Test Report

IS-139ASEH

Total Dose Testing

AN1821
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Introduction

This report summarizes the results of a low dose rate (LDR) total dose test of the IS-139ASEH single event radiation hardened quad voltage comparator. The test was specifically conducted to demonstrate LDR performance to support offering the 50krad(Si) LDR assurance tested "EH" version of the existing IS-139ASRH high dose rate (HDR) assurance tested part.

Both the IS-139ASRH and IS-139ASEH are wafer-by-wafer assurance tested per MIL-STD-883H at 300krad(Si) of HDR (50 to 300 rad(Si)/s. Only the IS-139ASEH is wafer-by-wafer assurance tested at 50krad(Si) LDR (0.01 rad(Si)/s). LDR characterization beyond 50krad(Si) is included as indicative, but no assurance testing beyond 50krad(Si) LDR is performed in production of the "EH" part.

Reference Documents

- MIL-STD-883H Method 1019.8 (Ionizing Radiation (Total Dose) Test Procedure) and 5010.4 (Test Procedures For Complex Monolithic Microcircuits)
- MIL-PRF-38535 (QML)
- IS-139ASEH data sheet (FN9000)
- DLA Standard Microcircuit Drawing SMD 5962-01510

Part Description

The IS-139ASRH and IS-139ASEH quad voltage comparator are specifically designed to suppress single event upsets (SEU). The four independent comparators can operate from a single or dual supply voltage with low supply current. These types were designed to interface directly with TTL and CMOS inputs.

The IS-139ASRH and IS-139ASEH are constructed with the Intersil Rad Hard Silicon Gate (RSG) Dielectric Isolation BiCMOS process. The process is in production under MIL-PRF 38535 certification and is used for a range of space qualified products.

Key Specifications

- Electrically screened to DLA SMD 5962-01510
- QML qualified per MIL-PRF-38535 requirements
- Maximum high dose rate total dose . . . . 300krad(Si)
- Maximum low dose rate total dose . . . . .50krad(Si)
- Single event latch-up immunity . . . .>84MeV*cm^2/mg
- Single event upset immunity . . . .>84MeV*cm^2/mg
- Operating supply voltage range . . . . 9V to 30V
- Input offset voltage(V_{IO}) . . . .<5mV
- Quiescent supply current . . . . <3mA
- Differential input voltage range equal to the supply voltage

IS-139ASEH Single Comparator Conceptual Schematic

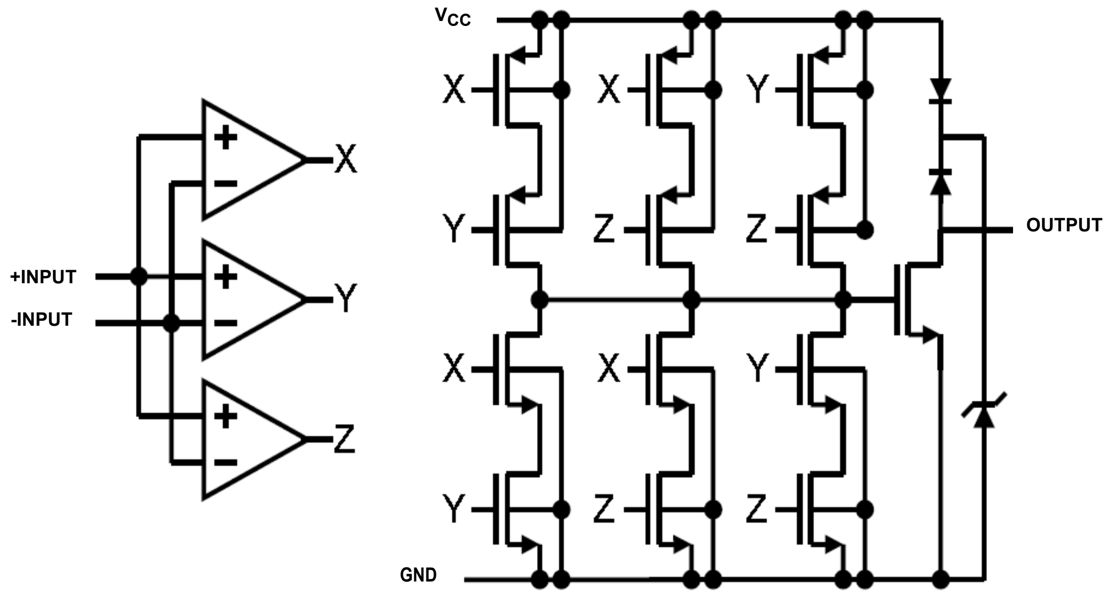


FIGURE 1A. REDUNDANT COMPARATOR AND VOTER FOR SET SUPPRESSION

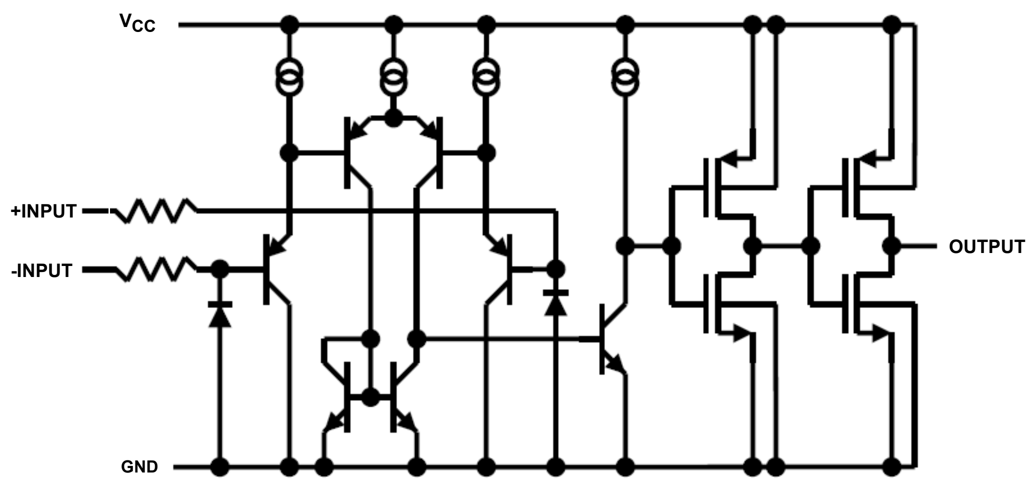


FIGURE 1B. INDIVIDUAL COMPARATOR CHANNEL TOPOLOGY

Test Description

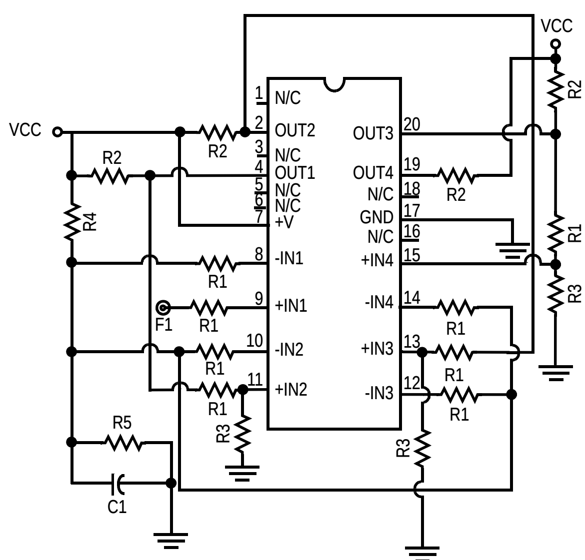
Irradiation Facilities

Low dose rate testing was done at Intersil's low dose rate irradiation facility in Palm Bay, Florida. This facility was built expressly for supporting production LDR assurance testing of Intersil products. A description of the Intersil LDR facility can be found on the Intersil web site. The facility uses a 60Co source and maintains a 10mrad(Si)/s flux-by-device positioning relative to the source. Devices are situated in PbAl boxes to shield them against low energy secondary gamma radiation, as required by MIL-STD-883. The production HDR testing was done at Intersil's production HDR chamber in Palm Bay, Florida.

Test Fixturing

Figure 2 shows the configuration used for biased irradiation in conformance with Standard Microcircuit Drawing (SMD) 5962-01510. This configuration has been used for the biased low dose rate irradiation and all biased anneals. The unbiased low dose rate irradiation was carried out with all pins grounded.

Figure 2 shows the Irradiation bias configuration for the IS-139ASEH, as used for both LDR and HDR reported in this document and used for production assurance testing.



VCC = 30VDC ± 2V
R1 = 10kΩ, 1/4 Watt, 10% Tolerance
R2 = 6.3kΩ, 1/4 Watt, 10% Tolerance
R3 = 1.7kΩ, 1/4 Watt, 10% Tolerance
R4 = 27kΩ, 1/4 Watt, 10% Tolerance
R5 = 2kΩ, 1/4 Watt, 10% Tolerance
C1 = 1.5µf, 5% Tolerance
F1 = 1kHz, 50% Duty Cycle
V_{IH} = +5VDC ±5%
V_{IL} = 0VDC ±.5V
0.01µF Cap, Per Socket Or 0.1µF Per Board

FIGURE 2. IRRADIATION BIAS CONFIGURATION FOR THE IS-139ASEH

Characterization Equipment and Procedures

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

Experimental Matrix

The experimental matrix consisted of two irradiation groups, biased and unbiased, tested at a sequence of dose downpoints. Test units were cumulatively dosed up to the maximum doses listed. Table 1 on page 4 summarizes the test points and identifies the number of units tested for each condition along with functional and parametric yields. For comparison, a set of production results for the 300krad(Si) HDR assurance testing done on the IS-139ASRH is included.

Samples of the IS-139ASEH were drawn from preproduction inventory for the IS-139ASRH, and were packaged in the standard hermetic 16-pin ceramic flatpack (CFP) production package. Samples were processed through the standard burn-in cycle before irradiation, as required by MIL-STD-883, and were screened to the SMD 5962-01510 limits at room (low-and-high) temperature before the radiation testing.

SMD Electrical Parameter Results

Results for key parameters are presented in Figures 3 through 13. Response time-low-to high(t_{PLH}). The plots show the median parameter values as connected points against total dose. Unconnected markers are the extremes recorded. Table 2 on page 4 lists the SMD parameters limits, along with chart number and page. These omitted charts added no information beyond those included.

The "LDR" and "HDR" are low and high dose rate respectively. "Biased" indicates the parts were biased as in Figure 2 during irradiation. "Grounded" indicates all pins were grounded during irradiation. "T" is number of units tested; "F" is number of units found functional; "P" is number of units passing SMD parametric limits.

TABLE 1. SUMMARY OF ATE DOWNPOINT RESULTS

	TOTAL DOSE														
	0krad			50krad			100krad			150krad			300krad		
	T	F	P	T	F	P	T	F	P	T	F	P	T	F	P
LDR Biased	14	14	14	14	14	14	14	14	14	14	14	13			
LDR Grounded	14	14	14	14	14	14	14	13	3	14	13	0			
HDR Biased													80	80	80

TABLE 2. 5962-01510 ELECTRICAL PARAMETERS, LIMITS AND CHART PAGES

SMD ELECTRICAL PARAMETER	SYMBOL	PRE/POST RADIATION LIMITS +25°C MIN	MAX	UNIT	CHART NUMBER & PAGES
Input Offset Voltage	V_{IO}	-5/-9	5/9	mV	3, 6
Saturation Voltage	V_{SAT}		300	mV	4, 6
Common Mode Input Range (Functional Only)	V_{ICR}	0	VCC - 2.5	V	
Input Offset Current	I_{IO}	-150/-500	150/500	nA	5, 6
Input Bias Current	I_{IB}	-400/-1000	400/1000	nA	6, 6
Total Supply Current	+ICC		3/3.5	mA	7, 7
Input Voltage Common Mode Rejection Ratio	CMRR		70	dB	8, 7
Output Leakage Current	I_{CEX}		500	nA	9, 7
Output Sink Current	I_{OSK}	12		mA	10, 7
Voltage Gain	AOL	25		V/mV	11, 8
Response Time H to L	t_{PHL}		4	µs	12, 8
Response Time L to H	t_{PLH}		5	µs	13, 8

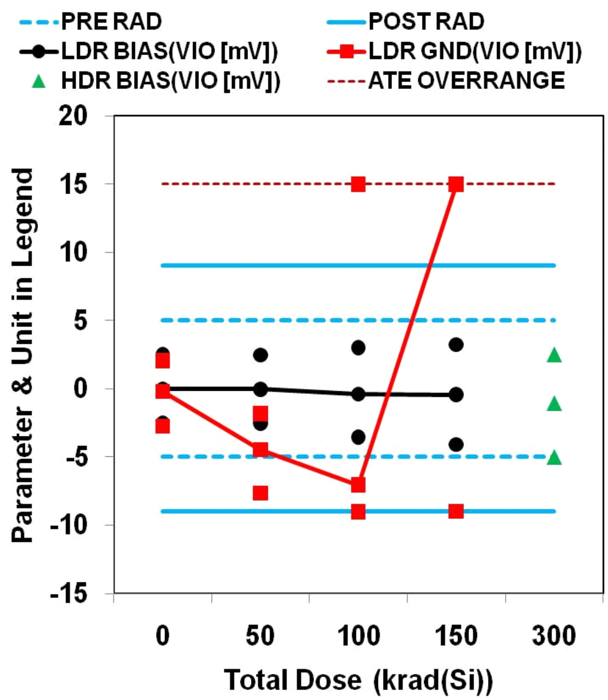


FIGURE 3. INPUT OFFSET VOLTAGE (V_{IO}). AT 150krad (Si) LDR GND 71% OF TESTS WERE OVER-RANGE

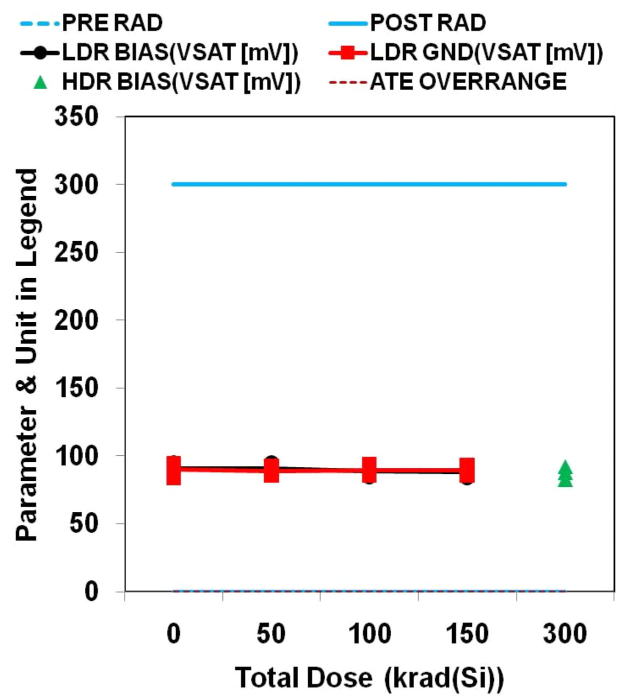


FIGURE 4. OUTPUT SATURATION VOLTAGE AT 4mA (V_{SAT})

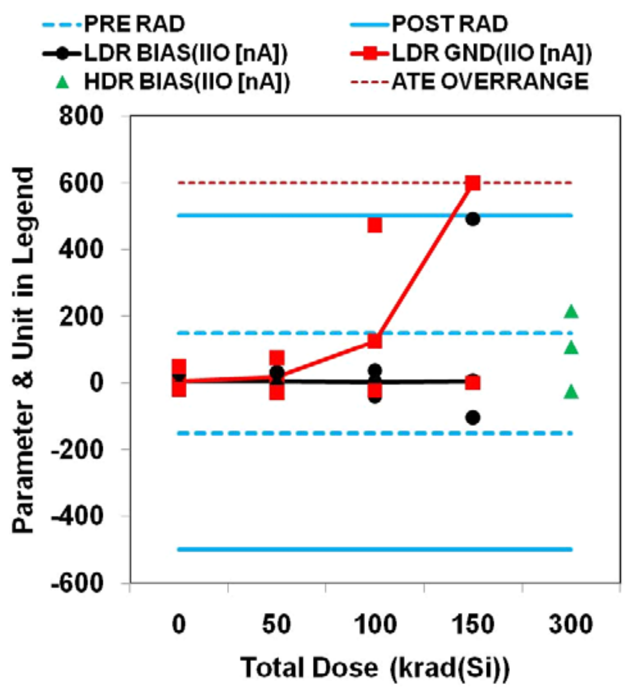


FIGURE 5. INPUT OFFSET CURRENT (I_{IO}). 7% of LDR GND WAS OVER-RANGE AT 100krad(Si) AND 51% AT 150krad(Si)

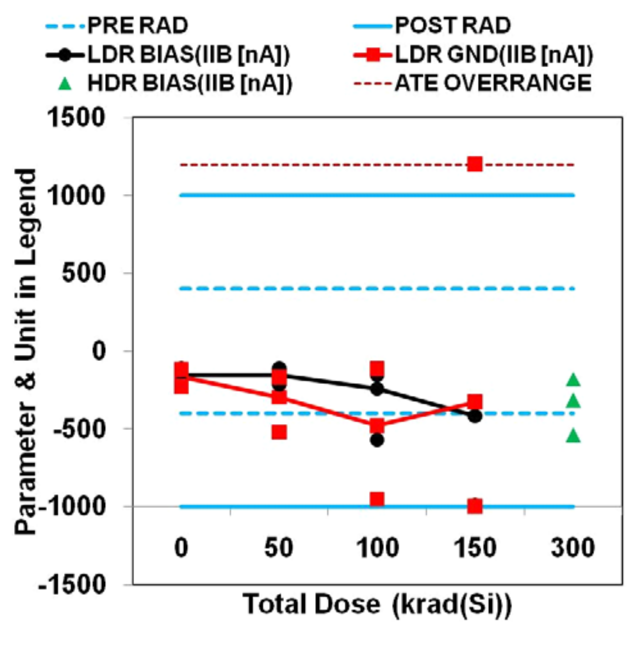


FIGURE 6. INPUT BIAS CURRENT (I_{IB}). THE OVER-RANGE RATE WAS 12% OF INPUTS AT 150krad(Si) LDR BIAS. FOR LDR GND AT 150 krad(Si) THE RATE WAS UNDER 4%

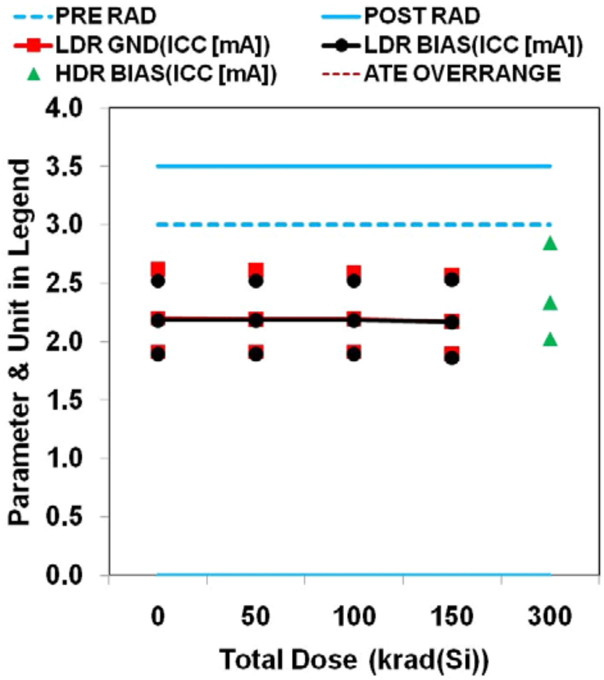


FIGURE 7. TOTAL SUPPLY CURRENT (+ICC)

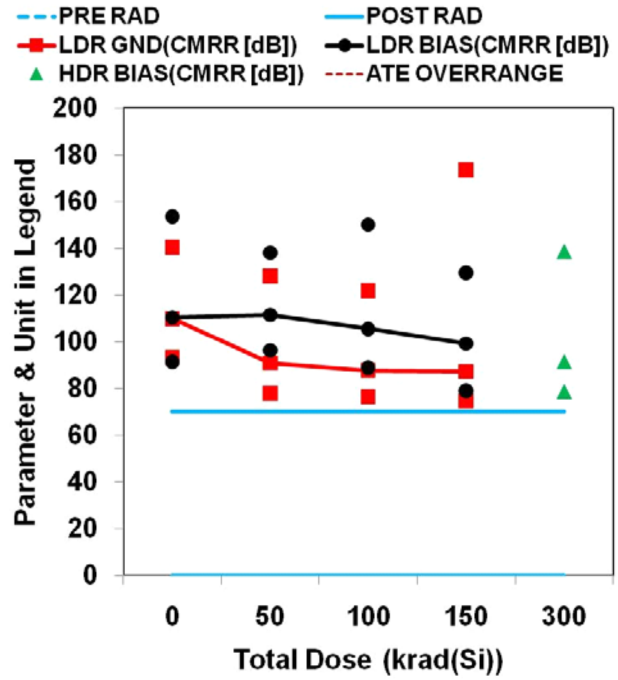


FIGURE 8. INPUT VOLTAGE COMMON MODE REJECTION RATIO (CMRR)

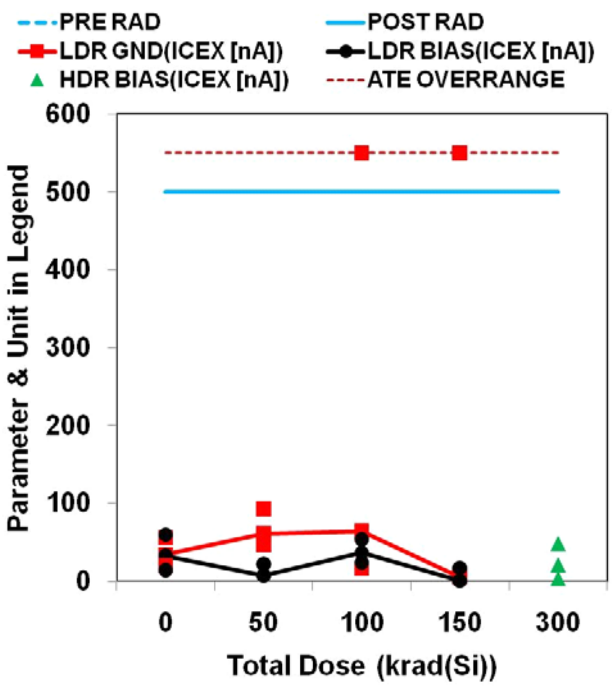


FIGURE 9. OUTPUT LEAKAGE CURRENT (I_{CEX})

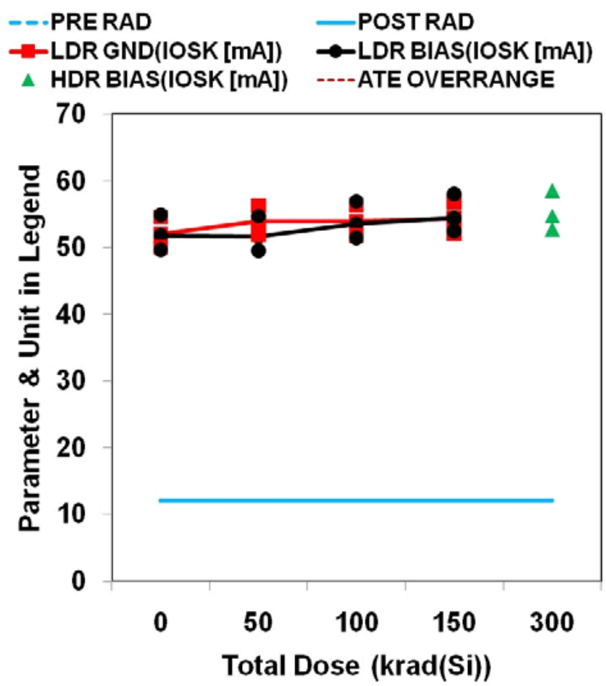


FIGURE 10. OUTPUT SINK CURRENT (I_{OSK})

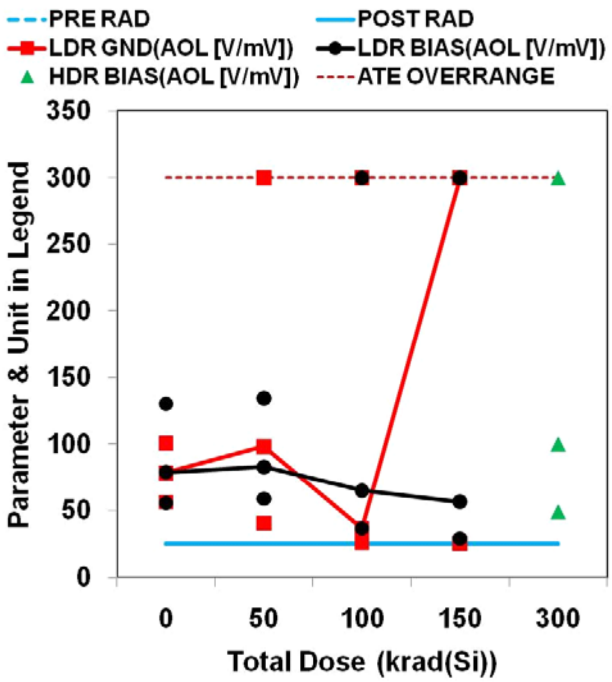


FIGURE 11. VOLTAGE GAIN (AOL). VALUES IN EXCESS OF 300V/mV ARE CONSIDERED OVER-RANGED. 1 OUT OF 56 COMPARATORS OVER-RANGED AT 50krad(Si) LDR GND. AT 150krad(Si) 60% WERE OVER-RANGING

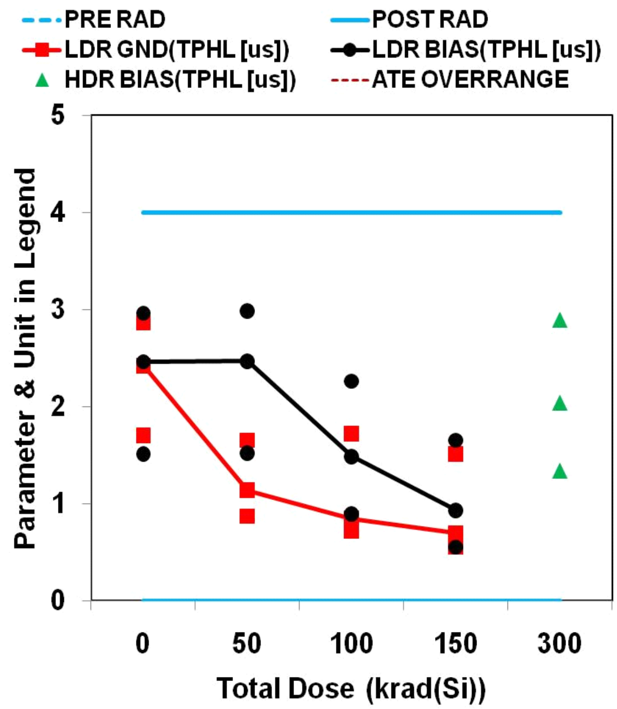


FIGURE 12. RESPONSE TIME HIGH-TO-LOW (t_{PHL})

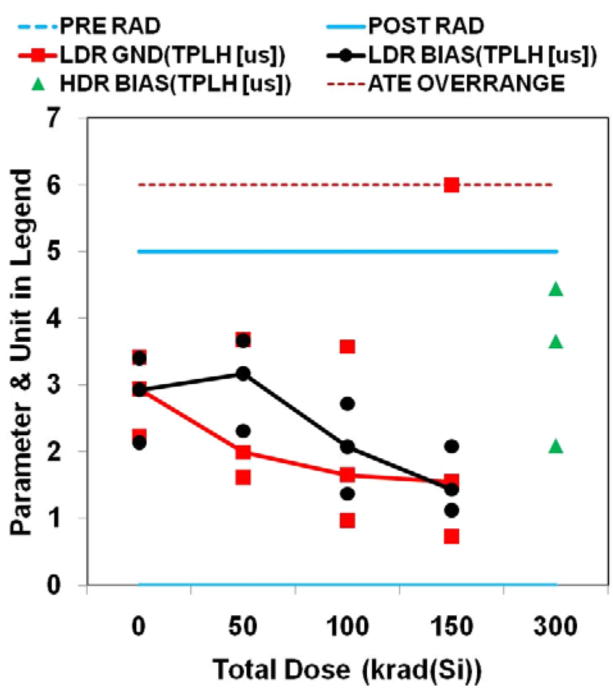


FIGURE 13. RESPONSE TIME LOW-TO-HIGH (t_{PLH})

Discussion

Only one part failed functionally and this was from the LDR GND group. Functional failure means the output did not achieve its DC specification in response to input commands. This part failed one of the four channels at 100krad(Si) and again at 150krad(Si). The other 27 parts exposed up to 150krad(Si) LDR were functional, as were all the HDR 300krad(Si) parts.

The parametric yield results are in Table 2 and show 100% parametric yield at initial test and at 50krad(Si) for all LDR parts, for both biased and grounded irradiation conditions. This data supports the release of the IS-139ASEH as a LDR assurance tested part at 50krad(Si). The HDR 300krad(Si) parts also demonstrated 100% yield as would be expected.

The LDR BIAS group had 100% parametric yield at 100krad(Si), but the LDR GND group suffered 77% parametric failure (11/14) at 100krad(Si) LDR. The parametric failures were for V_{IO} and AOL. At 150krad(Si) the LDR GND group failed 100% for V_{IO}, I_{IB}, I_{IO}, and AOL. The LDR BIAS group failed only 1 of 14 (7%) at 150krad(Si) for I_{IB} on all channels. Clearly, the grounded pin irradiation configuration shows the most degradation.

All data for 50krad(Si) of LDR irradiation was within the post radiation limits for the IS-139ASRH. However, a single parametric measurement in question was the voltage gain (AOL, Figure 11); a single channel out of 56 (4 on each of 14 units) yielded an unrealistically high gain value. Since the reading was high, this parameter did not constitute a parametric failure (there is only a minimum limit on ALO), but the reading was anomalous. The average of the other 55 channels only moved from 80V/mV to 110V/mV. Figure 14 is a histogram of the 0krad(Si) and 50krad(Si) AOL data for the LDR GND population. As dose increased, the incidence of unrealistic measurements did increase to 34/56 (61%) at 150krad(Si) for the LDR GND treatment. The LDR BIAS group had only 1/56 bad measurement at 150krad(Si), while the HDR BIAS group had 11 bad measurements out of 320 (3.44%) at 300krad(Si). Again, it should be noted that despite the bad AOL readings, only one part failed functionality, so the poor AOL readings did not indicate loss of function.

Two other parameters (V_{IO} and I_{CEX}) showed over-range measurements at 100krad(Si) for the LDR GND group. In the case of V_{IO}, the over-range measurements appeared to be leaders in a trend that included most measurements at 150krad(Si). For I_{CEX}, it is only a single channel of a single unit of the total 56 channels that failed, at both 100krad(Si) and 150krad(Si).

At 150krad(Si) a few of the input bias current (I_{IB}) measurements showed problems for both LDR groups. Approximately 7% (16/112) and 14% of (32/112) of the LDR BIAS and LDR GND inputs went out of post radiation specification at 150krad(Si) LDR. Again it should be noted that most of this did not constitute functional failures.

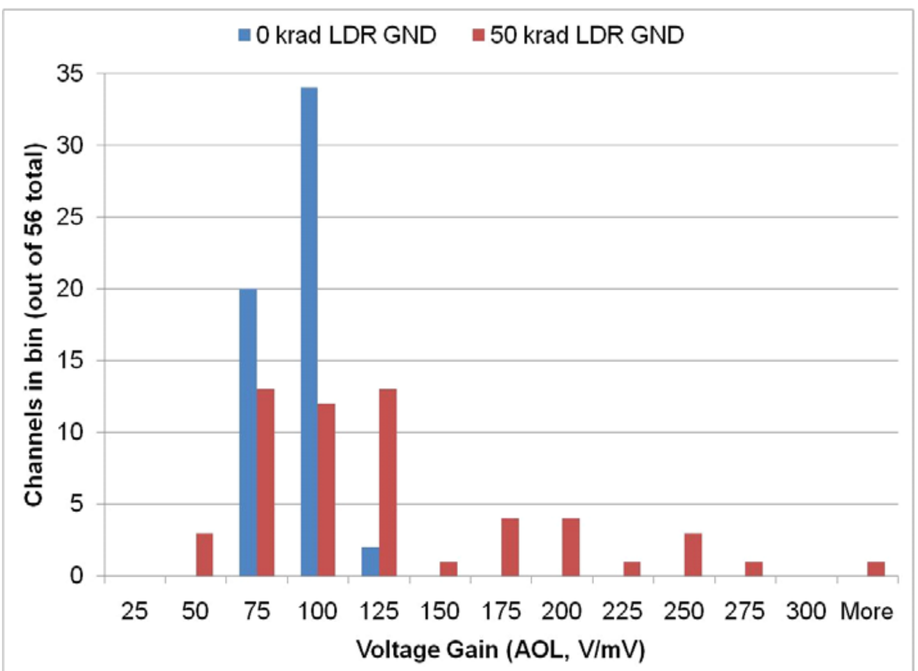


FIGURE 14. HISTOGRAM OF AOL FOR THE LDR GND POPULATION AT 0krad(Si) AND 50krad(Si).

Test Conclusions

The offering of the IS-139ASEH as a part capable of 50krad(Si) at low dose rate (10mrad(Si)/s) is supported by 100% functionality and 100% parametric yield to post-radiation specification at 50krad(Si) LDR downpoint. Wafer-by-wafer assurance testing to 50krad(Si) guarantees that subsequent material conforms to this performance.

By 100krad(Si) of LDR exposure with grounded pins, the IS-139ASEH experienced substantial parametric failure, (primarily in V_{IO} and I_{OB}), although most parts (13 of 14) remained functional. The parts that were biased during the 100krad(Si) LDR irradiation fared much better as all 14 functioned and passed parametric testing. Thus, survival and performance of the IS-139ASEH to 100krad(Si) depends on the biasing conditions during the accumulation of the dose. A part in constant bias can be expected to fair much better than an unpowered one.

By 150krad(Si) LDR, all grounded parts failed parametric testing and even the biased parts were showing a failure and a few very marginal parts as well. It is safe to say the 150krad(Si) LDR is beyond a safe limit for parametric survival, regardless of the biasing conditions. The chances of functionality are still good, but degraded parametric performance should be expected.

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