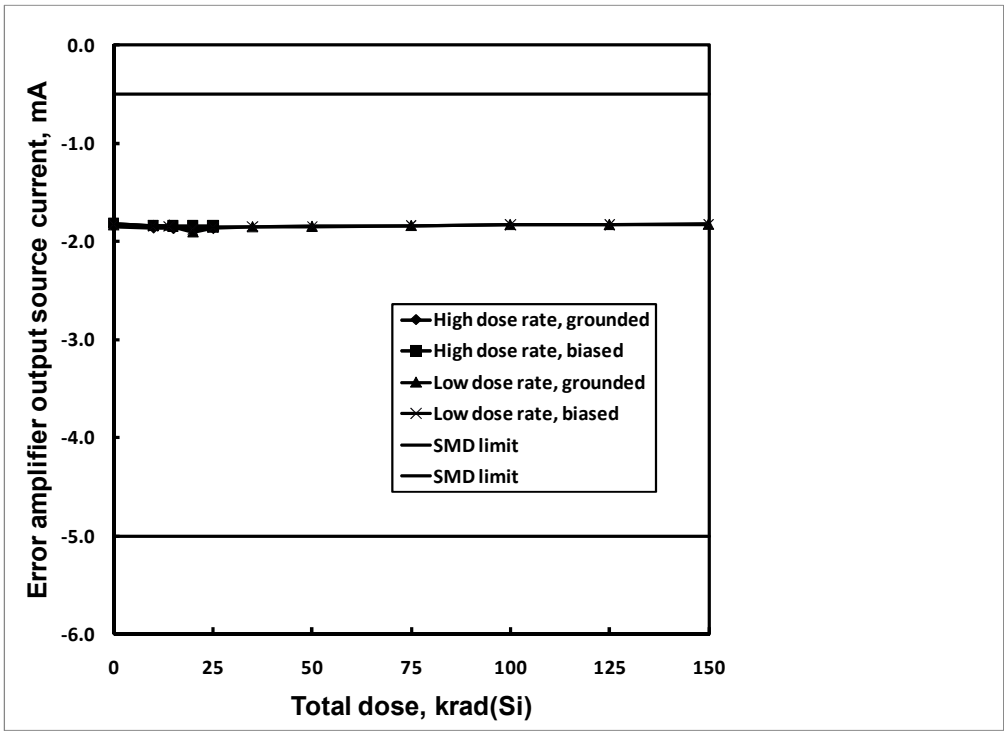

Figure 16: IS-1845ASRH median error amplifier output source current as a function of total dose irradiation at low and high dose rate for the unbiased and biased cases. The SMD limit for this parameter is -0.5mA minimum. The 5mA line is an ATE limit.

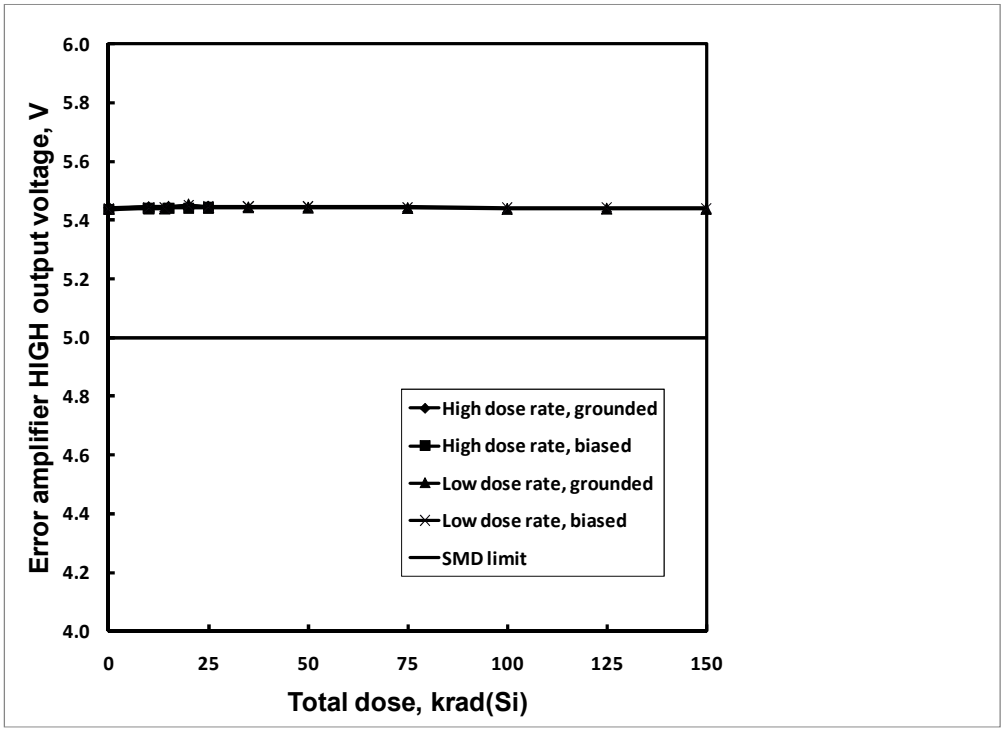

Figure 17: IS-1845ASRH median error amplifier HIGH output voltage as a function of total dose irradiation at low and high dose rate for the unbiased and biased cases. The SMD limit for this parameter is 5.0V minimum.

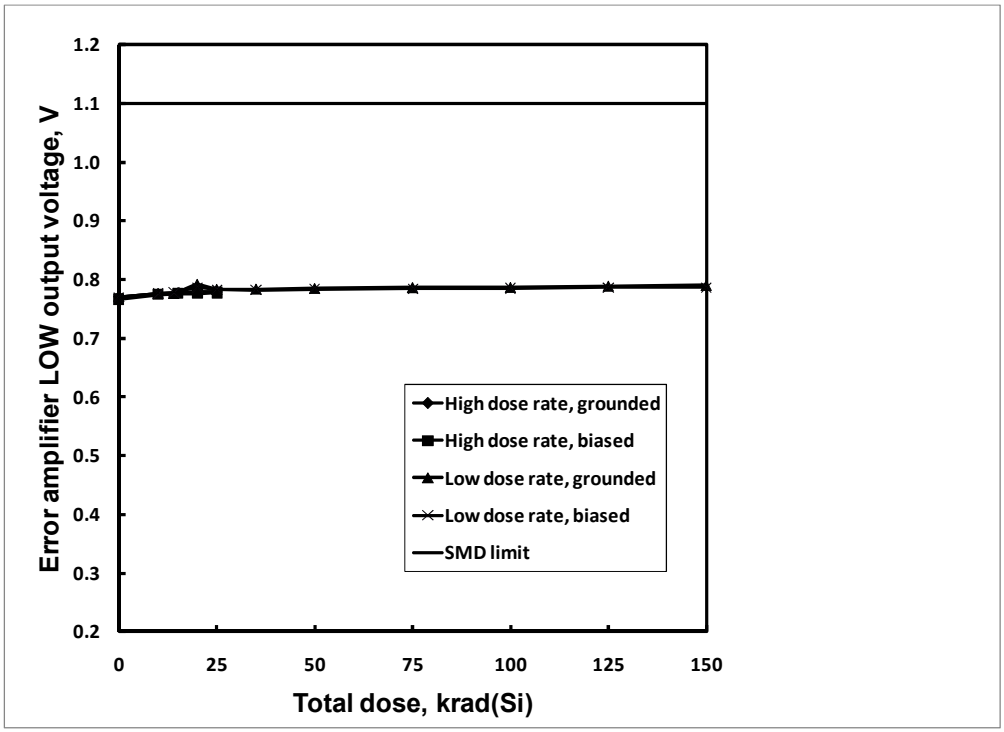

Figure 18: IS-1845ASRH median error amplifier LOW output voltage as a function of total dose irradiation at low and high dose rate for the unbiased and biased cases. The SMD limit for this parameter is 1.1V maximum.

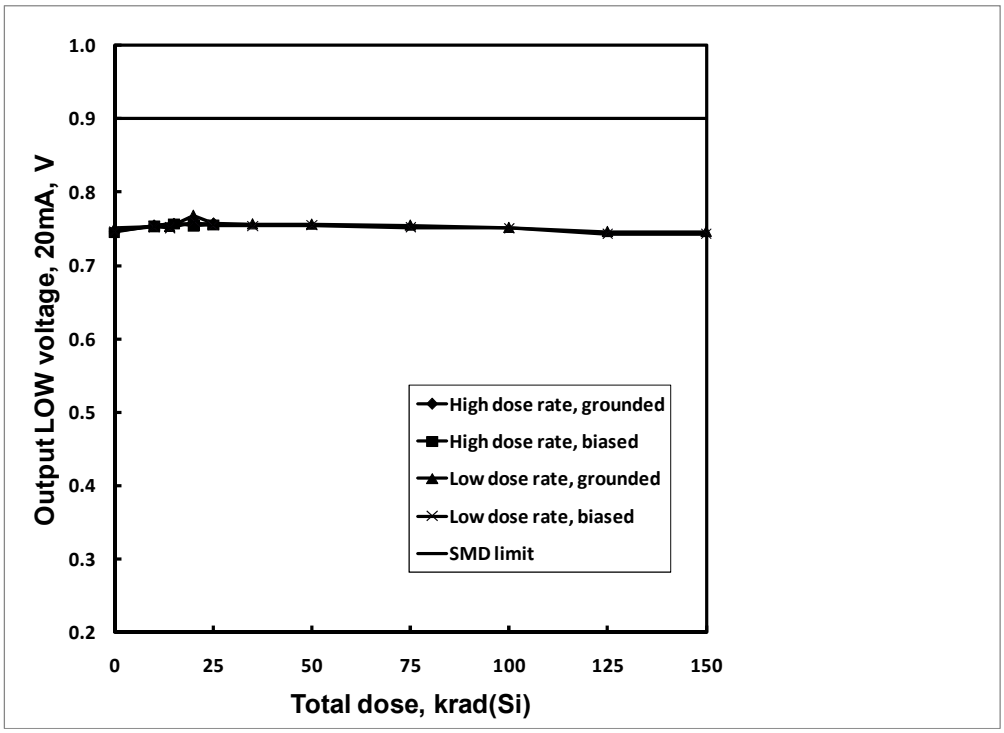

Figure 19: IS-1845ASRH median output LOW voltage at 20mA as a function of total dose irradiation at low and high dose rate for the unbiased and biased cases. The SMD limit for this parameter is 0.90V maximum.

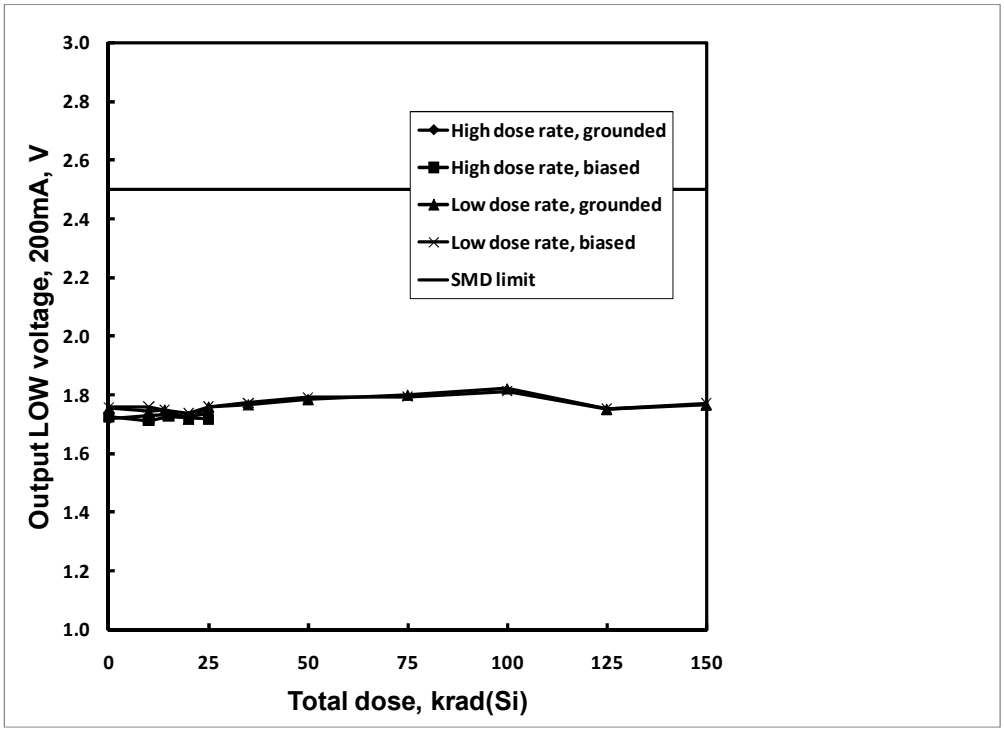

Figure 20: IS-1845ASRH median output LOW voltage at 200mA as a function of total dose irradiation at low and high dose rate for the unbiased and biased cases. The SMD limit for this parameter is 2.5V maximum.

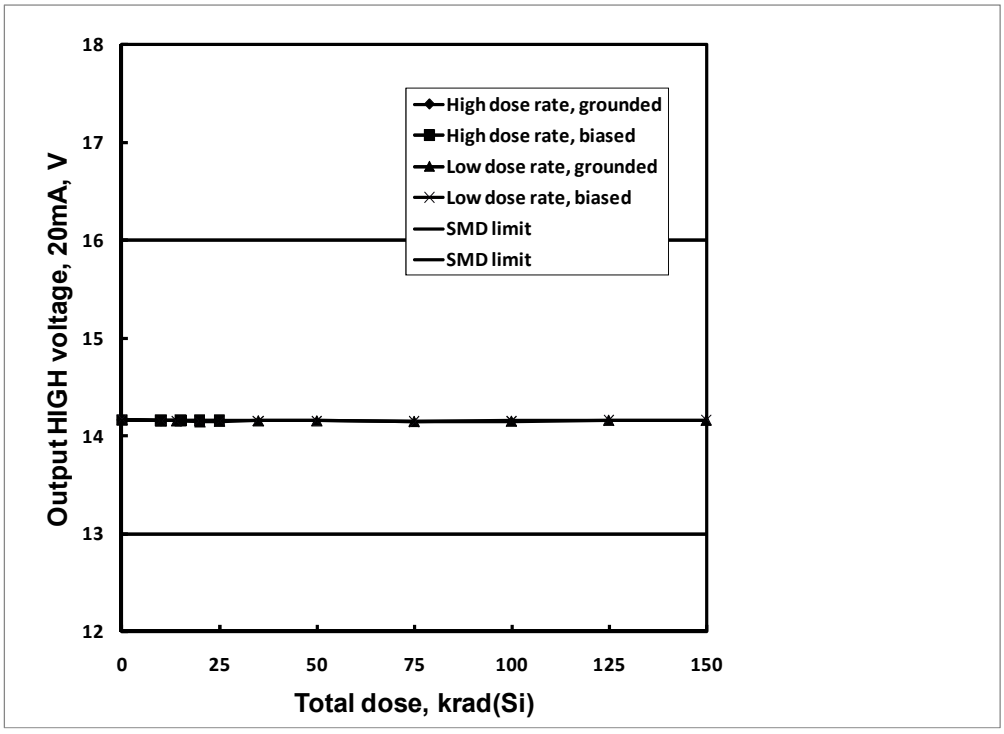

Figure 21: IS-1845ASRH median output HIGH voltage at 20mA as a function of total dose irradiation at low and high dose rate for the unbiased and biased cases. The SMD limits for this parameter are 13.0V to 16.0V.

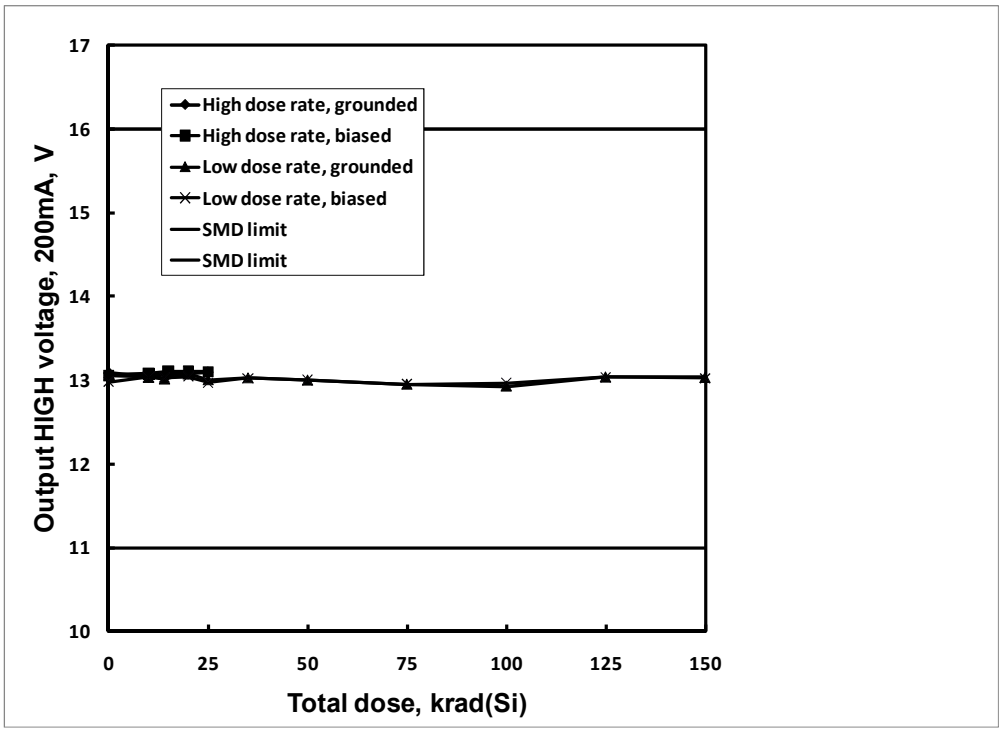

Figure 22: IS-1845ASRH median output HIGH voltage at 200mA as a function of total dose irradiation at low and high dose rate for the unbiased and biased cases. The SMD limits for this parameter are 11.0V to 16.0V.

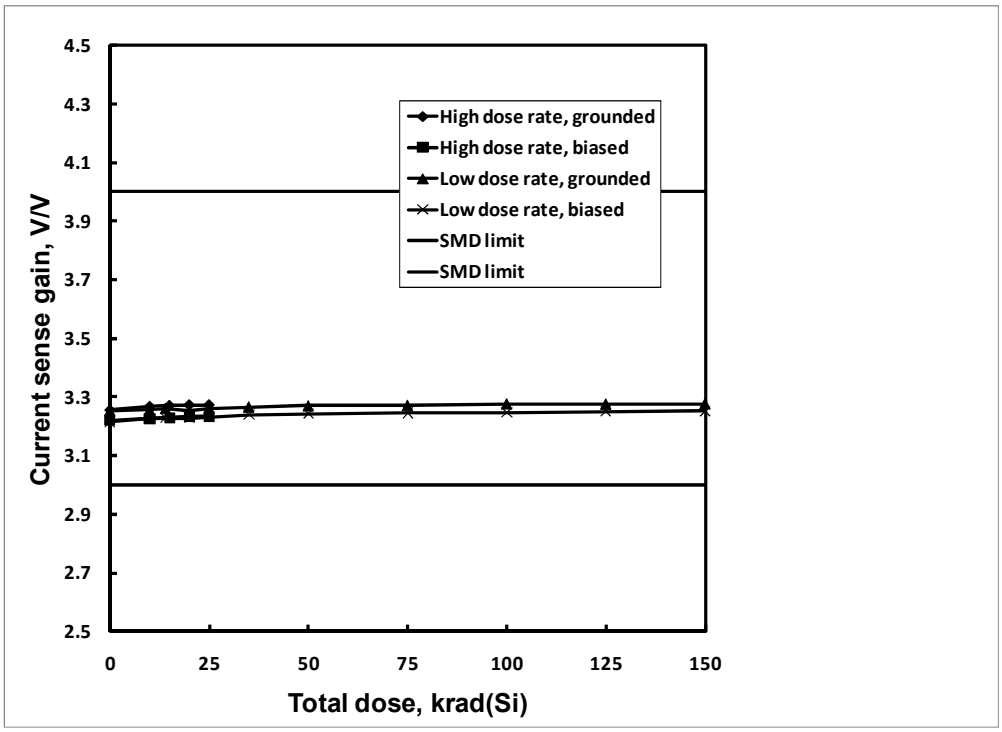

Figure 23: IS-1845ASRH median current sense amplifier gain as a function of total dose irradiation at low and high dose rate for the unbiased and biased cases. The SMD limits for this parameter are 3.0V/V to 4.0V/V.

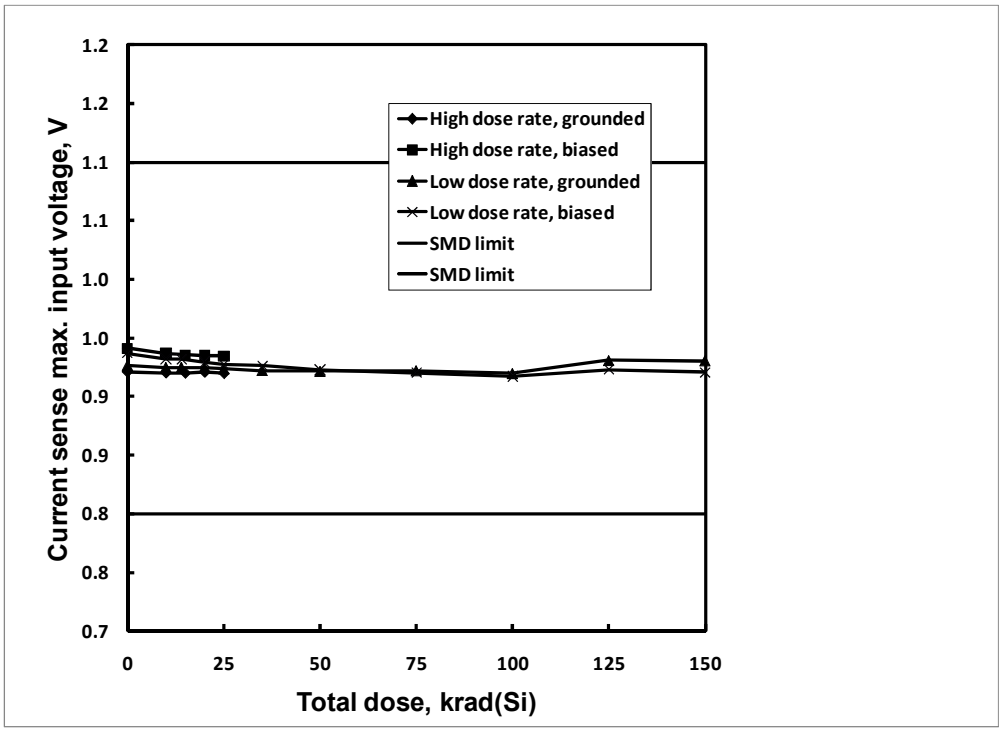

Figure 24: IS-1845ASRH median current sense amplifier maximum input voltage as a function of total dose irradiation at low and high dose rate for the unbiased and biased cases. The SMD limits for this parameter are 0.8V to 1.1V.

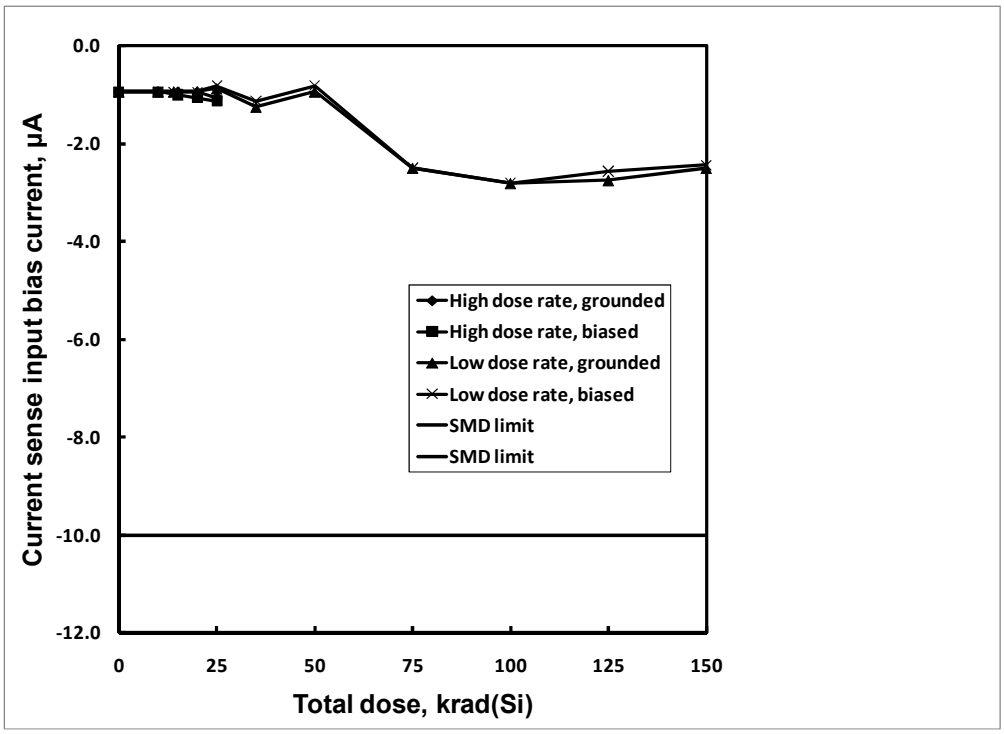

Figure 25: IS-1845ASRH median current sense amplifier input bias current as a function of total dose irradiation at low and high dose rate for the unbiased and biased cases. The SMD limit for this parameter is -10µA maximum.

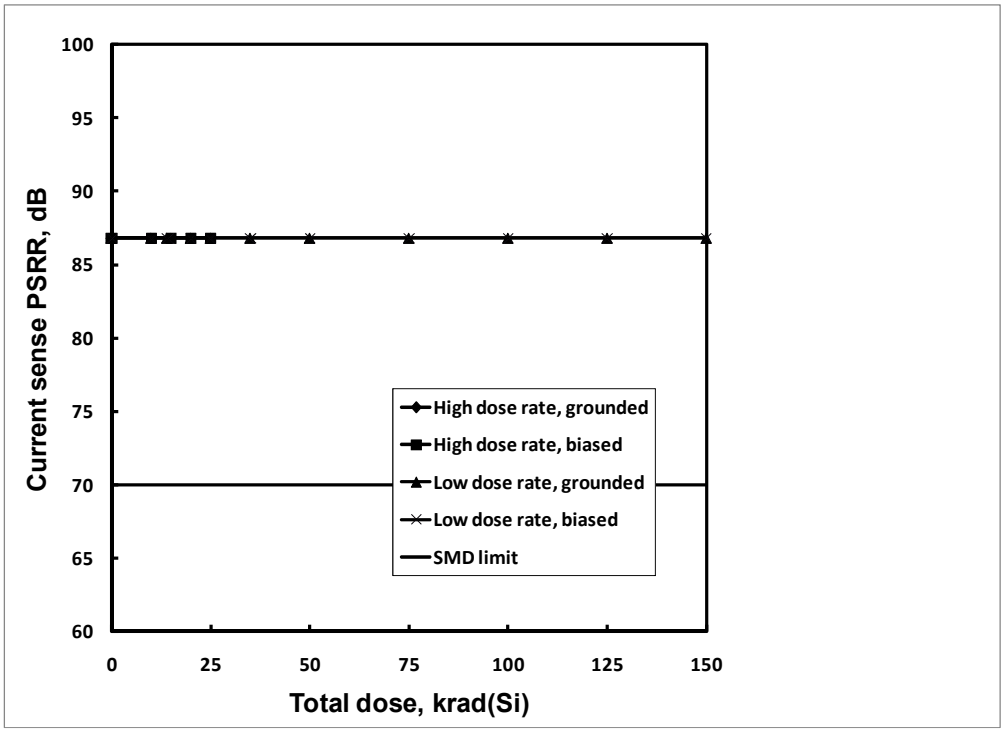

Figure 26: IS-1845ASRH median current sense amplifier power supply rejection ratio as a function of total dose irradiation at low and high dose rate for the unbiased and biased cases. The SMD limit for this parameter is 70dB minimum.

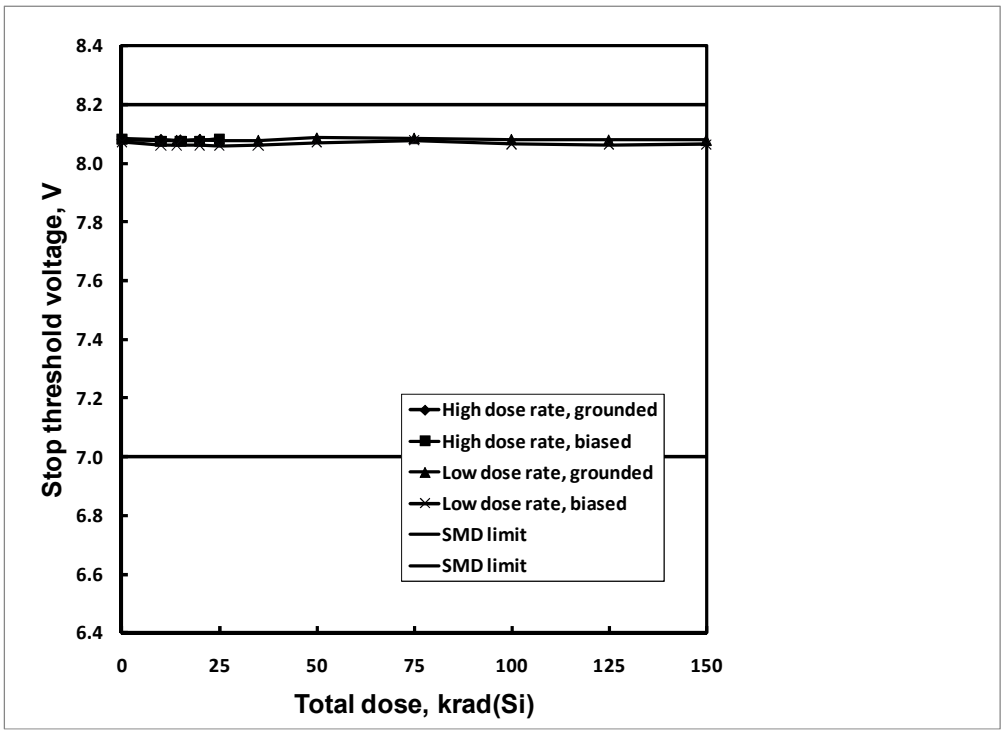

Figure 27: IS-1845ASRH median undervoltage lockout STOP threshold voltage as a function of total dose irradiation at low and high dose rate for the unbiased and biased cases. The SMD limits for this parameter are 7.0V to 8.2V.

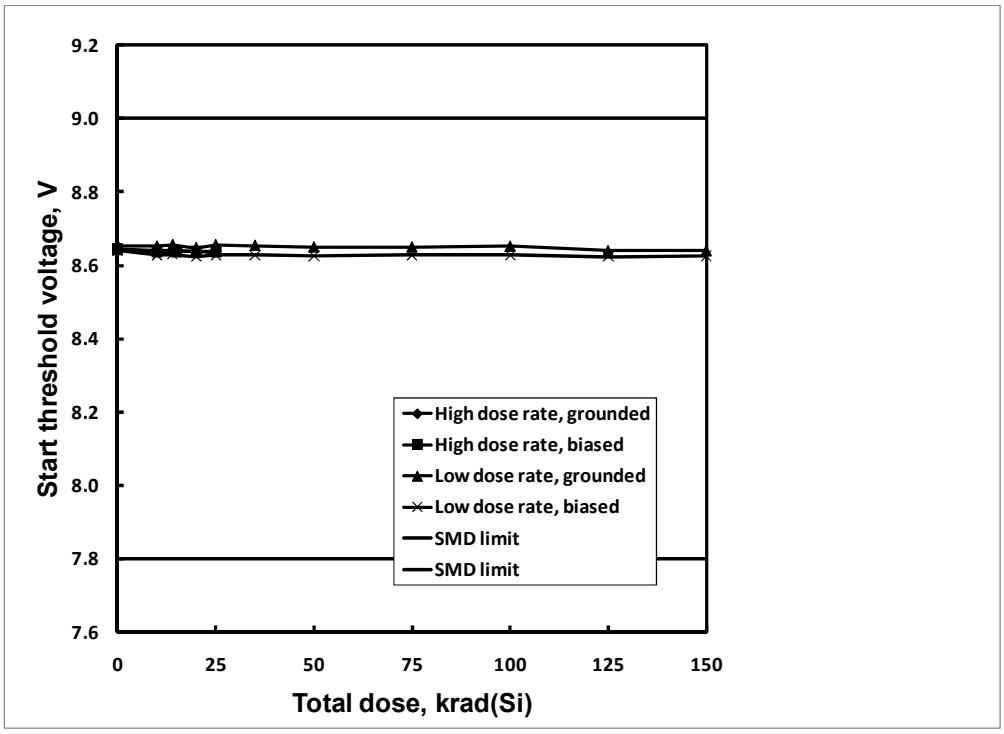

Figure 28: IS-1845ASRH median undervoltage lockout START threshold voltage as a function of total dose irradiation at low and high dose rate for the unbiased and biased cases. The SMD limits for this parameter are 7.8V to 9.0V.

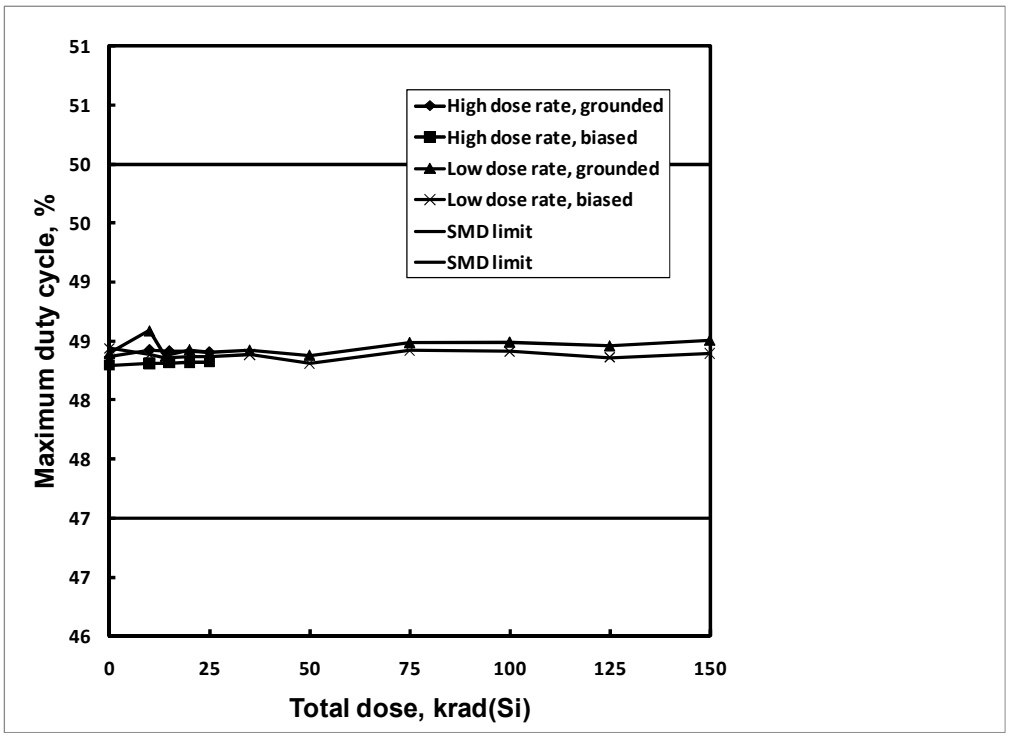

Figure 29: IS-1845ASRH median maximum duty cycle as a function of total dose irradiation at low and high dose rate for the unbiased and biased cases. The SMD limits for this parameter are 47% to 50%.

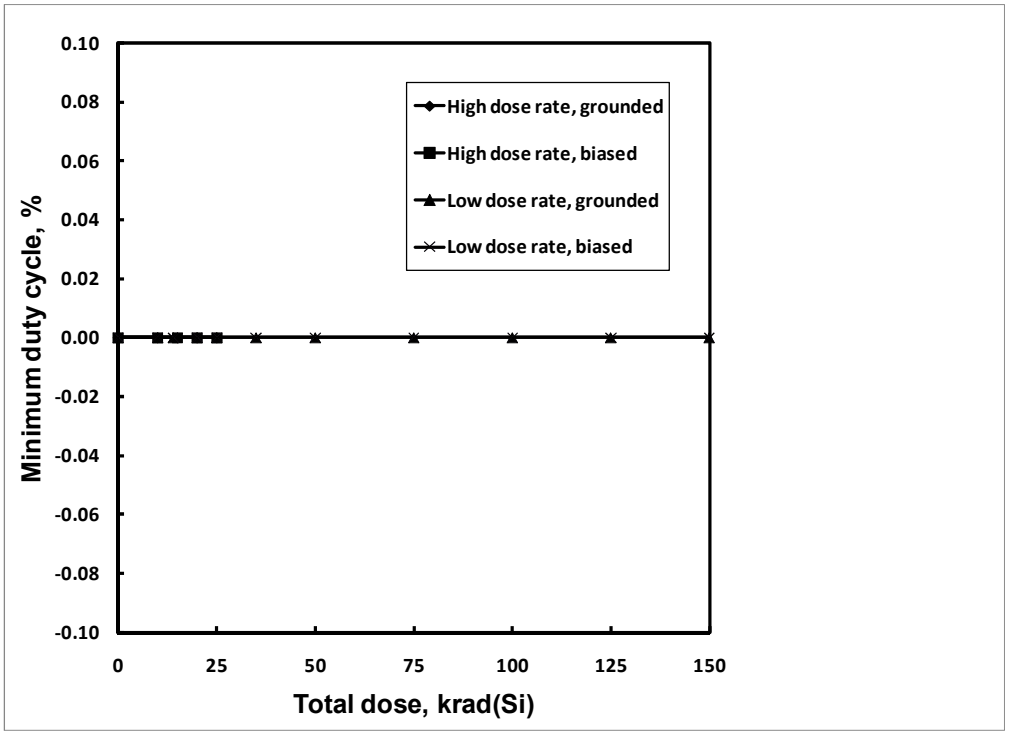

Figure 30: IS-1845ASRH median minimum duty cycle as a function of total dose irradiation at low and high dose rate for the unbiased and biased cases. The SMD limit for this parameter is 0%.

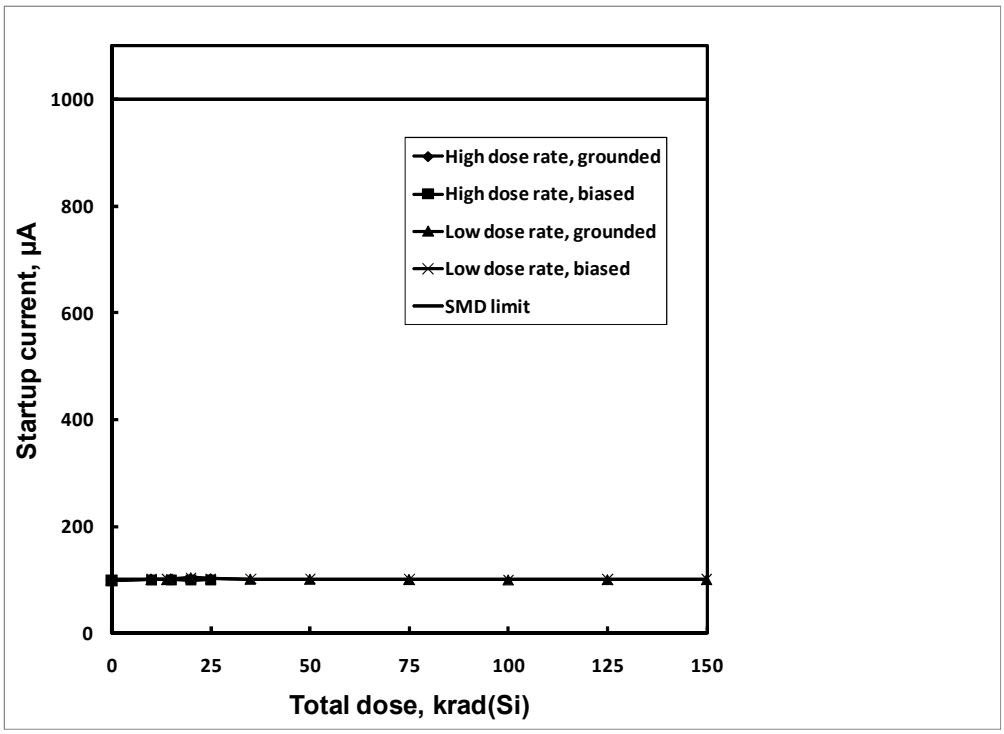

Figure 31: IS-1845ASRH median startup current as a function of total dose irradiation at low and high dose rate for the unbiased and biased cases. The SMD limit for this parameter is 1000 µA (1mA) maximum.

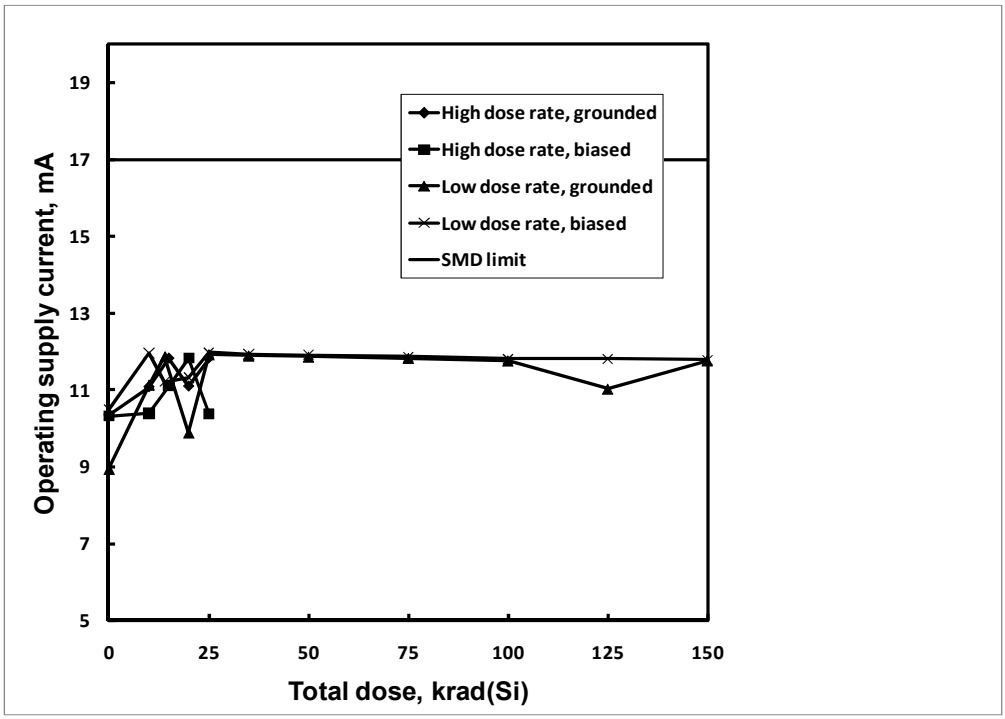

Figure 32: IS-1845ASRH median operating supply current as a function of total dose irradiation at low and high dose rate for the unbiased and biased cases. The SMD limit for this parameter is 17mA maximum.

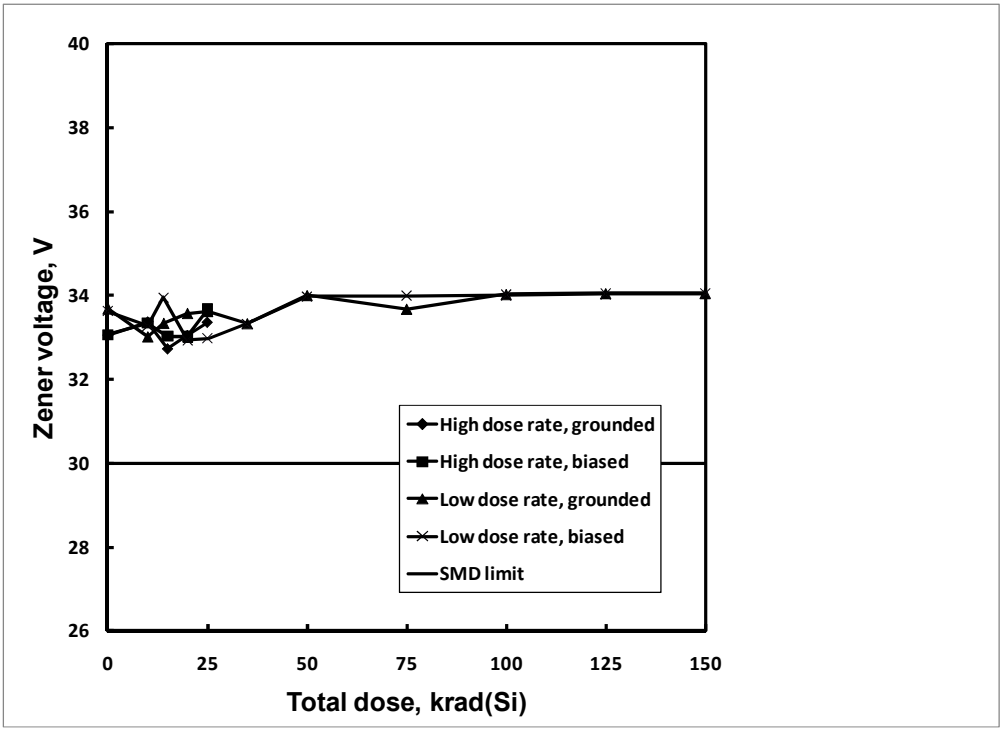

Figure 33: IS-1845ASRH median Zener voltage as a function of total dose irradiation at low and high dose rate for the unbiased and biased cases. The SMD limit for this parameter is 30.0V minimum.

6: Conclusion

This report summarizes the results of a total dose test of the IS-1845ASRH dual output PWM. Parts were tested at low and high dose rate under biased and unbiased conditions as outlined in MIL-STD-883 Test Method 1019.7. Five samples each were irradiated at low and high dose rate under biased and unbiased conditions. The high dose rate samples were exposed through 25krad(Si) and stopped. Intersil elected to reduce the radiation level and to increase the down points to 4 up to 25krad(Si). The high dose rate test focused on an increased number of down points up to 25krad(Si) in the event the data was needed in understanding ELDRS data taken at similar radiation levels. The low dose rate samples were exposed to multiple down points (10, 14, 20, 25krad(Si) to reach 25krad(Si) and then were continued to 150krad(Si). Six more down points (35, 50, 75, 100, 125 and 150krads(Si)) were completed in reaching the 150krad(Si) level.

All high dose rate samples passed the SMD criteria through 25krad(Si). All low dose rate samples passed the SMD rad criteria through 150krad(Si). The part was found to display no discernible dose rate sensitivity or bias sensitivity, with very stable performance out to the maximum total dose level. Nonetheless the part must be considered low dose rate sensitive as the maximum high dose rate baseline test proceeded to 25krad(Si) while the low dose rate test was run out to 150krad(Si). The demonstration of true low dose rate insensitivity as defined by MIL-STD-883 will require a high dose rate test to the 150krad(Si) level.

7: Appendix

7.1: Reported parameters.

Figure	Parameter	Limit, low	Limit, high	Units	Notes
3	Reference output voltage	4.90	5.10	V	
4	Reference line regulation	-20	20	mV	
5	Reference load regulation	-60	60	mV	
6	Reference output voltage variation	4.82	5.18	V	Over line, load and temperature.
7	Reference output short circuit current	-100	-30	mA	
8	Oscillator frequency	47	57	KHz	
9	Oscillator voltage stability	-1.0	1.0	%	
10	Oscillator discharge current	7.5	14	mA	
11	Error amplifier input voltage	2.42	2.58	V	
12	Error amplifier input bias current	-2.0	2.0	µA	
13	Error amplifier open loop voltage gain	60		dB	
14	Error amplifier power supply rejection ratio	55		dB	
15	Error amplifier output sink current	4.0		mA	
16	Error amplifier output source current	-0.5		mA	
17	Error amplifier HIGH output voltage	5.0		V	
18	Error amplifier LOW output voltage		1.1	V	
19	Output LOW voltage		.90	V	
20	Output LOW voltage		2.5	V	
21	Output HIGH voltage	13	16	V	
22	Output HIGH voltage	11	16	V	
23	Current sense amplifier gain	3.0	4.0	V/V	
24	Current sense amplifier max. input voltage	0.8	1.1	V	
25	Current sense amplifier input bias current		-10	µA	
26	Current sense amplifier power supply rejection ratio	70		dB	
27	UVLO STOP threshold voltage	7.0	8.2	V	
28	UVLO START threshold voltage	7.8	9.0	V	
29	PWM maximum duty cycle	47	50	%	
30	PWM minimum duty cycle		0	%	
31	Startup current		1.0	mA	
32	Operating supply current		17	mA	
33	Zener voltage	30		V	

Note 1: Limits are taken from Standard Microcircuit Drawing (SMD) 5962-01509.

8: Document revision history

Revision	Date	Pages	Comments
0	18 March 2011	All	Original issue