

## Introduction

This report documents the results of low rate total dose testing of the [ISL73051ASEH](#) low dropout regulator. The results also include post-irradiation high temperature biased annealing. The tests were conducted to provide an assessment of the total dose hardness of the part and to determine any bias or anneal sensitivity. Parts were irradiated under bias and with all pins grounded to 100krad(Si) followed by high temperature biased anneal. The ISL73051ASEH is rated at 50krad(Si) at low dose rate (0.01rad(Si)/s) and is acceptance tested on a wafer-by-wafer basis to these limits.

## Part Description

The ISL73051ASEH is a radiation hardened low voltage, high current single output Low Dropout (LDO) linear voltage regulator specified for a 3.0A continuous output current. The device operates across an input voltage range of 2.2V to 6.0V and is capable of providing output voltages of 0.8V to 5.0V, with the output voltage adjusted by an external resistor divider network. Dropout voltages as low as 65mV can be achieved.

The OCP pin allows the short-circuit output current limit threshold to be programmed by a resistor from the OCP pin to GND. The OCP setting range is 0.5A minimum to 8.5A maximum. The resistor sets the constant current threshold for the output under fault conditions. The thermal shutdown disables the output if the device temperature exceeds the specified value. It subsequently enters an ON/OFF cycle until the fault is removed. The ENABLE feature allows the part to be placed into a low current shutdown mode that typically draws about 10µA.

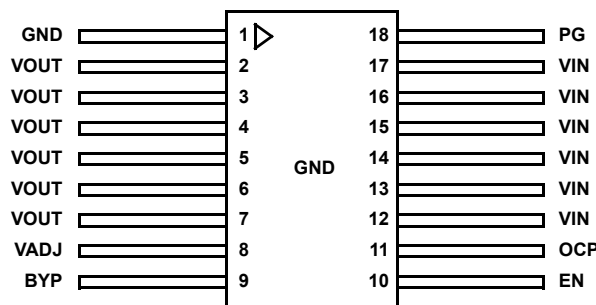
The ISL73051ASEH is implemented in the submicron P6 power management process, with 0.6µm minimum ground rules and three layers of interconnect. Active devices include low voltage CMOS and high voltage DMOS devices in addition to complementary bipolar junction transistors. This process is in volume production under MIL-PRF-38535 certification and is used for a wide range of commercial power management devices.

The ISL73051ASEH pinout configuration is shown in [Figure 1](#), with the pin descriptions shown in [Table 1 on page 2](#). The part is available in an 18 Ld CDFP Package.

## Related Literature

For a full list of related documents, visit our website:

- [ISL73051ASEH](#) product page
- MIL-STD-883 Test Method 1019



Note: The ESD triangular mark indicates Pin #1. It is a part of the device marking and is placed on the lid in the quadrant in which Pin #1 is located.

**Figure 1. ISL73051ASEH Pinout Configuration**

Table 1. ISL73051ASEH Pinout and Pin Descriptions

Pin Number	Pin Name	Description
1	GND	GND pin
2, 3, 4, 5, 6, 7	VOU	Output voltage pins
8	VADJ	Allows $V_{OUT}$ to be programmed with an external resistor divider.
9	BYP	To filter the internal reference, connect a 0.1 $\mu$ F capacitor from the BYP pin to GND.
10	EN	$V_{IN}$ independent chip enable. TTL and CMOS compatible.
11	OCP	Allows the current limit to be programmed with an external resistor.
12, 13, 14, 15, 16, 17	VIN	Input supply pins
18	PG	$V_{OUT}$ in regulation signal. Logic low defines when $V_{OUT}$ is not in regulation. Must be grounded if not used.
Top Lid	GND	The top lid is connected to the GND pin of the package.
Bottom Metal	-	The bottom E-pad is available on the K18.E package only and is not electrically connected.

## 1. Test Description

### 1.1 Irradiation Facilities

Low Dose Rate (LDR) testing was performed at 0.01rad(Si)/s using the Renesas Palm Bay Hopewell Designs N40 panoramic irradiator. A PbAl spectrum hardening filter was used to shield the test board and devices under test against low energy secondary gamma radiation. Half of the samples were irradiated under bias and the other half were grounded during irradiation. Both sets of samples underwent post-irradiation anneal at +100°C for 168 hours in a small temperature chamber.

### 1.2 Test Fixturing

Figure 2 shows the configuration used for biased irradiation. Note that the part is biased at 6.0V.

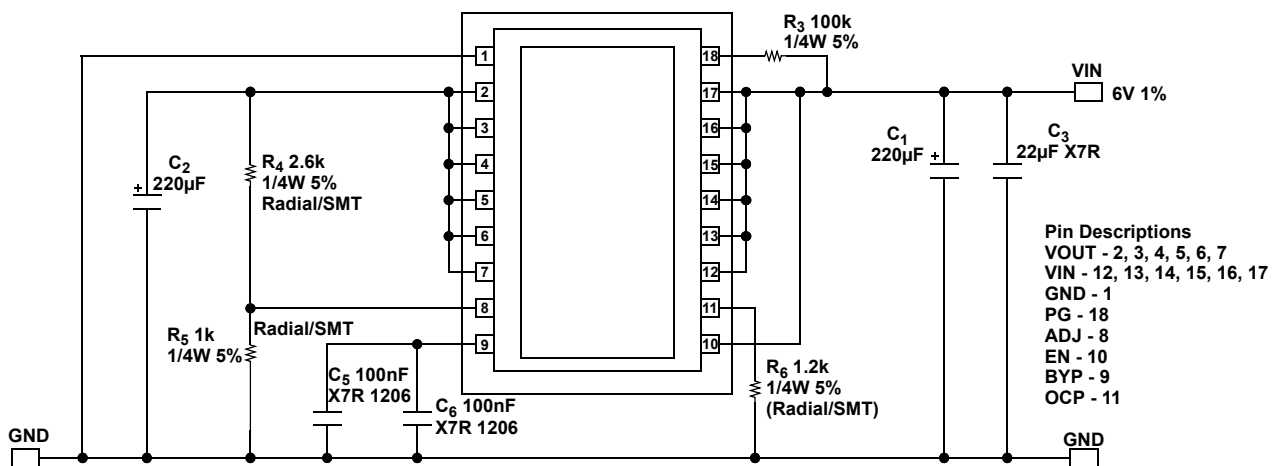


Figure 2. ISL73051ASEH TID Bias Schematic

### 1.3 Characterization Equipment and Procedures

All electrical testing was performed at room temperature outside the irradiator, using production Automated Test Equipment (ATE) with data-logging at each downpoint.

## 1.4 Experimental Matrix

Irradiation was performed in accordance with the guidelines of MIL-STD-883 Test Method 1019. The experimental matrix consisted of 24 samples irradiated under bias and 24 samples irradiated with all pins grounded. All anneal samples were biased. Due to oven size limitations, only 24 samples could be annealed at a time, so 12 biased samples and 12 unbiased samples were randomly chosen for the biased anneal. Three control units were used.

The ISL73051ASEH samples were from wafer lot 1JLUB. All samples were packaged in the 18 Ld ceramic flatpack package (package code K18.D). Samples were processed through the standard burn-in cycle before irradiation.

## 1.5 Downpoints

Downpoints for the LDR tests were 0, 10, 30, 50, 75, and 100krad(Si), followed by a 168 hour high temperature anneal at +100°C under bias.

## 2. Test Results

### 2.1 Attributes Data

Total dose testing of the ISL73051ASEH is complete. All tested parameters passed the SMD limits. [Table 2](#) summarizes the results.

**Table 2. ISL73051ASEH Total Dose Test Attributes Data**

Dose Rate (rad(Si)/s)	Bias	Sample Size	Downpoint	Pass ( <a href="#">Note 1</a> )	Fail
0.01	Biased ( <a href="#">Figure 2</a> )	24	Pre-irradiation	24	
			10krad(Si)	24	0
			30krad(Si)	24	0
			50krad(Si)	24	0
			75krad(Si)	24	0
			100krad(Si)	24	0
			Anneal	12	0
0.01	Gnd	24	Pre-irradiation	24	
			10krad(Si)	24	0
			30krad(Si)	24	0
			50krad(Si)	24	0
			75krad(Si)	24	0
			100krad(Si)	24	0
			Anneal	12	0

Note:

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

## 2.2 Key Parameter Listing

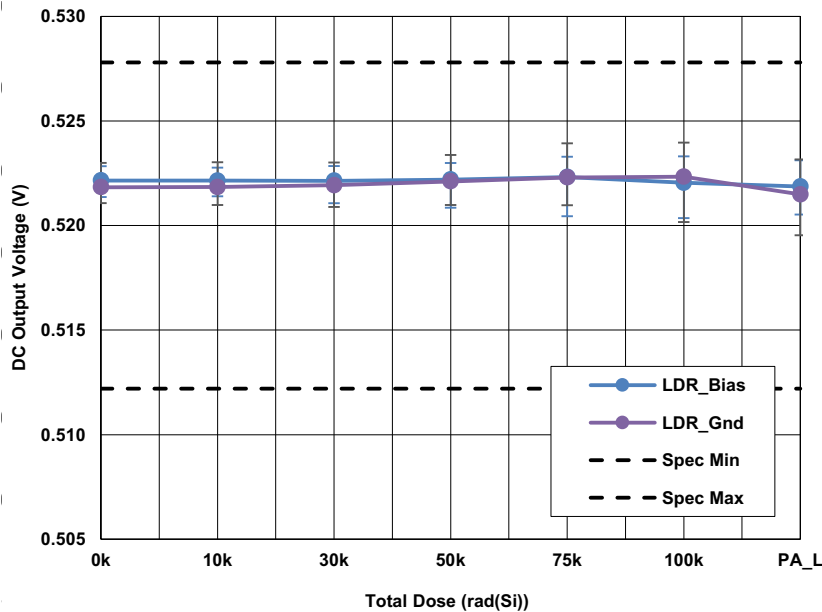
Table 3 lists 35 key selected parameters that are considered indicative of part performance. These parameters are plotted in Figures 3 through 37. All limits are taken from the ISL73051ASEH SMD; refer to SMD 5962-11212 for further details.

Table 3. ISL73051A SMD Total Dose Key SMD Parameters ( $T_A = +25^\circ\text{C}$ )

Figure	Parameter	Symbol	Limit, Low	Limit, High	Unit
<a href="#">3</a>	DC output voltage accuracy, 0.52V output, 2.2V input, no load	$V_{OUT}$	0.512	0.528	V
<a href="#">4</a>	DC output voltage accuracy, 0.52V output, 2.2V input, 3A load	$V_{OUT}$	0.512	0.528	V
<a href="#">5</a>	DC output voltage accuracy, 0.52V output, 3.6V input, no load	$V_{OUT}$	0.512	0.528	V
<a href="#">6</a>	DC output voltage accuracy, 0.52V output, 3.6V input, 3A load	$V_{OUT}$	0.512	0.528	V
<a href="#">7</a>	DC output voltage accuracy, 0.52V output, 5.5V input, no load	$V_{OUT}$	0.512	0.528	V
<a href="#">8</a>	DC output voltage accuracy, 1.5V output, 2.2V input, no load	$V_{OUT}$	1.478	1.522	V
<a href="#">9</a>	DC output voltage accuracy, 1.5V output, 2.2V input, 3A load	$V_{OUT}$	1.478	1.522	V
<a href="#">10</a>	DC output voltage accuracy, 1.5V output, 3.6V input, no load	$V_{OUT}$	1.478	1.522	V
<a href="#">11</a>	DC output voltage accuracy, 1.5V output, 3.6V input, 3A load	$V_{OUT}$	1.478	1.522	V
<a href="#">12</a>	DC output voltage accuracy, 1.5V output, 5.5V input, no load	$V_{OUT}$	1.478	1.522	V
<a href="#">13</a>	DC output voltage accuracy, 1.8V output, 2.2V input, no load	$V_{OUT}$	1.773	1.827	V
<a href="#">14</a>	DC output voltage accuracy, 1.8V output, 2.2V input, 3A load	$V_{OUT}$	1.773	1.827	V
<a href="#">15</a>	DC output voltage accuracy, 1.8V output, 3.6V input, no load	$V_{OUT}$	1.773	1.827	V
<a href="#">16</a>	DC output voltage accuracy, 1.8V output, 3.6V input, 3A load	$V_{OUT}$	1.773	1.827	V
<a href="#">17</a>	DC output voltage accuracy, 1.8V output, 5.5V input, no load	$V_{OUT}$	1.773	1.827	V
<a href="#">18</a>	DC output voltage accuracy, 5.0V output, 5.4V input, no load	$V_{OUT}$	4.925	5.075	V
<a href="#">19</a>	DC output voltage accuracy, 5.0V output, 5.4V input, 3A load	$V_{OUT}$	4.925	5.075	V
<a href="#">20</a>	DC output voltage accuracy, 5.0V output, 6.0V input, no load	$V_{OUT}$	4.925	5.075	V
<a href="#">21</a>	DC output voltage accuracy, 5.0V output, 6.0V input, 3A load	$V_{OUT}$	4.925	5.075	V
<a href="#">22</a>	Feedback pin, 1.5V output, 2.2V input, no load	$V_{ADJ}$	514.8	525.2	mV
<a href="#">23</a>	Feedback pin, 1.5V output, 6.0V input, no load	$V_{ADJ}$	514.8	525.2	mV
<a href="#">24</a>	DC input line regulation, 1.5V output			3.50	mV
<a href="#">25</a>	DC input line regulation, 1.8V output			3.50	mV
<a href="#">26</a>	DC input line regulation, 5.0V output			20.0	mV
<a href="#">27</a>	DC output load regulation, 1.5V output		-4.00	-0.10	mV
<a href="#">28</a>	DC output load regulation, 1.8V output		-4.80	-0.05	mV
<a href="#">29</a>	DC output load regulation, 5.0V output		-15.0	-0.05	mV
<a href="#">30</a>	Feedback input current, $V_{ADJ} = 0.5\text{V}$			1.00	$\mu\text{V}$
<a href="#">31</a>	Ground pin current, 1.5V output, 2.2V input, no load	$I_Q$		13.0	mA
<a href="#">32</a>	Ground pin current, 5.0V output, 6.0V input, no load	$I_Q$		19.0	mA
<a href="#">33</a>	Ground pin current, 1.5V output, 2.2V input, 3A load	$I_Q$		14.0	mA
<a href="#">34</a>	Ground pin current, 5.0V output, 6.0V input, 3A load	$I_Q$		20.0	mA
<a href="#">35</a>	Dropout voltage, 2.5V output, 1A load	$V_{DO}$		100	mV
<a href="#">36</a>	Dropout voltage, 2.5V output, 2A load	$V_{DO}$		200	mV
<a href="#">37</a>	Dropout voltage, 2.5V output, 3A load	$V_{DO}$		300	mV

### 2.3 Key Parameter Variables Data

The plots in [Figures 3](#) through [37](#) illustrate the Total Ionizing Dose (TID) response of key selected SMD parameters outlined in [“Key Parameter Listing”](#) on [page 4](#). The plots show the average tested values of the parameters as a function of total dose and high temperature biased anneal for each of the irradiation conditions, biased and grounded. For example, the legend LDR\_Bias indicates the average LDR response for biased parts. On the x-axis, along with the total dose, PA\_L represents the Post-Anneal LDR points. The plots also include error bars at each datapoint, representing the minimum and maximum measured values of the samples, although in some plots the error bars might not be visible due to their values compared to the scale of the graph.



**Figure 3.** ISL73051ASEH DC output voltage accuracy (VOUT), 0.52V output, 2.2V input, no load, as a function of total dose irradiation at LDR for biased and grounded configurations and subsequent high temperature anneal. The error bars represent the minimum and maximum measured values. The post-irradiation SMD limits are 0.512V minimum and 0.528V maximum.

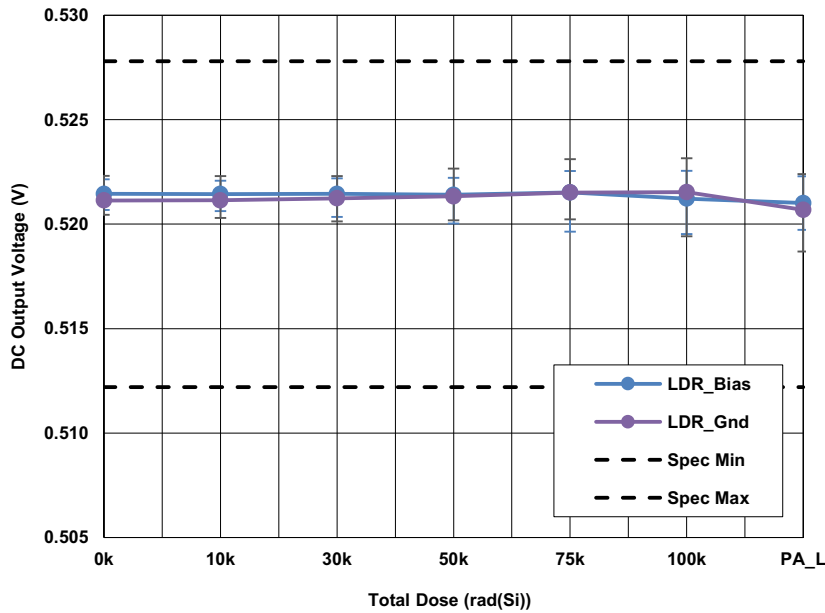


Figure 4. ISL73051ASEH DC output voltage accuracy ( $V_{OUT}$ ), 0.52V output, 2.2V input, 3A load, as a function of total dose irradiation at LDR for biased and grounded configurations and subsequent high temperature anneal. The error bars represent the minimum and maximum measured values. The post-irradiation SMD limits are 0.512V minimum and 0.528V maximum.

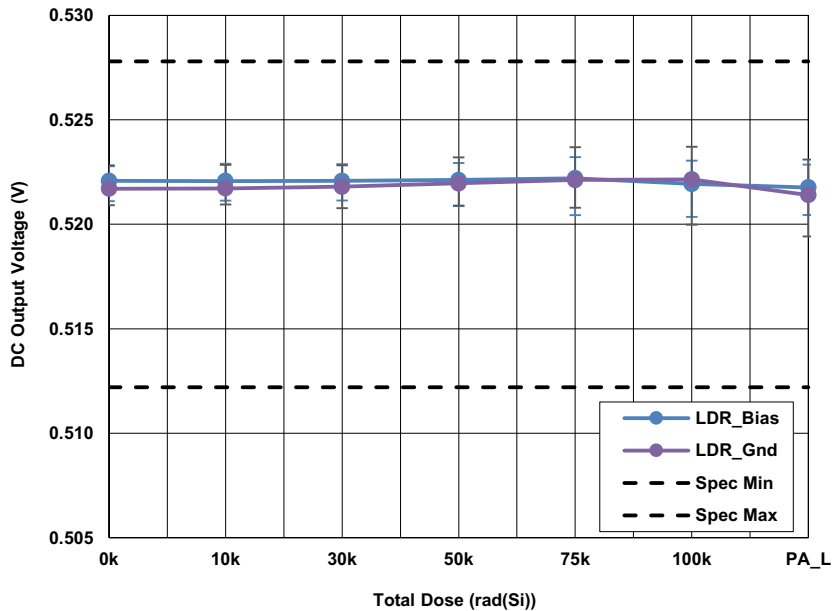


Figure 5. ISL73051ASEH DC output voltage accuracy ( $V_{OUT}$ ), 0.52V output, 3.6V input, no load, as a function of total dose irradiation at LDR for biased and grounded configurations and subsequent high temperature anneal. The error bars represent the minimum and maximum measured values. The post-irradiation SMD limits are 0.512V minimum and 0.528V maximum.

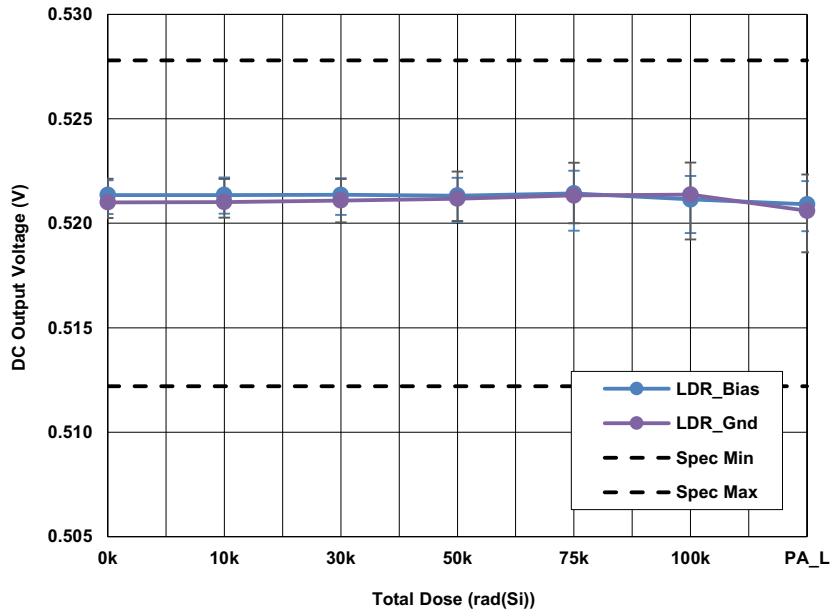


Figure 6. ISL73051ASEH DC output voltage accuracy ( $V_{OUT}$ ), 0.52V output, 3.6V input, 3A load, as a function of total dose irradiation at LDR for biased and grounded configurations and subsequent high temperature anneal. The error bars represent the minimum and maximum measured values. The post-irradiation SMD limits are 0.512V minimum and 0.528V maximum.

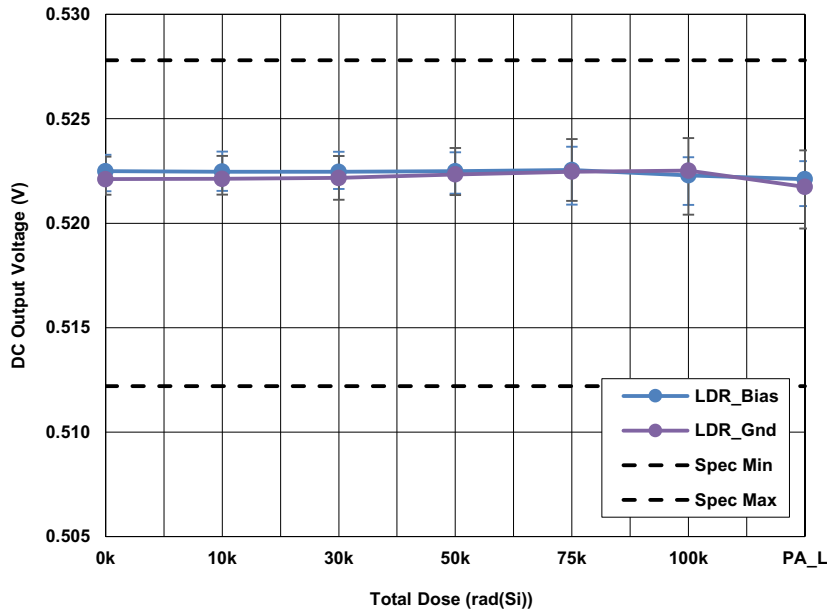


Figure 7. ISL73051ASEH DC output voltage accuracy ( $V_{OUT}$ ), 0.52V output, 5.5V input, no load, as a function of total dose irradiation at LDR for biased and grounded configurations and subsequent high temperature anneal. The error bars represent the minimum and maximum measured values. The post-irradiation SMD limits are 0.512V minimum and 0.528V maximum.

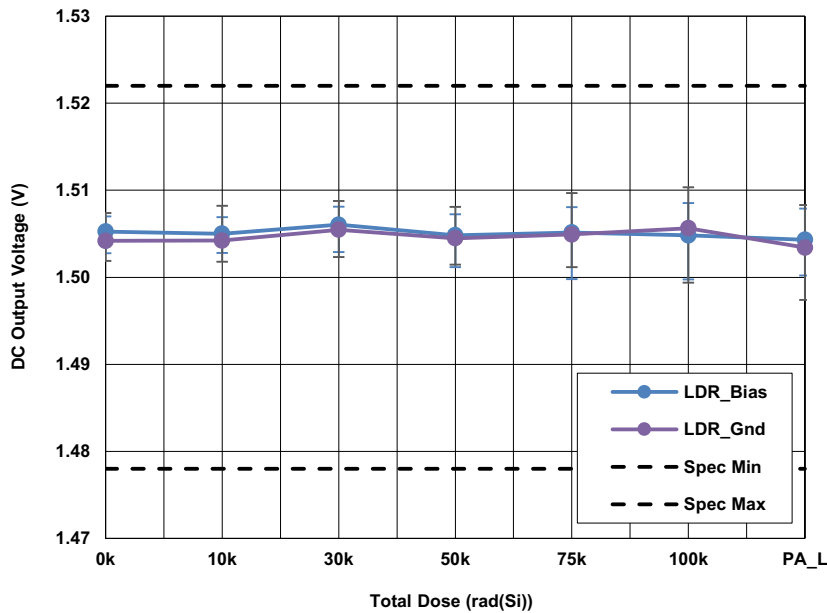


Figure 8. ISL73051ASEH DC output voltage accuracy ( $V_{OUT}$ ), 1.5V output, 2.2V input, no load, as a function of total dose irradiation at LDR for biased and grounded configurations and subsequent high temperature anneal. The error bars represent the minimum and maximum measured values. The post-irradiation SMD limits are 1.478V minimum and 1.522V maximum.

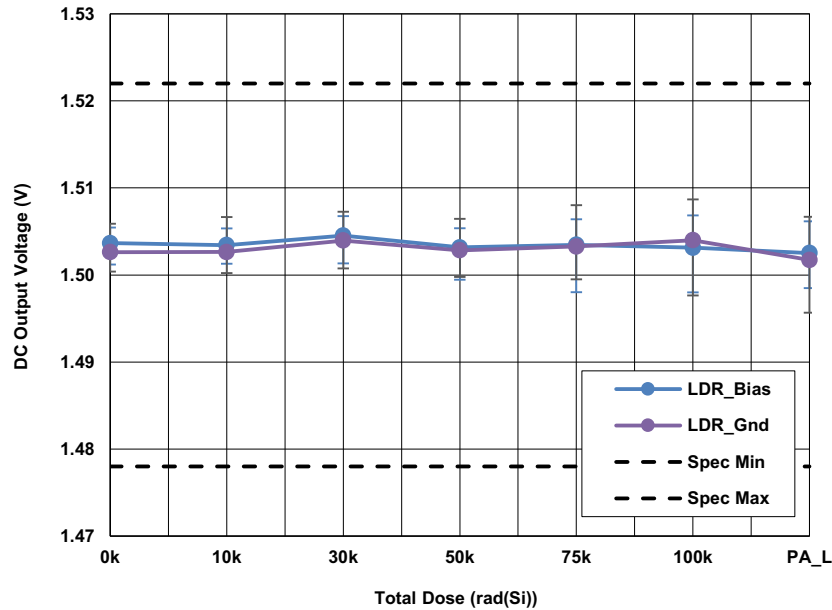


Figure 9. ISL73051ASEH DC output voltage accuracy ( $V_{OUT}$ ), 1.5V output, 2.2V input, 3A load, as a function of total dose irradiation at LDR for biased and grounded configurations and subsequent high temperature anneal. The error bars represent the minimum and maximum measured values. The post-irradiation SMD limits are 1.478V minimum and 1.522V maximum.



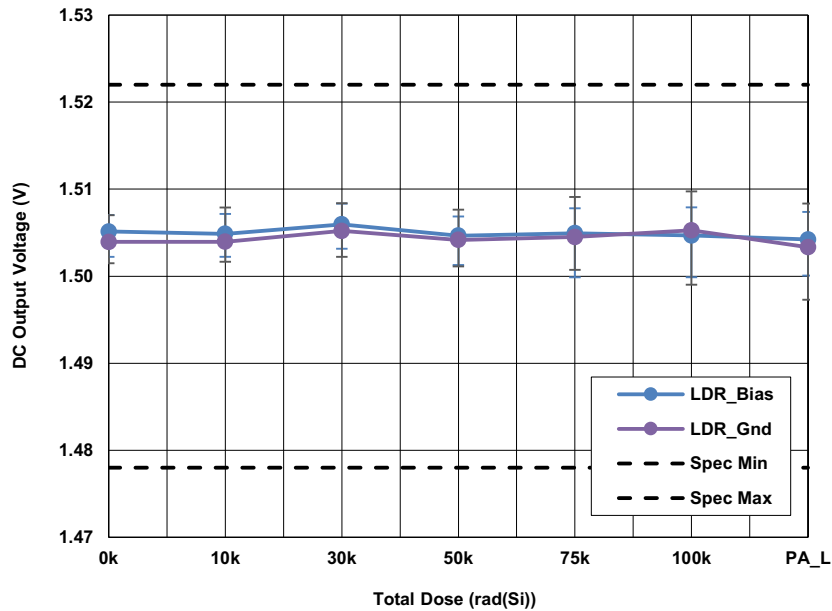


Figure 10. ISL73051ASEH DC output voltage accuracy ( $V_{OUT}$ ), 1.5V output, 3.6V input, no load, as a function of total dose irradiation at LDR for biased and grounded configurations and subsequent high temperature anneal. The error bars represent the minimum and maximum measured values. The post-irradiation SMD limits are 1.478V minimum and 1.522V maximum.

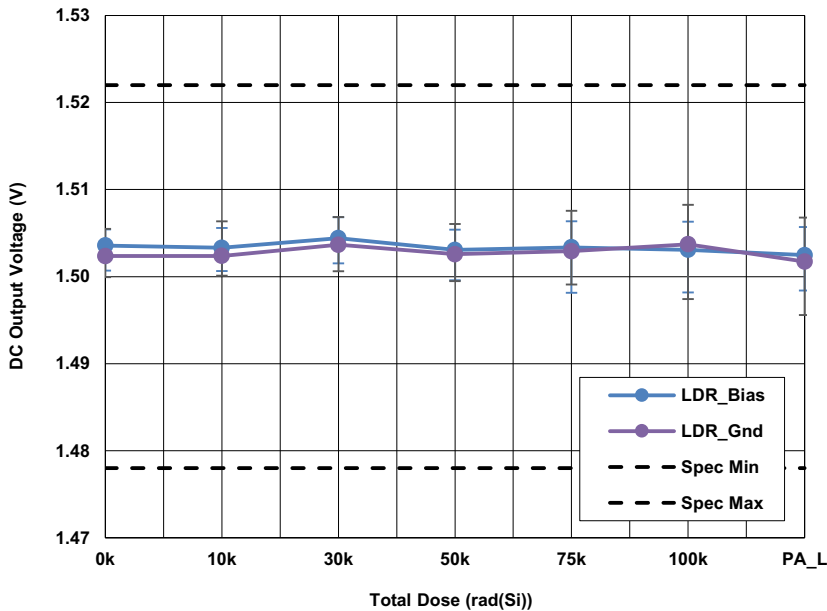


Figure 11. ISL73051ASEH DC output voltage accuracy ( $V_{OUT}$ ), 1.5V output, 3.6V input, 3A load, as a function of total dose irradiation at LDR for biased and grounded configurations and subsequent high temperature anneal. The error bars represent the minimum and maximum measured values. The post-irradiation SMD limits are 1.478V minimum and 1.522V maximum.

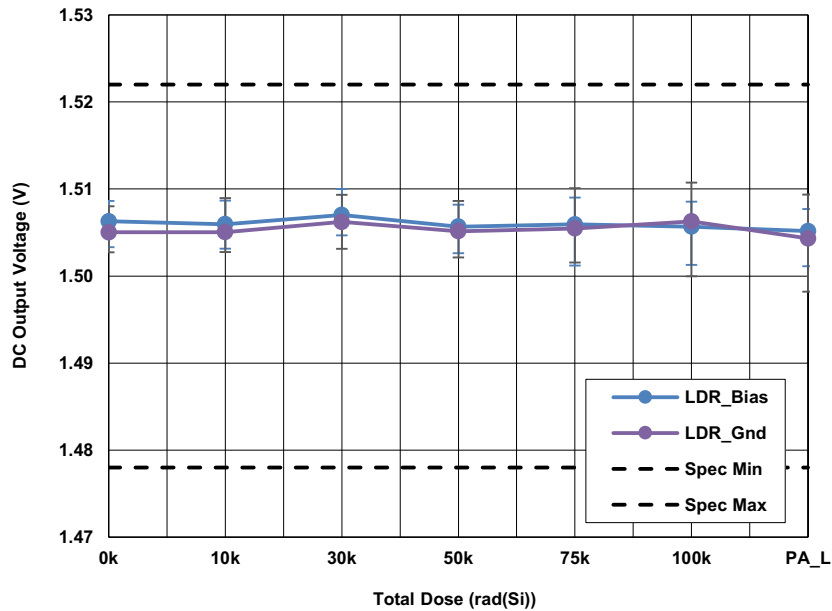


Figure 12. ISL73051ASEH DC output voltage accuracy ( $V_{OUT}$ ), 1.5V output, 5.5V input, no load, as a function of total dose irradiation at LDR for biased and grounded configurations and subsequent high temperature anneal. The error bars represent the minimum and maximum measured values. The post-irradiation SMD limits are 1.478V minimum and 1.522V maximum.

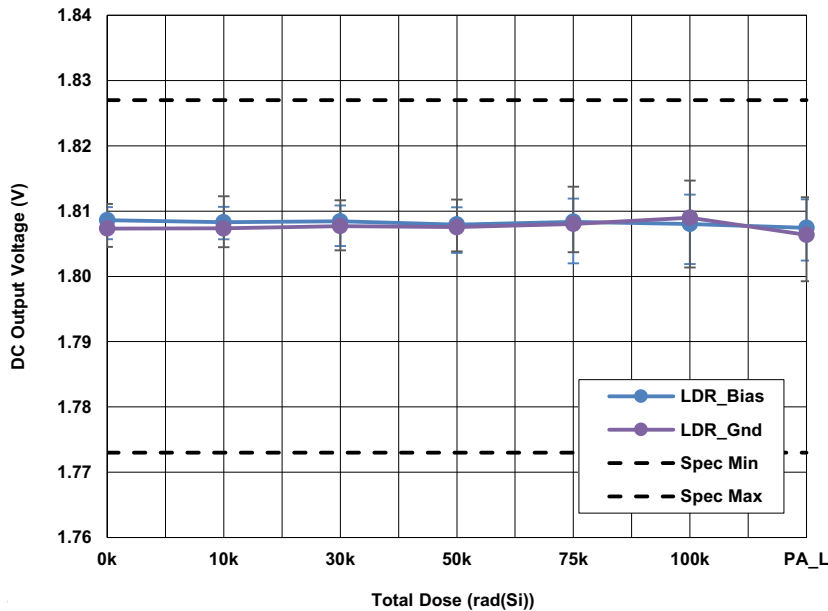


Figure 13. ISL73051ASEH DC output voltage accuracy ( $V_{OUT}$ ), 1.8V output, 2.2V input, no load, as a function of total dose irradiation at LDR for biased and grounded configurations and subsequent high temperature anneal. The error bars represent the minimum and maximum measured values. The post-irradiation SMD limits are 1.773V minimum and 1.827V maximum.

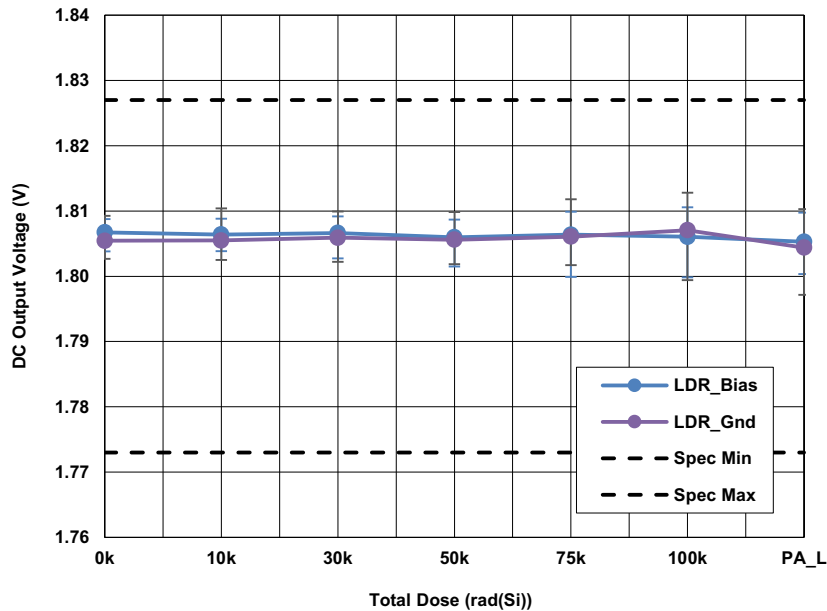


Figure 14. ISL73051ASEH DC output voltage accuracy ( $V_{OUT}$ ), 1.8V output, 2.2V input, 3A load, as a function of total dose irradiation at LDR for biased and grounded configurations and subsequent high temperature anneal. The error bars represent the minimum and maximum measured values. The post-irradiation SMD limits are 1.773V minimum and 1.827V maximum.

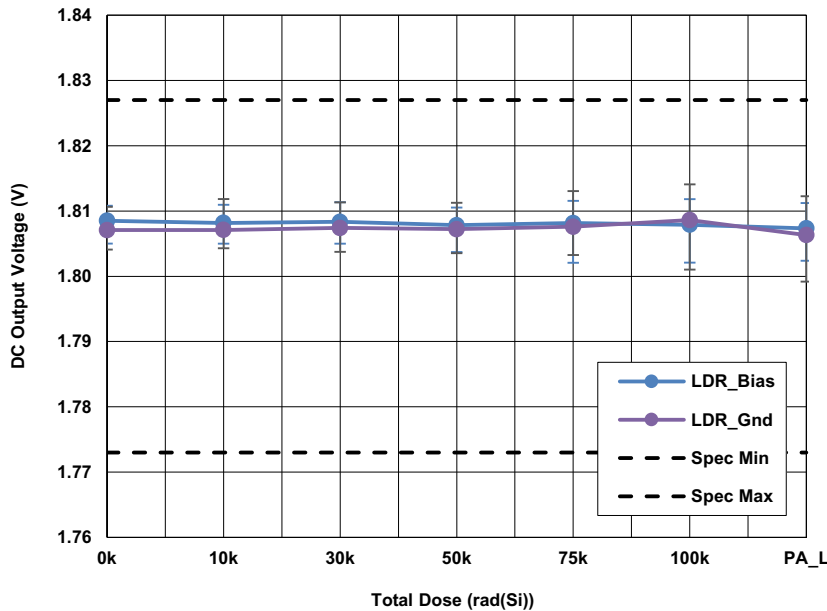


Figure 15. ISL73051ASEH DC output voltage accuracy ( $V_{OUT}$ ), 1.8V output, 3.6V input, no load, as a function of total dose irradiation at LDR for biased and grounded configurations and subsequent high temperature anneal. The error bars represent the minimum and maximum measured values. The post-irradiation SMD limits are 1.773V minimum and 1.827V maximum.

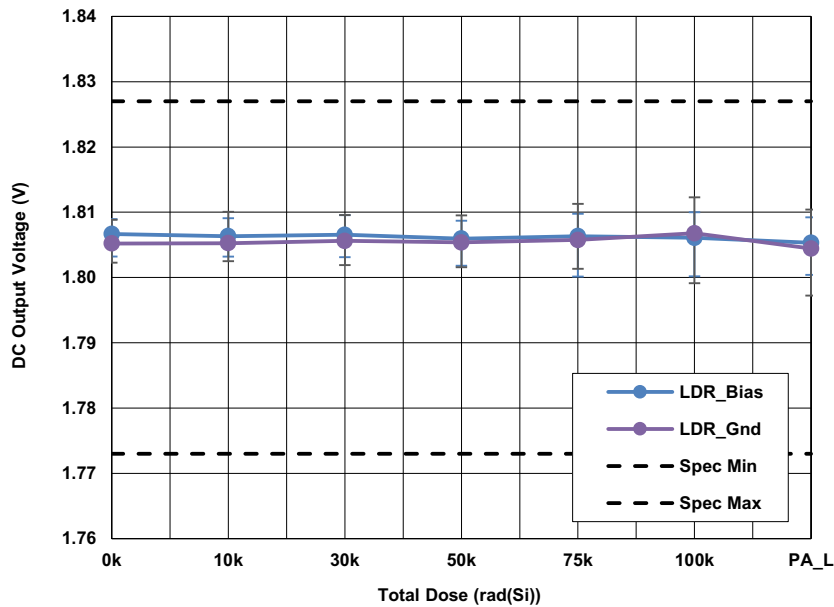


Figure 16. ISL73051ASEH DC output voltage accuracy ( $V_{OUT}$ ), 1.8V output, 3.6V input, 3A load, as a function of total dose irradiation at LDR for biased and grounded configurations and subsequent high temperature anneal. The error bars represent the minimum and maximum measured values. The post-irradiation SMD limits are 1.773V minimum and 1.827V maximum.

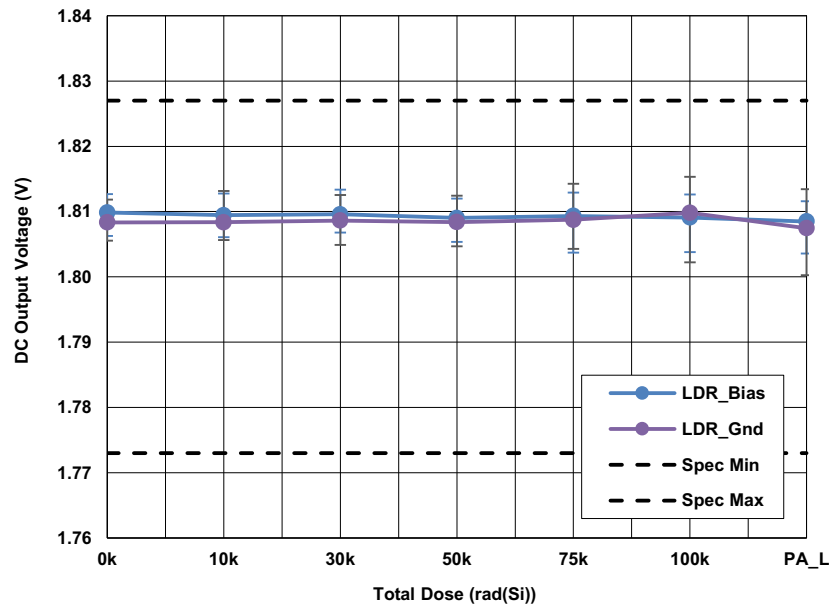


Figure 17. ISL73051ASEH DC output voltage accuracy ( $V_{OUT}$ ), 1.8V output, 5.5V input, no load, as a function of total dose irradiation at LDR for biased and grounded configurations and subsequent high temperature anneal. The error bars represent the minimum and maximum measured values. The post-irradiation SMD limits are 1.773V minimum and 1.827V maximum.

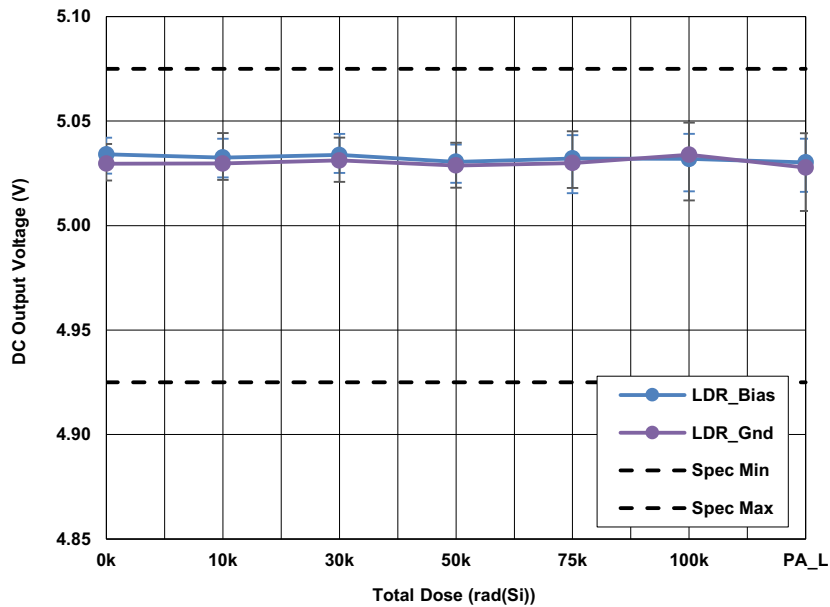


Figure 18. ISL73051ASEH DC output voltage accuracy ( $V_{OUT}$ ), 5.0V output, 5.4V input, no load, as a function of total dose irradiation at LDR for biased and grounded configurations and subsequent high temperature anneal. The error bars represent the minimum and maximum measured values. The post-irradiation SMD limits are 4.925V minimum and 5.075V maximum.

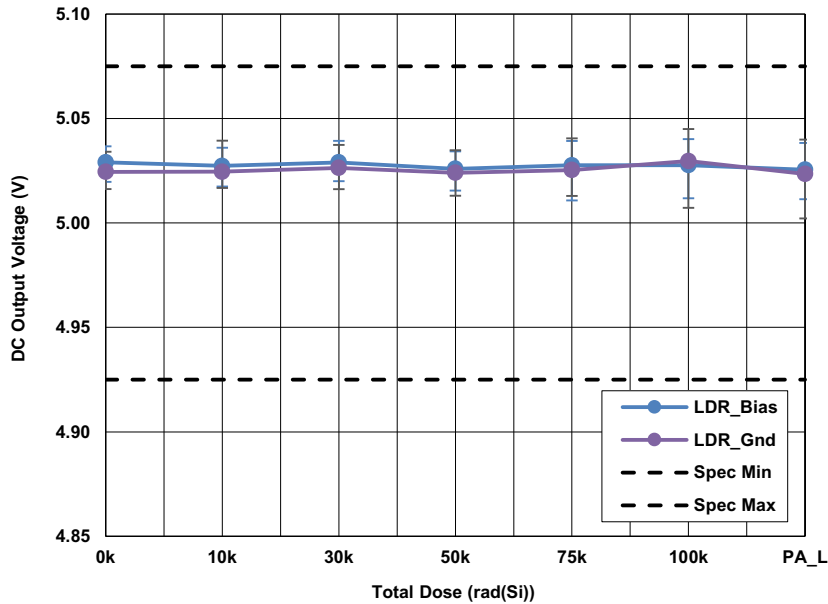


Figure 19. ISL73051ASEH DC output voltage accuracy ( $V_{OUT}$ ), 5.0V output, 5.4V input, 3A load, as a function of total dose irradiation at LDR for biased and grounded configurations and subsequent high temperature anneal. The error bars represent the minimum and maximum measured values. The post-irradiation SMD limits are 4.925V minimum and 5.075V maximum.

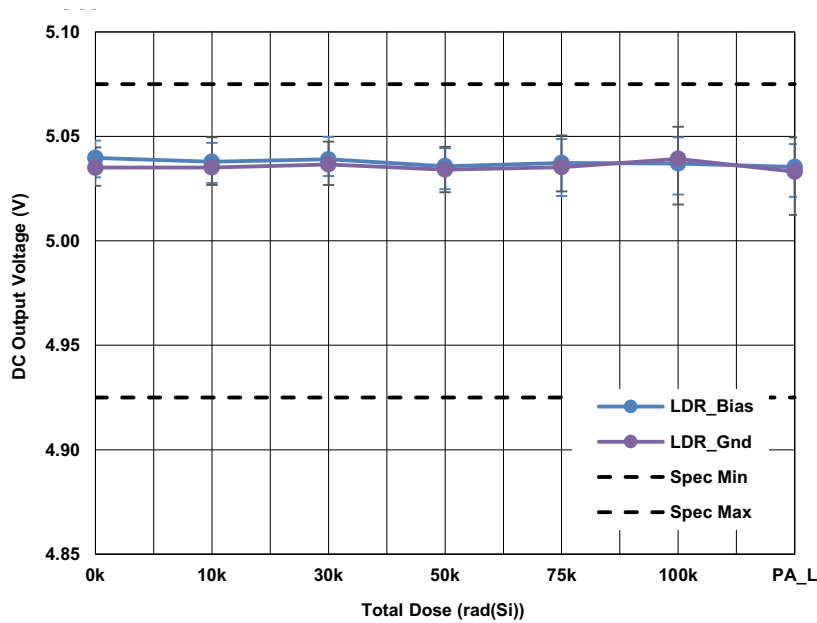


Figure 20. ISL73051ASEH DC output voltage accuracy ( $V_{OUT}$ ), 5.0V output, 6.0V input, no load, as a function of total dose irradiation at LDR for biased and grounded configurations and subsequent high temperature anneal. The error bars represent the minimum and maximum measured values. The post-irradiation SMD limits are 4.925V minimum and 5.075V maximum.

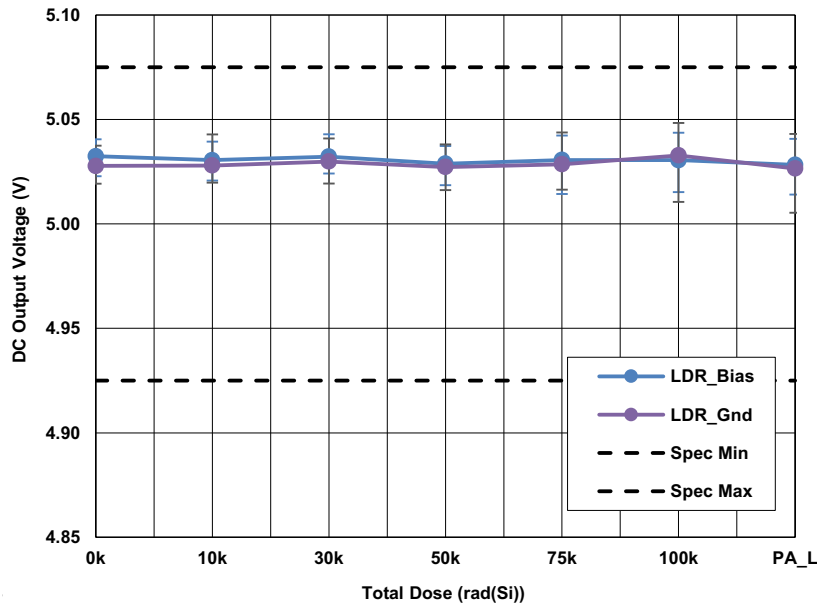


Figure 21. ISL73051ASEH DC output voltage accuracy ( $V_{OUT}$ ), 5.0V output, 6.0V input, 3A load, as a function of total dose irradiation at LDR for biased and grounded configurations and subsequent high temperature anneal. The error bars represent the minimum and maximum measured values. The post-irradiation SMD limits are 4.925V minimum and 5.075V maximum.

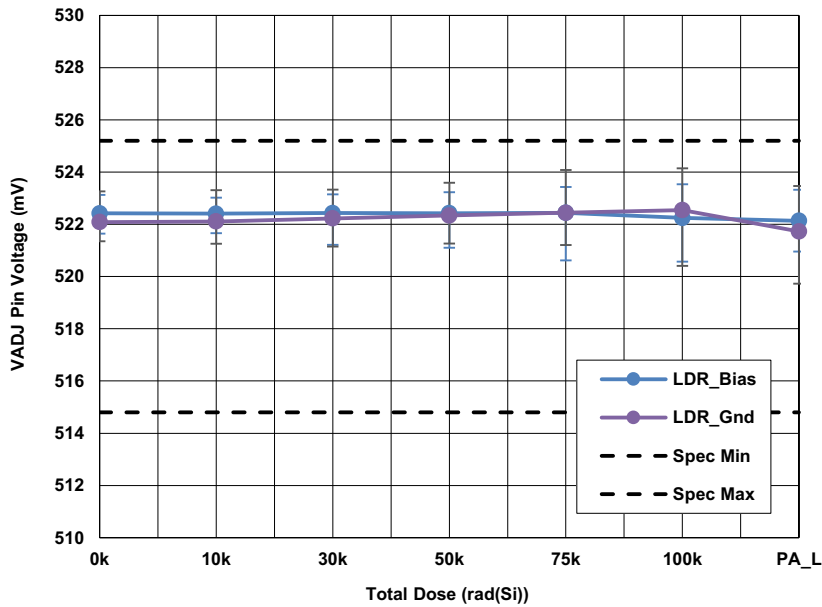


Figure 22. ISL73051ASEH feedback pin ( $V_{ADJ}$ ), 1.5V output, 2.2V input, no load, as a function of total dose irradiation at LDR for biased and grounded configurations and subsequent high temperature anneal. The error bars represent the minimum and maximum measured values. The post-irradiation SMD limits are 514.8mV minimum and 525.2mV maximum.

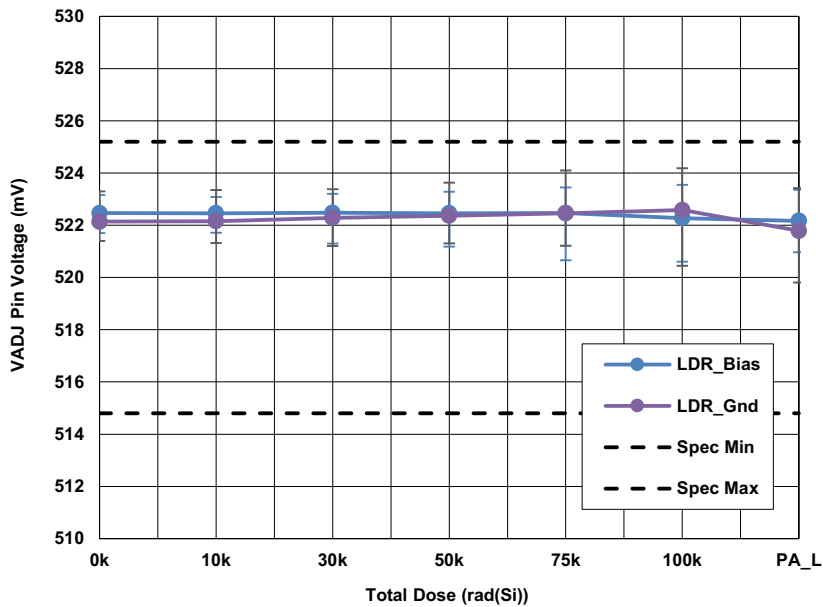


Figure 23. ISL73051ASEH feedback pin ( $V_{ADJ}$ ), 1.5V output, 6.0V input, no load, as a function of total dose irradiation at LDR for biased and grounded configurations and subsequent high temperature anneal. The error bars represent the minimum and maximum measured values. The post-irradiation SMD limits are 514.8mV minimum and 525.2mV maximum.

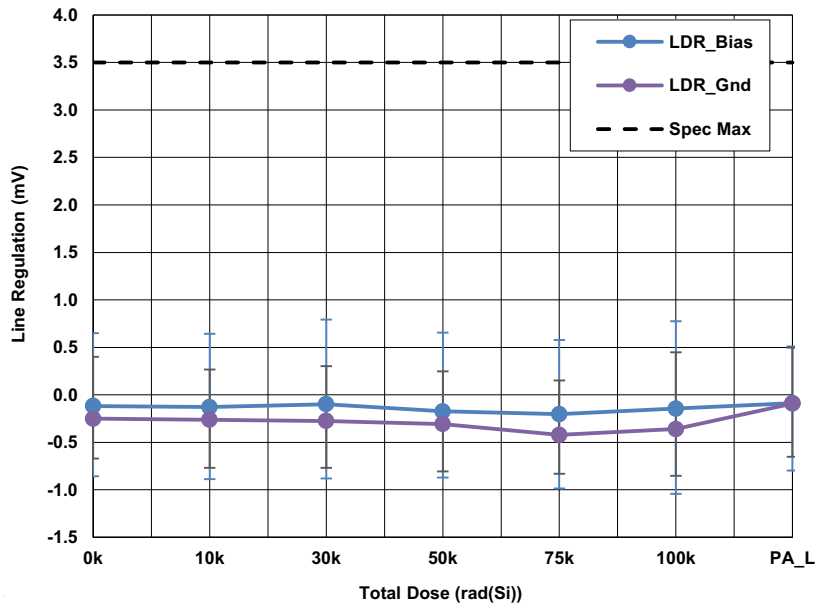


Figure 24. ISL73051ASEH DC input line regulation, 1.5V output, as a function of total dose irradiation at LDR for biased and grounded configurations and subsequent high temperature anneal. The error bars represent the minimum and maximum measured values. The post-irradiation SMD limit is 3.5mV maximum.

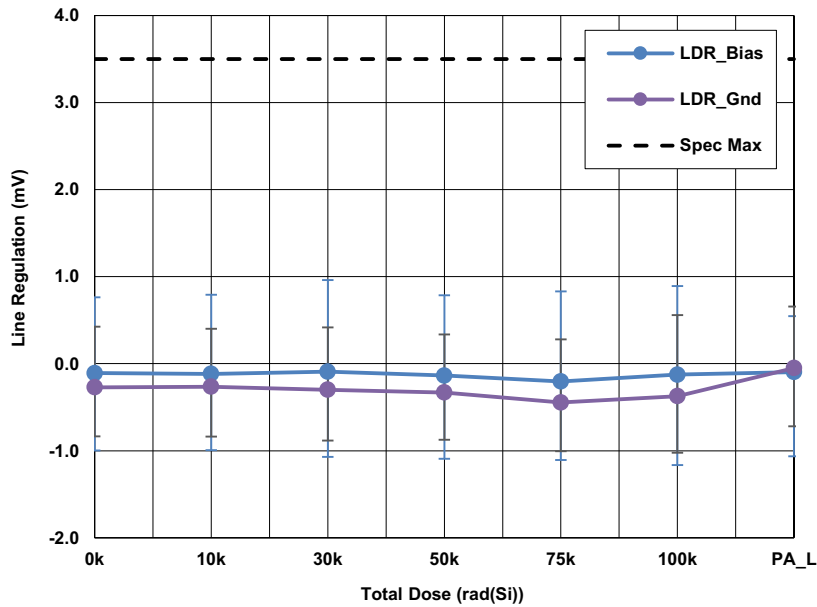


Figure 25. ISL73051ASEH DC input line regulation, 1.8V output, as a function of total dose irradiation at LDR for biased and grounded configurations and subsequent high temperature anneal. The error bars represent the minimum and maximum measured values. The post-irradiation SMD limit is 3.5mV maximum.



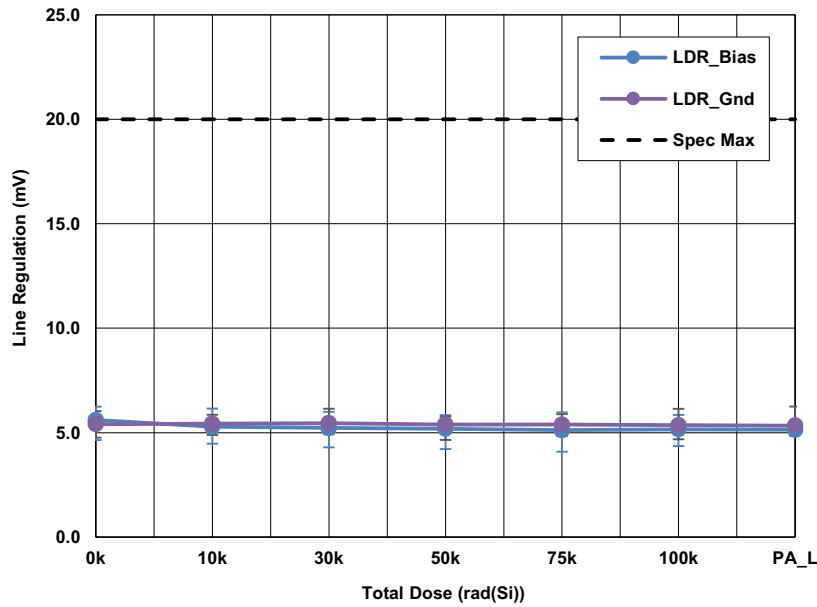


Figure 26. ISL73051ASEH DC input line regulation, 5.0V output, as a function of total dose irradiation at LDR for biased and grounded configurations and subsequent high temperature anneal. The error bars represent the minimum and maximum measured values. The post-irradiation SMD limit is 20.0mV maximum.

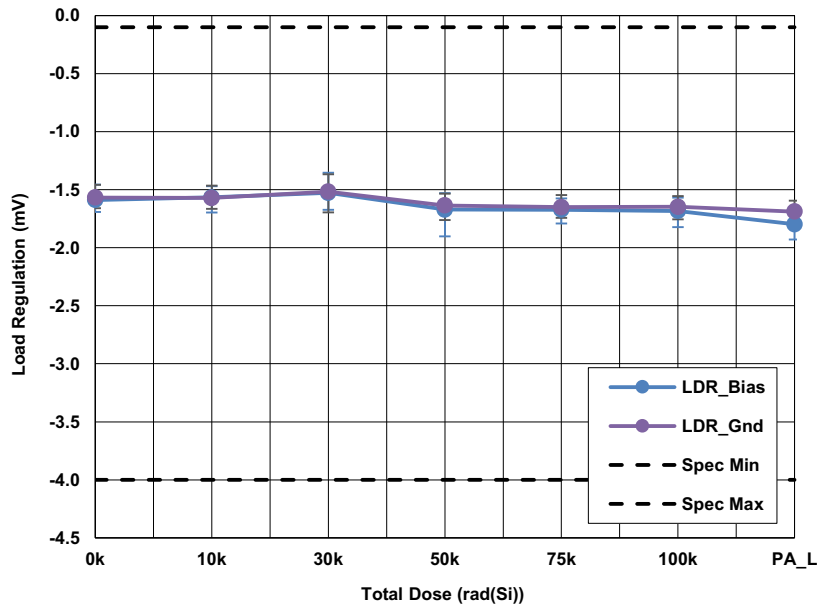


Figure 27. ISL73051ASEH DC output load regulation, 1.5V output, as a function of total dose irradiation at LDR for biased and grounded configurations and subsequent high temperature anneal. The error bars represent the minimum and maximum measured values. The post-irradiation SMD limits are -4.00mV minimum and -0.10mV maximum.

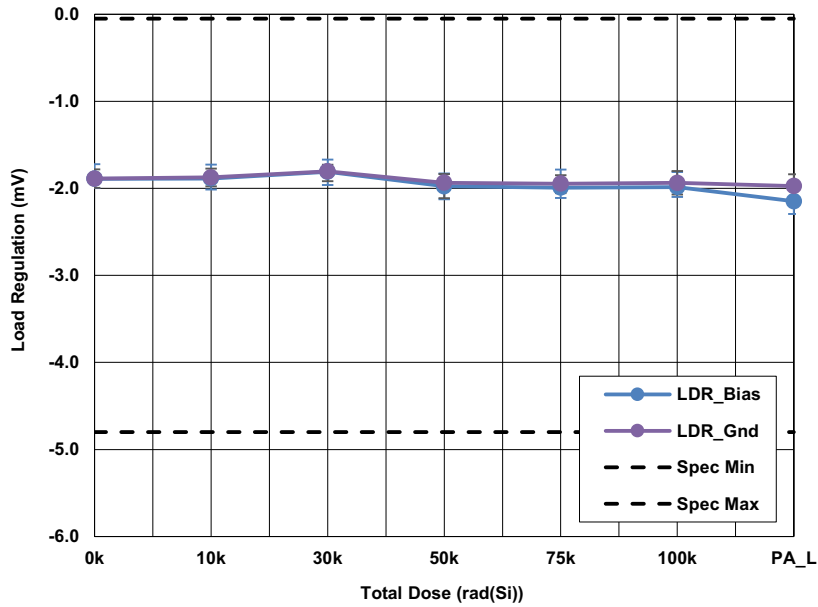


Figure 28. ISL73051ASEH DC output load regulation, 1.8V output, as a function of total dose irradiation at LDR for biased and grounded configurations and subsequent high temperature anneal. The error bars represent the minimum and maximum measured values. The post-irradiation SMD limits are -4.80mV minimum and -0.05mV maximum.

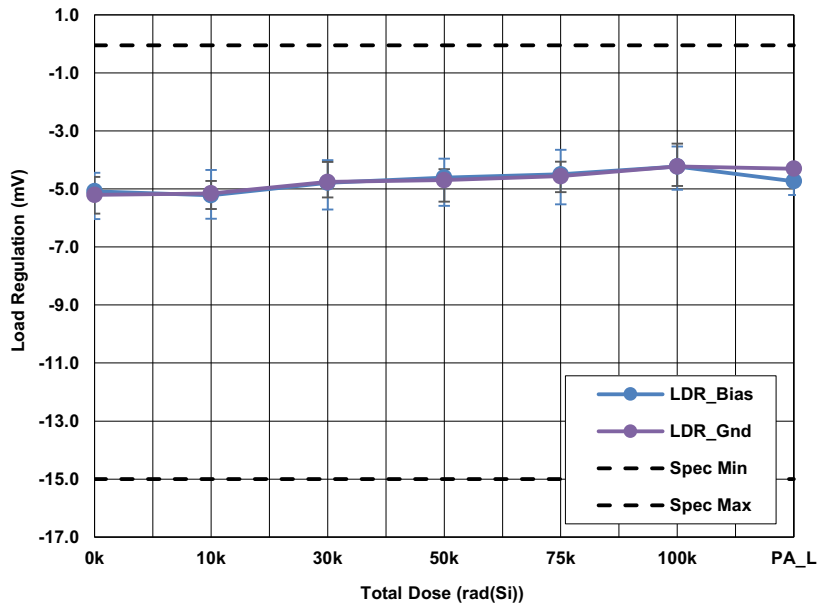


Figure 29. ISL73051ASEH DC output load regulation, 5.0V output, as a function of total dose irradiation at LDR for biased and grounded configurations and subsequent high temperature anneal. The error bars represent the minimum and maximum measured values. The post-irradiation SMD limits are -15.0mV minimum and -0.05mV maximum.

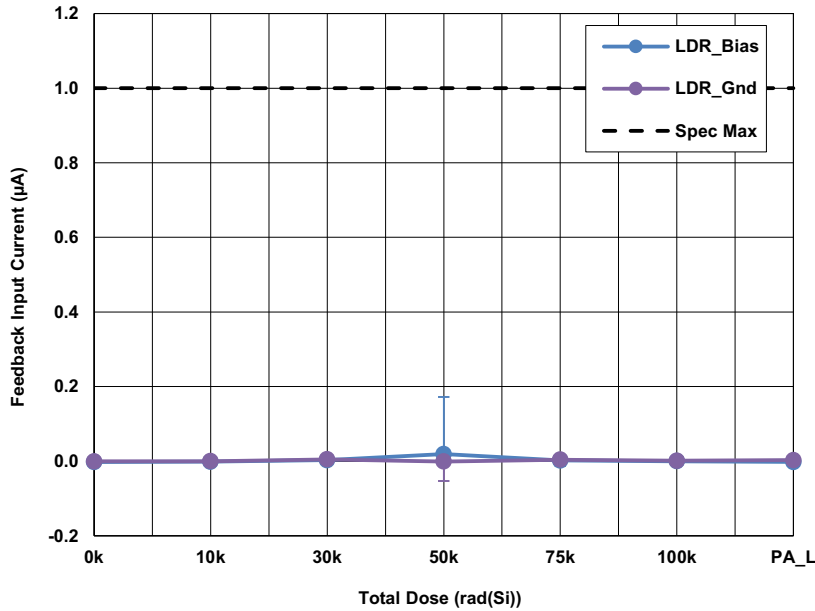


Figure 30. ISL73051ASEH feedback input current, VADJ = 0.5V, as a function of total dose irradiation at LDR for biased and grounded configurations and subsequent high temperature anneal. The error bars represent the minimum and maximum measured values. The post-irradiation SMD limit is 1.0µA maximum.

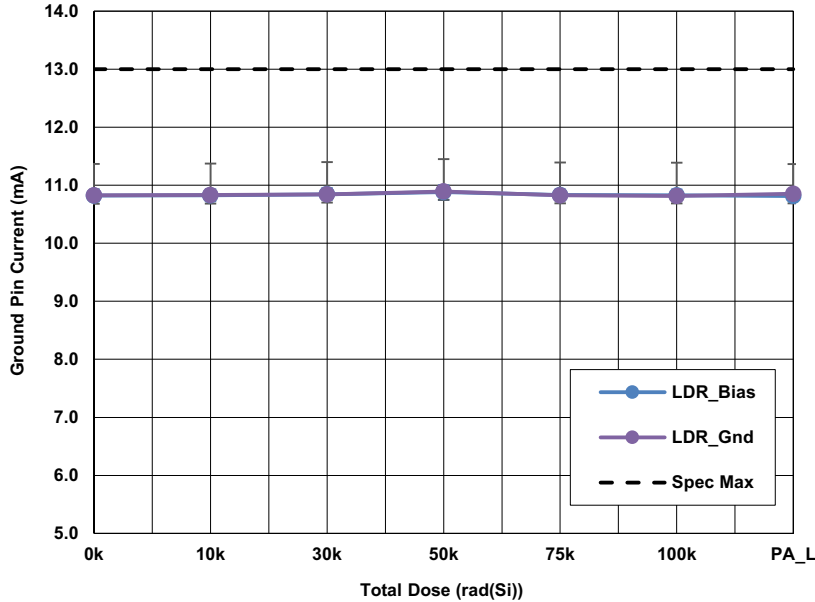


Figure 31. ISL73051ASEH ground pin current ( $I_Q$ ), 1.5V output, 2.2V input, no load, as a function of total dose irradiation at LDR for biased and grounded configurations and subsequent high temperature anneal. The error bars represent the minimum and maximum measured values. The post-irradiation SMD limit is 13.0mA maximum.

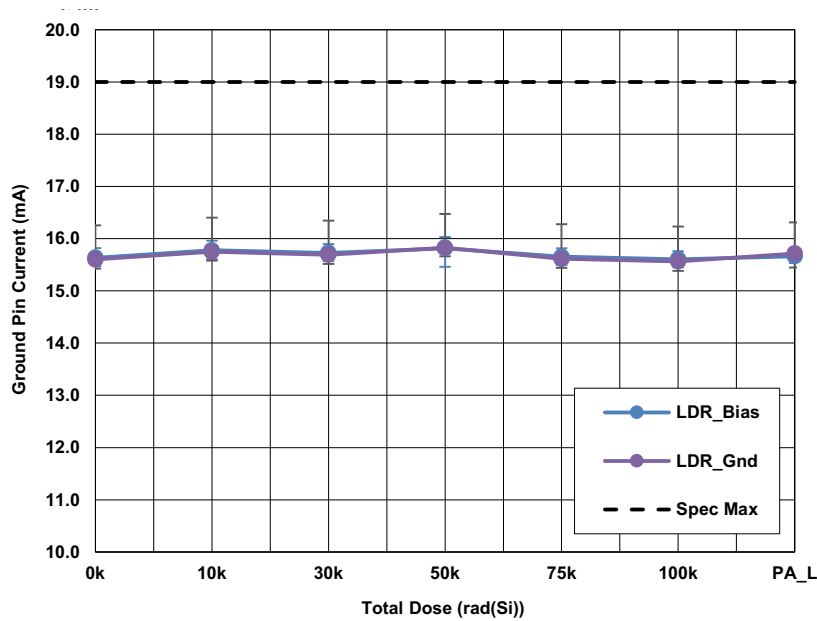


Figure 32. ISL73051ASEH ground pin current ( $I_Q$ ), 5.0V output, 6.0V input, no load, as a function of total dose irradiation at LDR for biased and grounded configurations and subsequent high temperature anneal. The error bars represent the minimum and maximum measured values. The post-irradiation SMD limit is 19.0mA maximum.

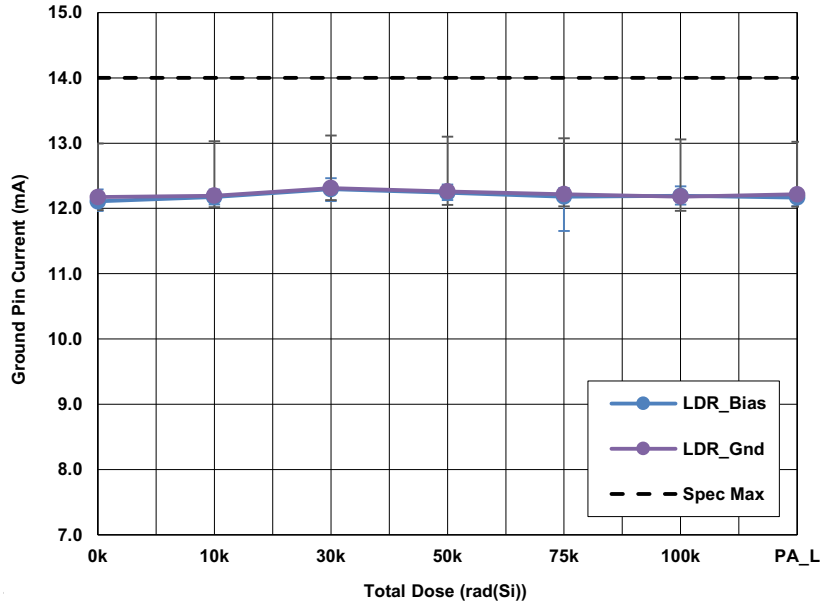


Figure 33. ISL73051ASEH ground pin current ( $I_Q$ ), 1.5V output, 2.2V input, 3A load, as a function of total dose irradiation at LDR for biased and grounded configurations and subsequent high temperature anneal. The error bars represent the minimum and maximum measured values. The post-irradiation SMD limit is 14.0mA maximum.

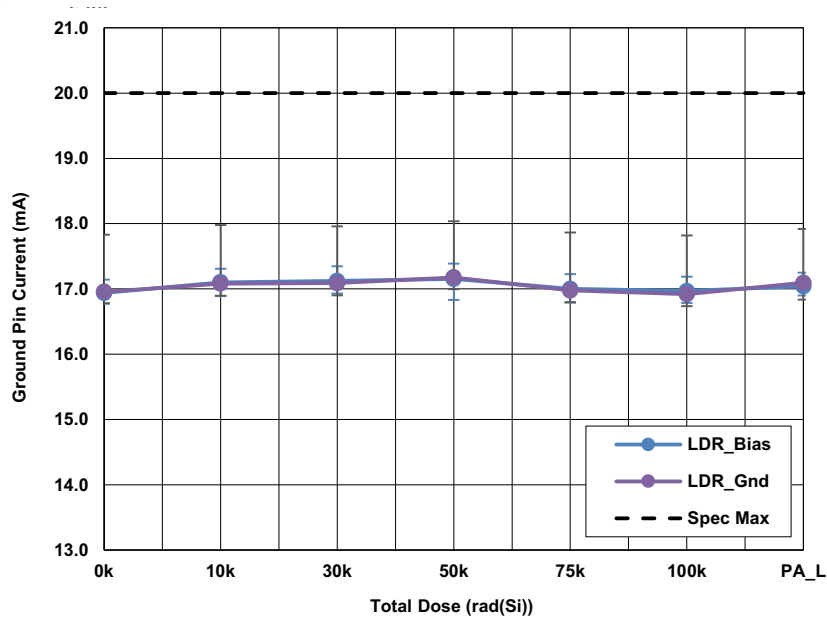


Figure 34. ISL73051ASEH ground pin current ( $I_Q$ ), 5.0V output, 6.0V input, 3A load, as a function of total dose irradiation at LDR for biased and grounded configurations and subsequent high temperature anneal. The error bars represent the minimum and maximum measured values. The post-irradiation SMD limit is 20.0mA maximum.

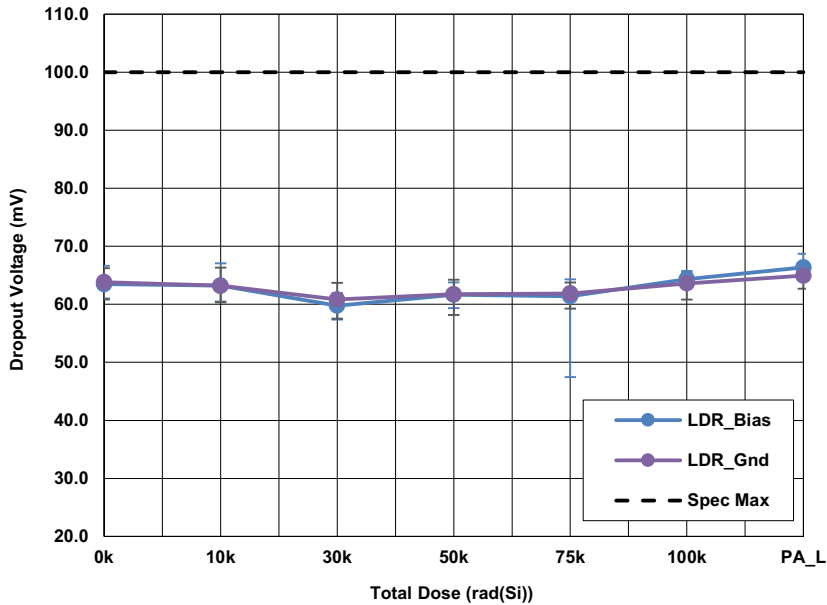


Figure 35. ISL73051ASEH dropout voltage ( $V_{DO}$ ), 2.5V output, 1A load, as a function of total dose irradiation at LDR for biased and grounded configurations and subsequent high temperature anneal. The error bars represent the minimum and maximum measured values. The post-irradiation SMD limit is 100.0mV maximum.

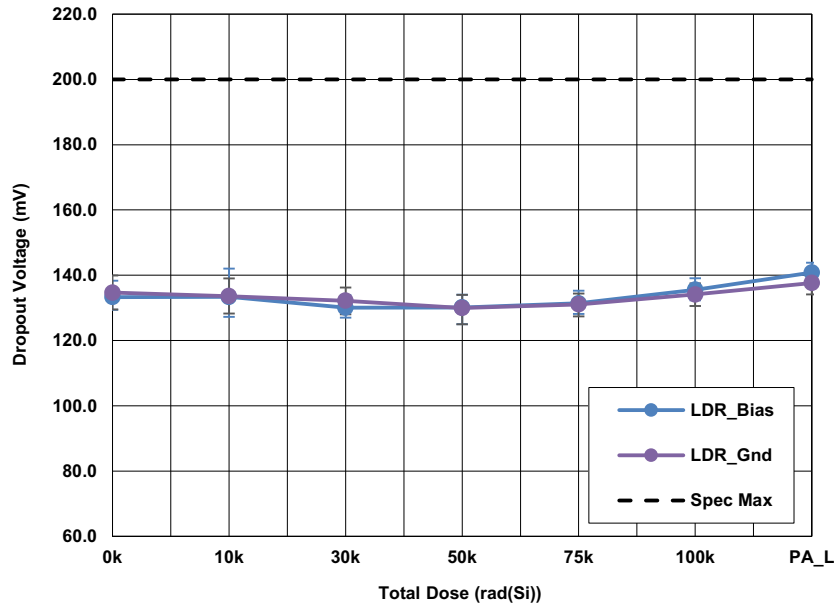


Figure 36. ISL73051ASEH dropout voltage ( $V_{DO}$ ), 2.5V output, 2A load, as a function of total dose irradiation at LDR for biased and grounded configurations and subsequent high temperature anneal. The error bars represent the minimum and maximum measured values. The post-irradiation SMD limit is 200.0mV maximum.

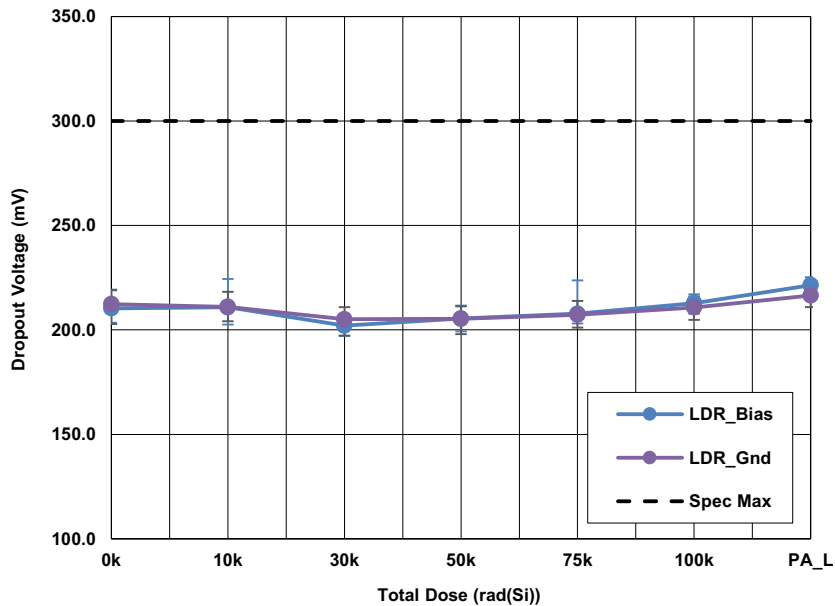


Figure 37. ISL73051ASEH dropout voltage ( $V_{DO}$ ), 2.5V output, 3A load, as a function of total dose irradiation at LDR for biased and grounded configurations and subsequent high temperature anneal. The error bars represent the minimum and maximum measured values. The post-irradiation SMD limit is 300.0mV maximum.

### 3. Discussion and Conclusion

All tested SMD parameters passed at all downpoints. No bias or anneal sensitivity was observed. [“Attributes Data” on page 3](#) summarizes the attributes data for the test. [“Key Parameter Listing” on page 4](#) summarizes selected key parameters for the part. Finally [“Key Parameter Variables Data” on page 5](#) provides plots of the total dose and anneal response for the selected critical parameters.

### 4. Revision History

Rev.	Date	Description
0.00	Nov 1, 2018	Initial release

## Notice

1. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation or any other use of the circuits, software, and information in the design of your product or system. Renesas Electronics disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use of these circuits, software, or information.
  2. Renesas Electronics hereby expressly disclaims any warranties against and liability for infringement or any other claims involving patents, copyrights, or other intellectual property rights of third parties, by or arising from the use of Renesas Electronics products or technical information described in this document, including but not limited to, the product data, drawings, charts, programs, algorithms, and application examples.
  3. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
  4. You shall not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.
  5. Renesas Electronics products are classified according to the following two quality grades: "Standard" and "High Quality". The intended applications for each Renesas Electronics product depends on the product's quality grade, as indicated below.  
"Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; industrial robots; etc.  
"High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment; etc.  
Unless expressly designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not intended or authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems; surgical implantations; etc.), or may cause serious property damage (space system; undersea repeaters; nuclear power control systems; aircraft control systems; key plant systems; military equipment; etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or any third parties arising from the use of any Renesas Electronics product that is inconsistent with any Renesas Electronics data sheet, user's manual or other Renesas Electronics document.
  6. When using Renesas Electronics products, refer to the latest product information (data sheets, user's manuals, application notes, "General Notes for Handling and Using Semiconductor Devices" in the reliability handbook, etc.), and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operating power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any malfunctions, failure or accident arising out of the use of Renesas Electronics products outside of such specified ranges.
  7. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics, such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Unless designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not subject to radiation resistance design. You are responsible for implementing safety measures to guard against the possibility of bodily injury, injury or damage caused by fire, and/or danger to the public in the event of a failure or malfunction of Renesas Electronics products, such as safety design for hardware and software, including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult and impractical, you are responsible for evaluating the safety of the final products or systems manufactured by you.
  8. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. You are responsible for carefully and sufficiently investigating applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive, and using Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
  9. Renesas Electronics products and technologies shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations. You shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries asserting jurisdiction over the parties or transactions.
  10. It is the responsibility of the buyer or distributor of Renesas Electronics products, or any other party who distributes, disposes of, or otherwise sells or transfers the product to a third party, to notify such third party in advance of the contents and conditions set forth in this document.
  11. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.
  12. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products.
- (Note 1) "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its directly or indirectly controlled subsidiaries.  
(Note 2) "Renesas Electronics product(s)" means any product developed or manufactured by or for Renesas Electronics.

(Rev.4.0-1 November 2017)



### SALES OFFICES

Renesas Electronics Corporation

<http://www.renesas.com>

Refer to "<http://www.renesas.com/>" for the latest and detailed information.

#### Renesas Electronics Corporation

TOYOSU FORESIA, 3-2-24 Toyosu, Koto-ku, Tokyo 135-0061, Japan

#### Renesas Electronics America Inc.

1001 Murphy Ranch Road, Milpitas, CA 95035, U.S.A.  
Tel: +1-408-432-8888, Fax: +1-408-434-5351

#### Renesas Electronics Canada Limited

9251 Yonge Street, Suite 8309 Richmond Hill, Ontario Canada L4C 9T3  
Tel: +1-905-237-2004

#### Renesas Electronics Europe Limited

Dukes Meadow, Millboard Road, Bourne End, Buckinghamshire, SL8 5FH, U.K  
Tel: +44-1628-651-700

#### Renesas Electronics Europe GmbH

Arcadiastrasse 10, 40472 Düsseldorf, Germany  
Tel: +49-211-6503-0, Fax: +49-211-6503-1327

#### Renesas Electronics (China) Co., Ltd.

Room 1709 Quantum Plaza, No.27 ZhichunLu, Haidian District, Beijing, 100191 P. R. China  
Tel: +86-10-8235-1155, Fax: +86-10-8235-7679

#### Renesas Electronics (Shanghai) Co., Ltd.

Unit 301, Tower A, Central Towers, 555 Langao Road, Putuo District, Shanghai, 200333 P. R. China  
Tel: +86-21-2226-0888, Fax: +86-21-2226-0999

#### Renesas Electronics Hong Kong Limited

Unit 1601-1611, 16/F., Tower 2, Grand Century Place, 193 Prince Edward Road West, Mongkok, Kowloon, Hong Kong  
Tel: +852-2265-6688, Fax: +852 2886-9022

#### Renesas Electronics Taiwan Co., Ltd.

13F, No. 363, Fu Shing North Road, Taipei 10543, Taiwan  
Tel: +886-2-8175-9600, Fax: +886 2-8175-9670

#### Renesas Electronics Singapore Pte. Ltd.

80 Bendemeer Road, Unit #06-02 Hyflux Innovation Centre, Singapore 339949  
Tel: +65-6213-0200, Fax: +65-6213-0300

#### Renesas Electronics Malaysia Sdn.Bhd.

Unit 1207, Block B, Menara Amcorp, Amcorp Trade Centre, No. 18, Jln Persiaran Barat, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia  
Tel: +60-3-7955-9390, Fax: +60-3-7955-9510

#### Renesas Electronics India Pvt. Ltd.

No.777C, 100 Feet Road, HAL 2nd Stage, Indiranagar, Bangalore 560 038, India  
Tel: +91-80-67208700, Fax: +91-80-67208777

#### Renesas Electronics Korea Co., Ltd.

17F, KAMCO Yangjae Tower, 262, Gangnam-daero, Gangnam-gu, Seoul, 06265 Korea  
Tel: +82-2-558-3737, Fax: +82-2-558-5338