Total dose testing of the IS-2981EH 8-channel source driver

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1. Introduction

This report reports the results of a low and high dose rate total dose test of the IS-2981EH radiation hardened 8-channel source driver. The low dose rate irradiations were followed by a 100°C biased anneal for 168 hours. The test was conducted in order to determine the sensitivity of the part to the total dose environment, to determine if dose rate and bias sensitivity exist and to determine the part's response to a high temperature (HT) post-irradiation biased anneal.

2. Reference Documents

MIL-STD-883G test method 1019
IS-2981EH data sheet
DLA Standard Microcircuit Drawing (SMD) 5962-00520

3: Part Description

The IS-2981RH and IS-2981EH are monolithic 8-channel source drivers designed for use in high-side switching applications that benefit from separate grounds for the logic and loads. The devices have a 5V to 80V operating supply voltage range and are capable of sourcing -200mA continuously from each output. The outputs are controlled by active-high inputs and may be paralleled to increase the drive current. Each channel has an output clamp diode to prevent device damage when switching inductive loads. Constructed with the Intersil bonded wafer, dielectrically isolated HVTDLM process, these single event latch-up immune devices will provide reliable performance in harsh radiation environments. The parts are guaranteed for 100krad(Si) high dose rate and 50krad(Si) low dose rate total dose performance through wafer-by-wafer acceptance testing.

The IS-2981RH and IS-2981EH use the same die and differ only in the total dose acceptance testing flow, which is performed on a wafer by wafer basis. The IS-2981EH is acceptance tested at low and high dose rate, while the IS-2981RH is acceptance tested at high dose rate only.

Specifications for radiation hardened MIL-PRF-38535 (QML) devices are controlled by the Defense Logistics Agency, Land and Maritime (DLA). The SMD number must be used when ordering. Detailed electrical specifications for these devices are contained in SMD 5962-00520.

4: Test Description

4.1 Irradiation Facilities

High dose rate testing to 100 krad(Si) was performed using a Gammacell 220 ^{60}Co irradiator located in the Palm Bay, Florida Intersil facility. Low dose rate testing to 200 krad(Si) was performed using a Hopewell Designs (Alpharetta, GA) N40 panoramic ^{60}Co irradiator, also located in the Palm Bay facility. The high dose rate irradiations were done at 65 rad(Si)/s and the low dose rate work was performed at 0.010 rad(Si)/s, both per MIL-STD-883 Method 1019.7. Post low dose rate anneals were performed in a small temperature chamber.

4.2 Test Fixturing

The configuration used for biased irradiation was in conformance with Standard Microcircuit Drawing (SMD) 5962-00520.

4.3 Characterization equipment and procedures

All electrical testing was performed outside the irradiator using production automated test equipment (ATE) with datalogging at each downpoint. Downpoint electrical testing was performed at room temperature.

4.4 Experimental matrix

Total dose irradiations proceeded in accordance with the guidelines of MIL-STD-883 Test Method 1019.7. The experimental matrix consisted of 8 samples irradiated at high dose rate under bias, 4 samples irradiated at low dose rate with all pins grounded and 4 samples irradiated at low dose rate under bias. All low dose rate samples were annealed under bias at 100^{o}C for 168 hours after the completion of irradiation. Two control units were used to insure repeatable data.

IS-2981EH die were drawn from Fab 59 production lot CC4TVEH/C and were packaged in the standard hermetic 18-pin solder-sealed dual inline (CDIP2-T18) production package. Samples were processed through the standard burnin cycle before irradiation, as required by MIL-STD-883, and were screened to the SMD 5962-00520 limits at room, low and high temperatures prior to the test.

4.5 Downpoints

Downpoints were 0, 50, 100, 150 and 200 krad(Si) for the low dose rate test, followed by the anneal, and 0 and 100 krad(Si) for the high dose rate test.

5: Results

5.1 Attributes data

Table 2: Attributes data.

Part	Dose rate, rad(Si)/s	Bias	Sample size	Downpoint	Pass (Note 1)	Fail
IS-2981EH	0.01	Biased	4	Pre-irradiation	4	0
				50 krad(Si)	4	0
				100 krad(Si)	4	0
				150 krad(Si)	4	0
				200 krad(Si)	4	0
				Anneal	4	0
IS-2981EH	0.01	Grounded	4	Pre-irradiation	4	0
				50 krad(Si)	4	0
				100 krad(Si)	4	0
				150 krad(Si)	4	0
				200 krad(Si)	4	0
				Anneal	4	0
IS-2981EH	65	Biased	8	Pre-irradiation	8	0
				100 krad(Si)	8	0

Note 1: ‘Pass’ indicates a sample that passes all post-irradiation SMD limits.

5.2 Variables data

The plots in Figs. 1 through 16 show data for key parameters at all downpoints. The plots show the median of key parameters as a function of total dose for each of the three irradiation conditions. We chose to plot the median for these parameters due to the relatively limited sample sizes involved. For clarity, two plots are supplied for each parameter; a first plot showing all eight channels, and a second plot showing Channel 1 only. We observed no channel to channel sensitivity in any of the parameters.

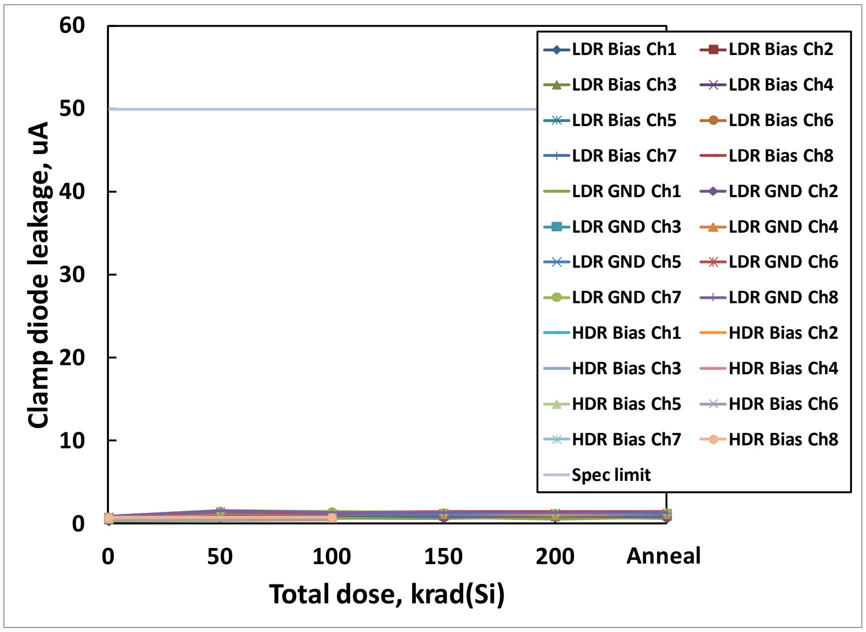

Fig. 1: IS-2981EH clamp diode leakage in µA, all eight channels, as a function of total dose irradiation at low dose rate for the unbiased (all pins grounded) and the biased cases, both of which were followed by a biased anneal at 100°C for 168 hours, and at high dose rate for the biased case. The low dose rate was 0.01 rad(Si)/s and the high dose rate was 65 rad(Si)/s. Sample size was 4 for each of the low dose rate cells and 8 for the high dose rate cell. The post-irradiation SMD limit is 50.0 µA maximum.

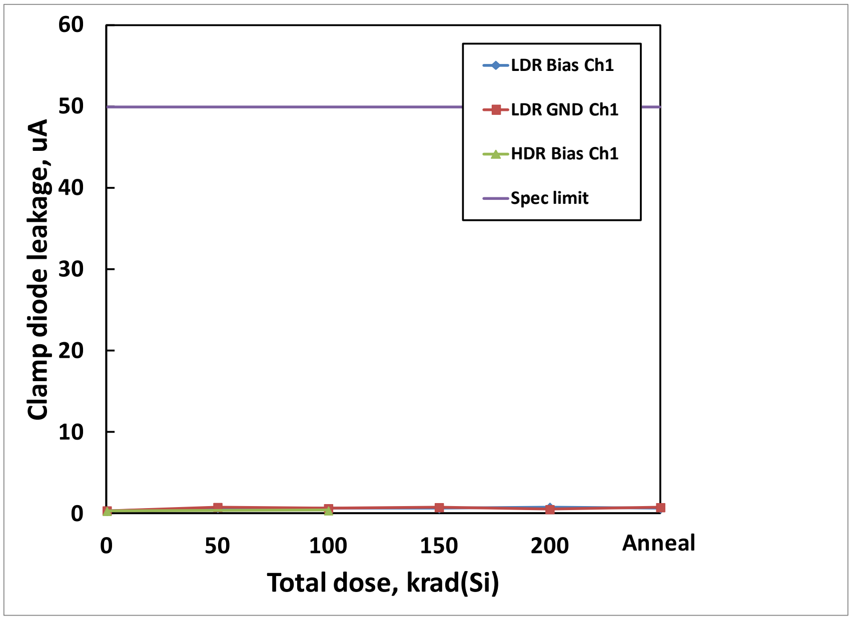

Fig. 2: IS-2981EH clamp diode leakage in µA, channel 1 only, as a function of total dose irradiation at low dose rate for the unbiased (all pins grounded) and the biased cases, both of which were followed by a biased anneal at 100°C for 168 hours, and at high dose rate for the biased case. The low dose rate was 0.01 rad(Si)/s and the high dose rate was 65 rad(Si)/s. Sample size was 4 for each of the low dose rate cells and 8 for the high dose rate cell. The post-irradiation SMD limit is 50.0 µA maximum.

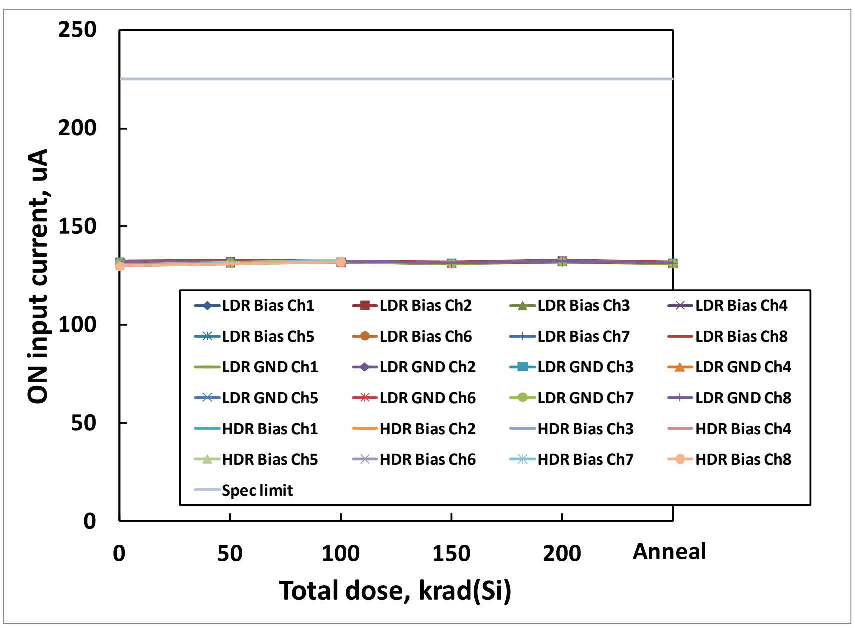

Fig. 3: IS-2981EH ON input current in µA, all eight channels, as a function of total dose irradiation at low dose rate for the unbiased (all pins grounded) and the biased cases, both of which were followed by a biased anneal at 100°C for 168 hours, and at high dose rate for the biased case. The low dose rate was 0.01 rad(Si)/s and the high dose rate was 65 rad(Si)/s. Sample size was 4 for each of the low dose rate cells and 8 for the high dose rate cell. The post-irradiation SMD limit is 225.0 µA maximum.

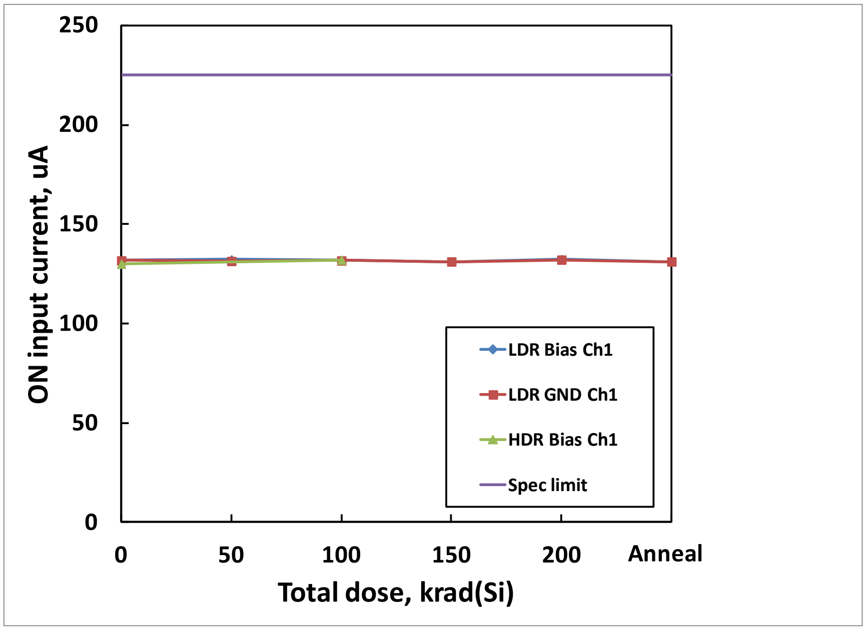

Fig. 4: IS-2981EH ON input current in µA, channel 1 only, as a function of total dose irradiation at low dose rate for the unbiased (all pins grounded) and the biased cases, both of which were followed by a biased anneal at 100oC for 168 hours, and at high dose rate for the biased case. The low dose rate was 0.01 rad(Si)/s and the high dose rate was 65 rad(Si)/s. Sample size was 4 for each of the low dose rate cells and 8 for the high dose rate cell. The post-irradiation SMD limit is 225.0 µA maximum.

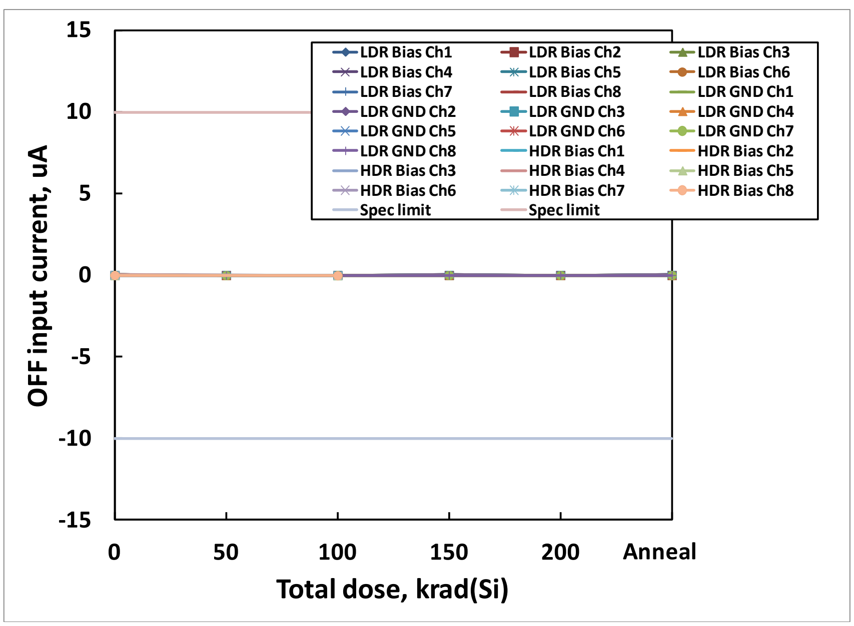

Fig. 5: IS-2981EH OFF input current in µA, all eight channels, as a function of total dose irradiation at low dose rate for the unbiased (all pins grounded) and the biased cases, both of which were followed by a biased anneal at 100^{o}C for 168 hours, and at high dose rate for the biased case. The low dose rate was 0.01 rad(Si)/s and the high dose rate was 65 rad(Si)/s. Sample size was 4 for each of the low dose rate cells and 8 for the high dose rate cell. The post-irradiation SMD limits are -10.0 µA to +10.0 µA.

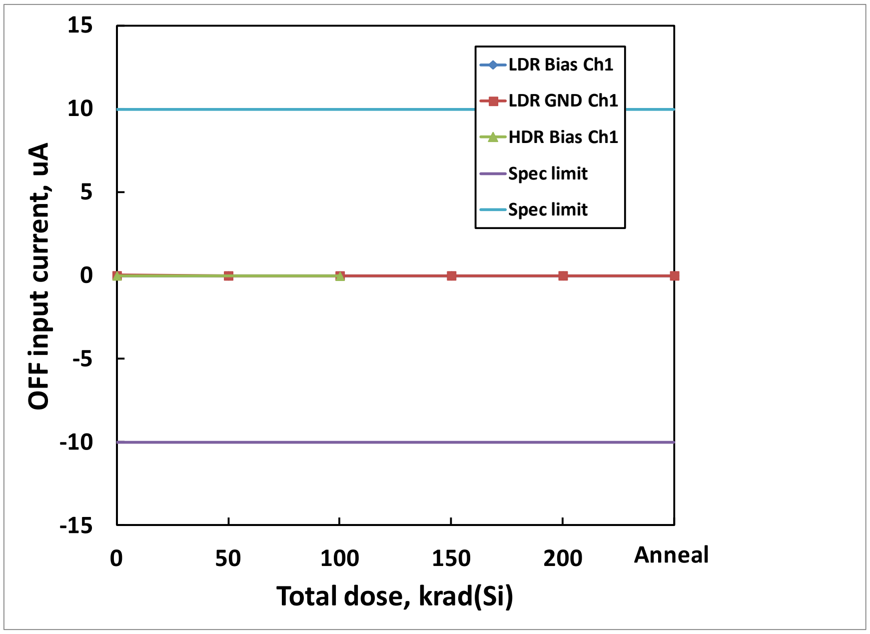

Fig. 6: IS-2981EH OFF input current in µA, channel 1 only, as a function of total dose irradiation at low dose rate for the unbiased (all pins grounded) and the biased cases, both of which were followed by a biased anneal at 100°C for 168 hours, and at high dose rate for the biased case. The low dose rate was 0.01 rad(Si)/s and the high dose rate was 65 rad(Si)/s. Sample size was 4 for each of the low dose rate cells and 8 for the high dose rate cell. The post-irradiation SMD limits are -10.0 µA to +10.0 µA.

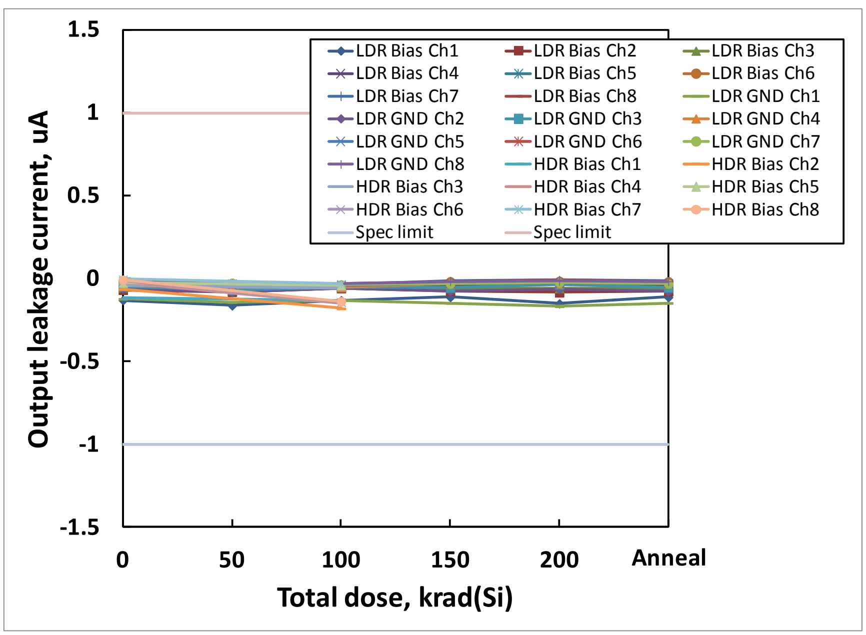

Fig. 7: IS-2981EH output leakage current in µA, all channels, as a function of total dose irradiation at low dose rate for the unbiased (all pins grounded) and the biased cases, both of which were followed by a biased anneal at 100°C for 168 hours, and at high dose rate for the biased case. The low dose rate was 0.01 rad(Si)/s and the high dose rate was 65 rad(Si)/s. Sample size was 4 for each of the low dose rate cells and 8 for the high dose rate cell. The post-irradiation SMD limits are -1.0 µA to +1.0 µA.

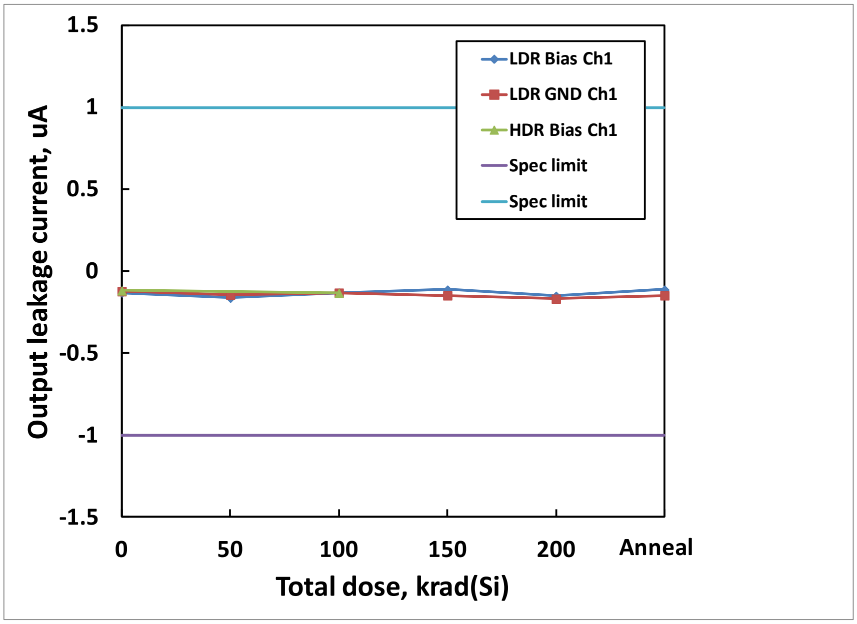

Fig. 8: IS-2981EH output leakage current in µA, channel 1 only, as a function of total dose irradiation at low dose rate for the unbiased (all pins grounded) and the biased cases, both of which were followed by a biased anneal at 100°C for 168 hours, and at high dose rate for the biased case. The low dose rate was 0.01 rad(Si)/s and the high dose rate was 65 rad(Si)/s. Sample size was 4 for each of the low dose rate cells and 8 for the high dose rate cell. The post-irradiation SMD limits are -1.0 µA to +1.0 µA.

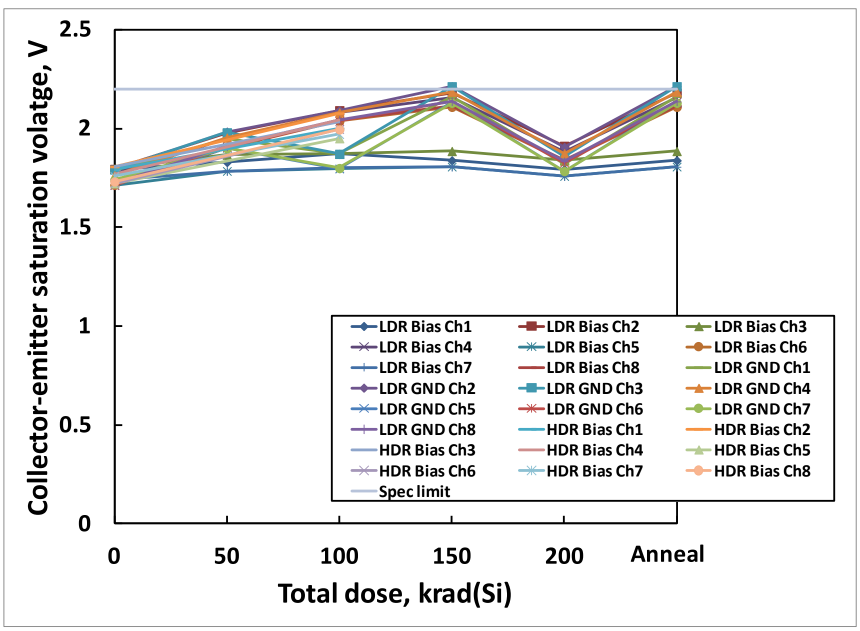

Fig. 9: IS-2981EH output collector-emitter saturation voltage in V, all channels, as a function of total dose irradiation at low dose rate for the unbiased (all pins grounded) and the biased cases, both of which were followed by a biased anneal at 100°C for 168 hours, and at high dose rate for the biased case. The low dose rate was 0.01 rad(Si)/s and the high dose rate was 65 rad(Si)/s. Sample size was 4 for each of the low dose rate cells and 8 for the high dose rate cell. The post-irradiation SMD limit is 2.25 V maximum.

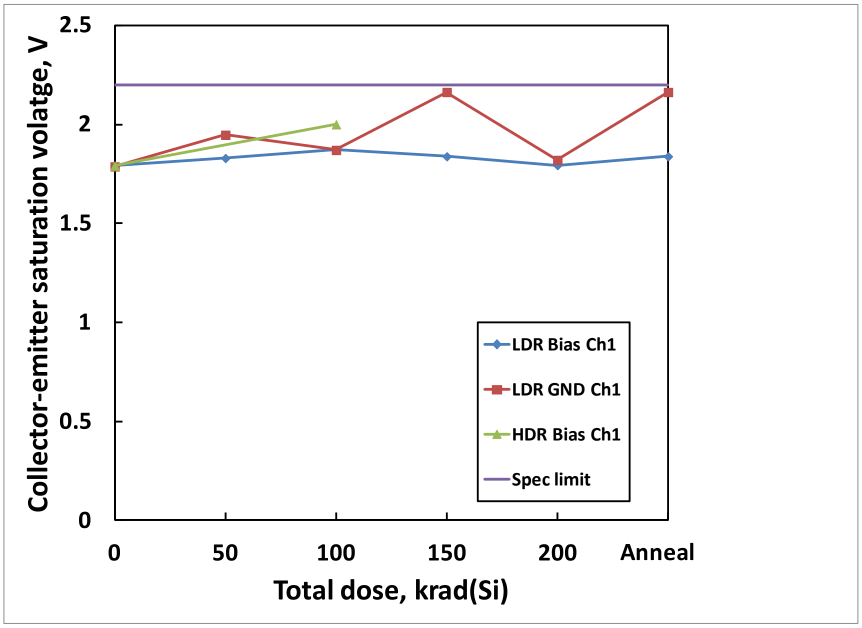

Fig. 10: IS-2981EH output collector-emitter saturation voltage in V, channel 1 only, as a function of total dose irradiation at low dose rate for the unbiased (all pins grounded) and the biased cases, both of which were followed by a biased anneal at 100°C for 168 hours, and at high dose rate for the biased case. The low dose rate was 0.01 rad(Si)/s and the high dose rate was 65 rad(Si)/s. Sample size was 4 for each of the low dose rate cells and 8 for the high dose rate cell. The post-irradiation SMD limit is 2.25 V maximum.

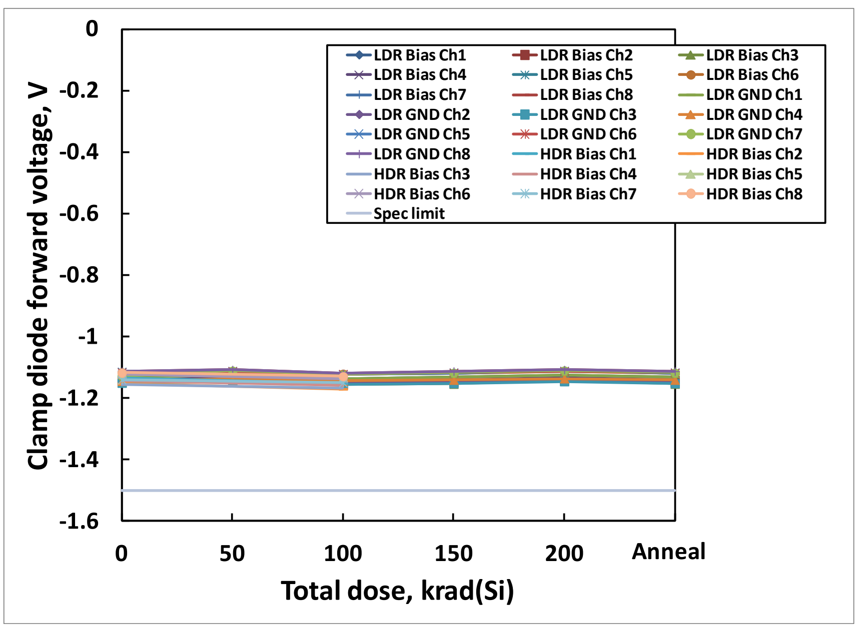

Fig. 11: IS-2981EH clamp diode forward voltage in V, all channels, as a function of total dose irradiation at low dose rate for the unbiased (all pins grounded) and the biased cases, both of which were followed by a biased anneal at 100°C for 168 hours, and at high dose rate for the biased case. The low dose rate was 0.01 rad(Si)/s and the high dose rate was 65 rad(Si)/s. Sample size was 4 for each of the low dose rate cells and 8 for the high dose rate cell. The post-irradiation SMD limit is -1.5 V maximum.

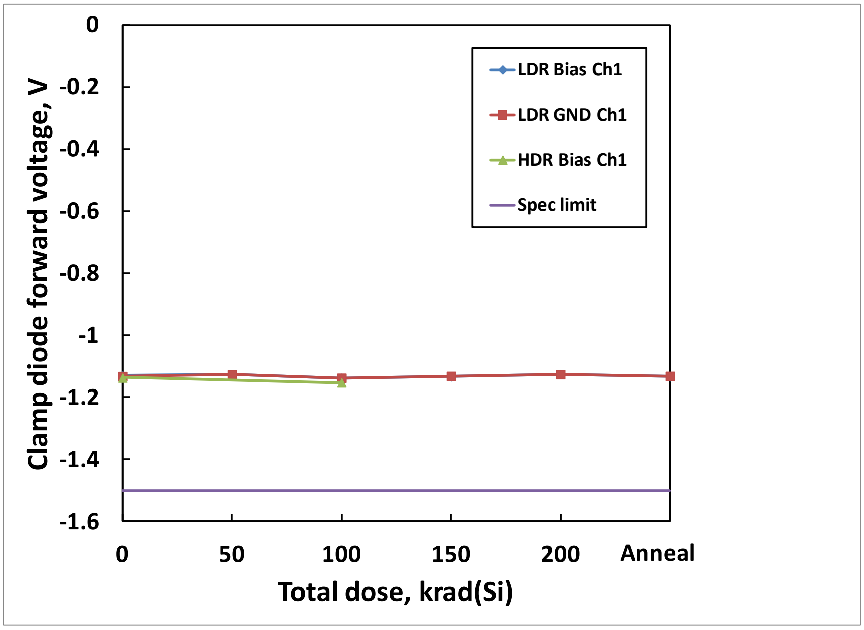

Fig. 12: IS-2981EH clamp diode forward voltage in V, channel 1 only, as a function of total dose irradiation at low dose rate for the unbiased (all pins grounded) and the biased cases, both of which were followed by a biased anneal at 100^{o}C for 168 hours, and at high dose rate for the biased case. The low dose rate was 0.01 rad(Si)/s and the high dose rate was 65 rad(Si)/s. Sample size was 4 for each of the low dose rate cells and 8 for the high dose rate cell. The post-irradiation SMD limit is -1.5 V maximum.

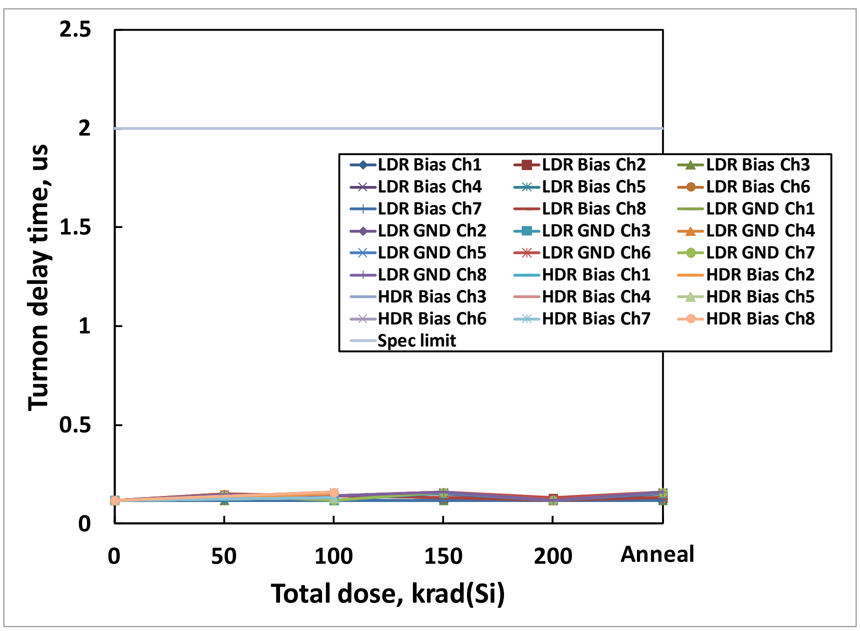

Fig. 13: IS-2981EH turnon delay time in µs, all channels, as a function of total dose irradiation at low dose rate for the unbiased (all pins grounded) and the biased cases, both of which were followed by a biased anneal at 100^{o}C for 168 hours, and at high dose rate for the biased case. The low dose rate was 0.01 rad(Si)/s and the high dose rate was 65 rad(Si)/s. Sample size was 4 for each of the low dose rate cells and 8 for the high dose rate cell. The post-irradiation SMD limit is 2.0 µs maximum.

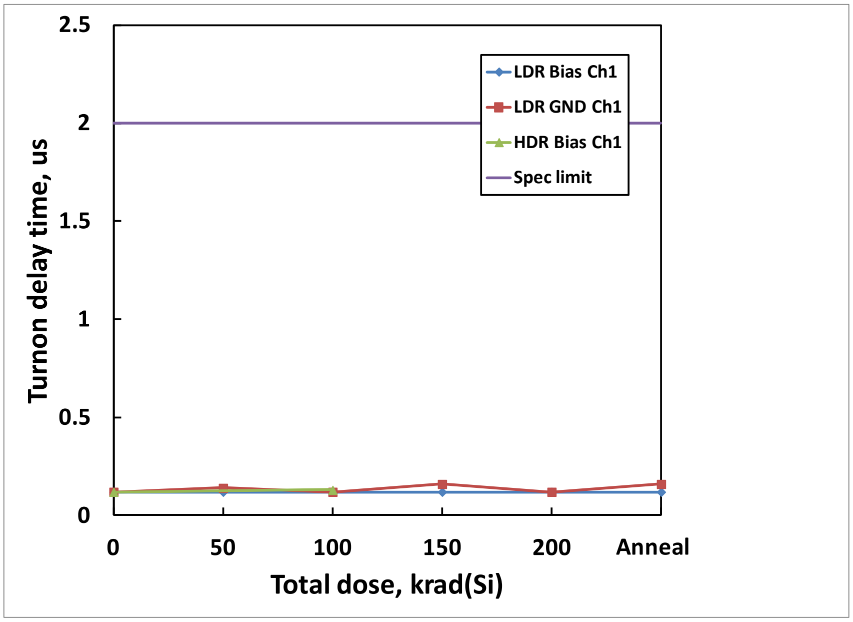

Fig. 14: IS-2981EH turnon delay time in µs, channel 1 only, as a function of total dose irradiation at low dose rate for the unbiased (all pins grounded) and the biased cases, both of which were followed by a biased anneal at 100°C for 168 hours, and at high dose rate for the biased case. The low dose rate was 0.01 rad(Si)/s and the high dose rate was 65 rad(Si)/s. Sample size was 4 for each of the low dose rate cells and 8 for the high dose rate cell. The post-irradiation SMD limit is 2.0 µs maximum.

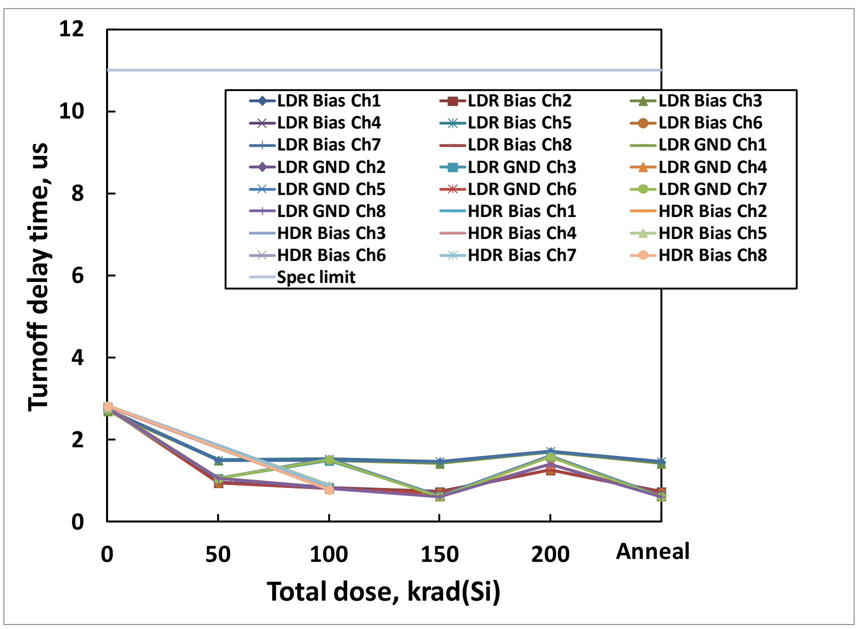

Fig. 15: IS-2981EH turnoff delay time in µs, all channels, as a function of total dose irradiation at low dose rate for the unbiased (all pins grounded) and the biased cases, both of which were followed by a biased anneal at 100°C for 168 hours, and at high dose rate for the biased case. The low dose rate was 0.01 rad(Si)/s and the high dose rate was 65 rad(Si)/s. Sample size was 4 for each of the low dose rate cells and 8 for the high dose rate cell. The post-irradiation SMD limit is 11.0 µs maximum.

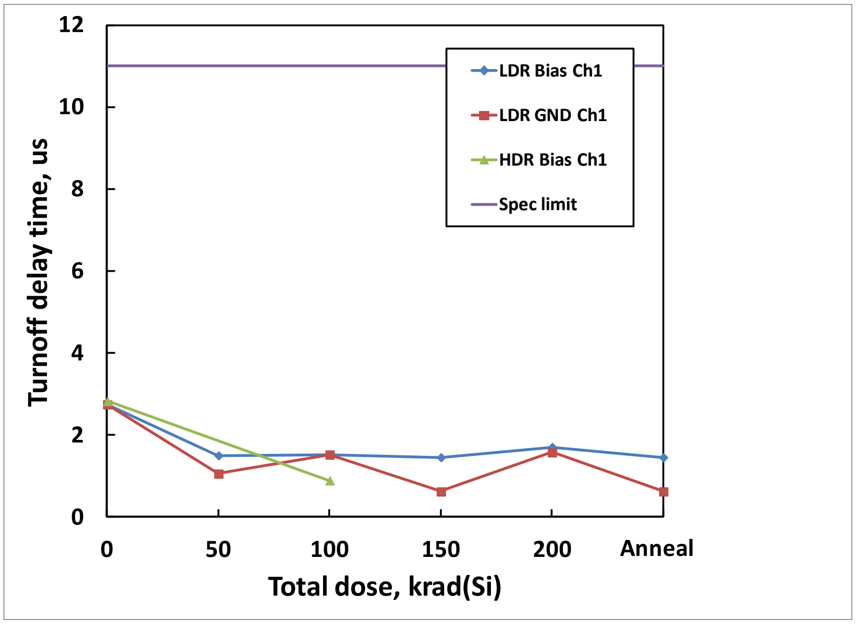

Fig. 16: IS-2981EH turnoff delay time in µs, channel 1 only, as a function of total dose irradiation at low dose rate for the unbiased (all pins grounded) and the biased cases, both of which were followed by a biased anneal at 100^{o}C for 168 hours, and at high dose rate for the biased case. The low dose rate was 0.01 rad(Si)/s and the high dose rate was 65 rad(Si)/s. Sample size was 4 for each of the low dose rate cells and 8 for the high dose rate cell. The post-irradiation SMD limit is 11.0 µs maximum.

6: Conclusion and Discussion

This document reports results of a total dose test of the IS-2981EH octal source driver. Parts were irradiated to 200 krad(Si) at low dose rate under biased and unbiased conditions as outlined in MIL-STD-883 Test Method 1019.7, followed by a 100^{o}C biased anneal for 168 hours. A second set of samples were irradiated to 100 krad(Si) at high dose rate only but omitted the anneal.

All parameters showed good stability at all downpoints. The clamp diode leakage (Figs. 1 and 2) showed little variation and was well below the pre- and post-irradiation SMD limits. The low dose rate and high dose rate responses were identical.

The ON input current (Figs. 3 and 4) and the OFF input current (Figs. 5 and 6) showed little variation and were well below the pre- and post-irradiation SMD limits. The low dose rate and high dose rate responses were identical.

The output leakage current (Figs. 7 and 8) showed little variation and was well below the pre- and post-irradiation SMD limits. The low dose rate and high dose rate responses were identical.

The output collector-emitter saturation voltage (Figs. 9 and 10) showed some increase at both low and high dose rate, followed by a recovery between 150 krad(Si) and 200 krad(Si) at low dose rate and then followed by a degradation over the anneal. There was some channel sensitivity in this behavior, with Channels 1, 3 and 5 remaining stable over biased low dose rate irradiation and not showing an anneal response. The reason for this behavior is unknown. The parameter was near the SMD limit at the 150 krad(Si) downpoint and then again post-anneal; note that the part is rated at 100 krad(Si) and was well within the limit at that downpoint.

The clamp diode forward voltage (Figs. 11 and 12) showed little variation and was well below the pre- and post-irradiation SMD limits.

The turnon delay (Figs. 13 and 14) showed little variation and was well below the pre- and post-irradiation SMD limits.

The turnoff delay (Figs. 15 and 16) showed an initial decrease and then remained stable, remaining well below the pre- and post-irradiation SMD limits.

The part is implemented in the Intersil HVTDLM process, which uses silicon nitride passivation. The IS-2981EH data showed little, if any, low dose rate or bias sensitivity. The data similarly showed very little annealing behaviour introduced by the post low dose rate irradiation anneal, nor did we observe any channel to channel sensitivity. The part is not considered low dose rate sensitive. The output saturation voltage was near the SMD limit at the 150 krad(Si) downpoint and then again post-anneal, but the part is rated at 100 krad(Si) and was well within the limit at that downpoint.

7: Appendices

7.1: Reported parameters, SMD limits and figure numbers.

Fig.	Parameter	Limit, low	Limit, high	Units	Notes
1	Clamp diode leakage	-	50.0	µA	All channels
2	Clamp diode leakage	-	50.0	µA	Channel 1
3	ON input current	-	225.0	µA	All channels
4	ON input current	-	225.0	µA	Channel 1
5	OFF input current	-10.0	10.0	µA	All channels
6	OFF input current	-10.0	10.0	µA	Channel 1
7	Output leakage current	-1.0	1.0	µA	All channels
8	Output leakage current	-1.0	1.0	µA	Channel 1
9	Output collector-emitter saturation voltage	-	2.25	V	All channels
10	Output collector-emitter saturation voltage	-	2.25	V	Channel 1
11	Clamp diode forward voltage	-	-1.5	V	All channels
12	Clamp diode forward voltage	-	-1.5	V	Channel 1
13	Turnon delay time	-	2.0	µs	All channels
14	Turnon delay time	-	2.0	µs	Channel 1
15	Turnoff delay time	-	11.0	µs	All channels
16	Turnoff delay time	-	11.0	µs	Channel 1

Note 1: Limits are taken from Standard Microcircuit Drawing (SMD) 5962-00520.

8: Document revision history

Revision	Date	Pages	Comments
0	January 2014	All	Original issue