Unisys

DATE: November 03, 1998 PPM-99-005
TO: S Hull/562
FROM: K. Sahu/S. Kniffin/300.1
SUBJECT: Radiation Report on **HI300 (Harris Semiconductor) (LDC 9816)**
PROJECT: IRAC

cc: R. Williams/722.0, R. Reed/562, A. Sharma/562, OFA Library/300.1

A radiation evaluation was performed on **HI300 (M38510/11601MPA) Analog Switch (Harris Semiconductor)** to determine the total ionizing dose (TID) tolerance of these parts. The TID testing was performed using a Co^{60} gamma ray source. During the radiation testing, eight parts were irradiated under bias (see Figure 1 for bias configuration) and two parts were used as control samples. The total dose radiation levels were 2.5, 5.0, 10.0, 15.0, 20.0, 30.0, and 50.0kRads.[1] The effective dose rate was 0.099kRads/hour (0.03 Rads/s). See Table II for the radiation schedule and effective dose rate calculation. After the 5.0 and 50.0kRad irradiations, the parts were annealed under bias at 25°C for 168 hours.[2] After each radiation exposure and annealing treatment, parts were electrically tested according to the test conditions and the specification limits[3] listed in Table III.

An executive summary of the test results is provided below in bold, followed by a detailed summary of the test results after each radiation level and annealing step. For detailed information, refer to Tables I through IV and Figures 1 through 4.

All parts passed all initial electrical tests. All parts showed significant degradation in Idon after 2.5 and 5.0kRads. However, all parts passed all tests after annealing for 168 hours at 25°C. On continued irradiation, all parts showed significant degradation in Isoff1, and Idon from 10 to 50kRads. All parts showed significant degradation in Idoff1 from 15 to 50kRads. Some parts showed degradation in ISS from 30 to 50kRads. All parts showed significant degradation in IDD_vil and Rds after 50kRads. However, all parts pass the functional test up to 50kRads. All parts showed significant recovery in most parameters after annealing for 168 hours at 25°C. See Figures 2 through 4 for the degradation of Isoff_1, Idoff_1, and Ison with increasing TID or annealing.

Initial electrical measurements were made on 10 samples. Eight samples (SN's 20, 21, 22, 23, 24, 25, 26, 27, and 28) were used as radiation samples while SN's 18 and 19 were used as control samples. All parts passed all tests during initial electrical measurements.

After the 2.5kRad irradiation, all parts exceeded the specification limit of 10nA for D1_Idon1, D2_Idon1, D1_Idon2, and D2_Idon2 with readings in the range of 33 to 415nA. **All parts passed all other tests including the functional tests.**

After the 5.0kRad irradiation, all parts continued to exceed the specification limit for D1_Idon1, D2_Idon1, D1_Idon2, and D2_Idon2 with readings in the range of 156 to 1576nA. **All parts passed all other tests including the functional test.**

After annealing the parts for 168 hours at 25°C, the parts showed significant recovery. **All parts passed all tests including the functional test.**

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[1] The term Rads, as used in this document, means Rads (silicon). All radiation levels cited are cumulative.
[2] The temperature 25°C as used in this document implies room temperature.
[3] These are manufacturer's pre-irradiation data specification limits. The manufacturer provided no post-irradiation limits at the time these tests were performed.

After the 10.0kRad irradiation, all parts exceeded the specification limit of 10nA for S1_Isoff1 and S2_Isoff1 with readings in the range of 138 to 222nA. All parts again exceeded the specification limit for D1_Idon1, D2_Idon1, D1_Idon2, and D2_Idon2 with readings in the range of 42 to 834nA. **All parts passed all other tests including the functional test.**

After the 15.0kRad irradiation, all parts exceeded the specification limit for S1_Isoff1 and S2_Isoff1 with readings in the range of 576 to 1017nA. All parts exceeded the specification limit of 10nA for D1_Idoff1 and D2_Idoff1 with readings in the range of 20 to 57nA. All parts continued to exceed the specification limit for D1_Idon1, D2_Idon1, D1_Idon2, and D2_Idon2 with readings in the range of 57 to 562nA. **All parts passed all other tests including the functional test.**

After the 20.0kRad irradiation, all parts exceeded the specification limit for S1_Isoff1 and S2_Isoff1 with readings in the range of 68 to 91nA. All parts exceeded the specification limit for D1_Idoff1 and D2_Idoff1 with readings in the range of 57 to 148nA. All parts exceeded the specification limit for D1_Idon1, D2_Idon1, D1_Idon2, and D2_Idon2 with readings in the range of 10.4 to 156nA. **All parts passed all other tests including the functional test.**

After the 30.0kRad irradiation, four parts marginally exceeded the specification limit of 10µA for IDD_vil with readings in the range of 10.1 to 12.1µA. Four parts fell marginally under the specification limit of -10µA for ISS_vil with readings in the range of -10.1 to -11.9µA. All parts exceeded the specification limit for S1_Isoff1 and S2_Isoff1 with readings in the range of 19 to 26nA. All parts exceeded the specification limit for D1_Idoff1 and D2_Idoff1 with readings in the range of 78 to 208nA. Most parts exceeded the specification limit for D1_Idon1, D2_Idon1, D1_Idon2, and D2_Idon2 with readings in the range of 10.3 to 98nA. Most parts marginally exceeded the specification limit of 70Ω for Rds_1n_10V and Rds_2n_10V with readings in the range of 71 to 75Ω. **All parts passed all other tests including the functional test.**

After the 50.0kRad irradiation, all parts exceeded the specification limit for IDD_vil with readings in the range of 18 to 45µA. All parts fell under the specification limit for ISS_vil with readings in the range of -19 to -49µA. All parts fell under the specification limit of -10µA for ISS_vih with readings in the range of -11 to -37µA. All parts exceeded the specification limit for S1_Isoff1 and S2_Isoff1 with readings in the range of 1236 to 2341nA. All parts exceeded the specification limit for D1_Idoff1 and D2_Idoff1 with readings in the range of 189 to 710nA. Most parts exceeded the specification limit for D1_Idon1, D2_Idon1, D1_Idon2, and D2_Idon2 with readings in the range of 45 to 1868nA. All parts exceeded the specification limit of 70Ω for all Rds_10V measurements with readings in the range of 93 to 112Ω. All parts exceeded the specification limit of 50Ω for all Rds_15V measurements with readings in the range of 53 to 955Ω. **All parts passed all other tests including the functional test.**

After annealing the parts for 168 hours at 25°C, the parts showed significant recovery in all IDD and ISS parameters with all parts readings within specification limits. No significant recovery was observed in Isoff1, however some recovery was observed in Idoff1. All parts showed significant recovery in all Idon parameters with most parts passing all four tests. Marginal recovery was noted in the Rds_10V measurements, however all parts continued to fail. All parts showed significant recovery in the Rds_p_15V tests with all parts passing and all parts showed significant recovery in the Rds_n_15V tests with readings only marginally exceeding the specification limit.

Table IV provides a summary of the test results with the mean and standard deviation values for each parameter after each irradiation exposure and annealing step.

Any further details about this evaluation can be obtained upon request. If you have any questions, please call us at (301) 731-8954.

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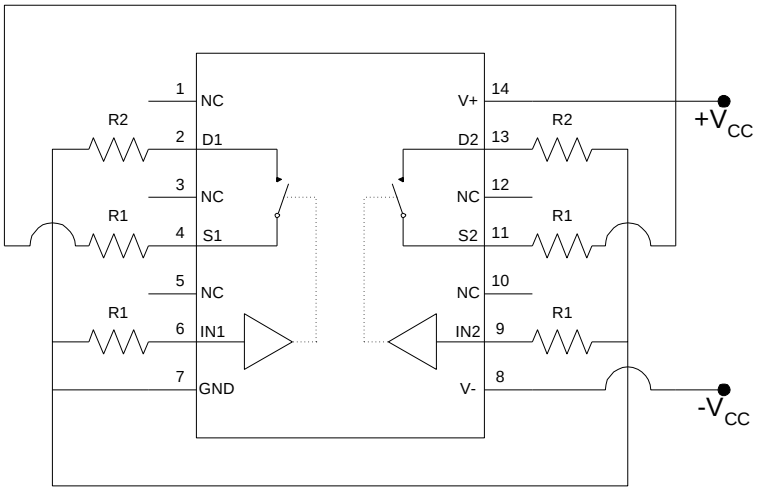
Figure 1. Radiation Bias Circuit for HI300



Notes:
1. V_{CC} = +15V ±0.5V, -V_{CC} = -15V ±0.5V.
2. R_1 = 2kΩ ±5%, ¼W, R_2 = 10kΩ ±5%, ¼W.

TABLE I. Part Information

Generic Part Number:	HI300
IRAC Part Number:	M38510/11601MPA
Charge Number:	M88539
Manufacturer:	Harris Semiconductor
Lot Date Code (LDC):	9816
Quantity Tested:	10
Serial Number of Control Samples:	18, 19
Serial Numbers of Radiation Samples:	20, 21, 22, 23, 24, 25, 26, 27, and 28
Part Function:	Analog Switch
Part Technology:	CMOS
Package Style:	14 Pin Dip
Test Equipment:	A540
Test Engineer:	A. Duvalsaint

- The manufacturer for this part guaranteed no radiation tolerance/hardness.

TABLE II. Radiation Schedule for HI300

EVENT	DATE
1) INITIAL ELECTRICAL MEASUREMENTS	10/02/98
2) 2.5 KRAD IRRADIATION (0.038 KRADS/HOUR)	10/05/98
POST-2.5 KRAD ELECTRICAL MEASUREMENT	10/06/98
3) 5.0 KRAD IRRADIATION (0.147 KRADS/HOUR)	10/06/98
POST-5.0 KRAD ELECTRICAL MEASUREMENT	10/07/98
4) 168 HOUR ANNEALING @25°C	10/07/98
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	10/14/98
5) 10.0 KRAD IRRADIATION (0.121 KRADS/HOUR)	10/14/98
POST-10.0 KRAD ELECTRICAL MEASUREMENT	10/16/98
6) 15.0 KRAD IRRADIATION (0.121 KRADS/HOUR)	10/16/98
POST-15.0 KRAD ELECTRICAL MEASUREMENT	10/19/98
7) 20.0 KRAD IRRADIATION (0.077 KRADS/HOUR)	10/19/98
POST-20.0 KRAD ELECTRICAL MEASUREMENT	10/21/98
8) 30.0 KRAD IRRADIATION (0.244 KRADS/HOUR)	10/21/98
POST-30.0 KRAD ELECTRICAL MEASUREMENT	10/23/98
9) 50.0 KRAD IRRADIATION (0.488 KRADS/HOUR)	10/23/98
POST-50.0 KRAD ELECTRICAL MEASUREMENT	10/26/98
10) 168 HOUR ANNEALING @25°C	10/26/98
POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	11/02/98

Effective Dose Rate = 50,000 RADS/21 DAYS=99.2 RADS/HOUR=0.03 RADS/SEC
The effective dose rate is lower than that of the individual radiation steps as it takes into account the interim annealing step and time needed to test the parts.

PARTS WERE IRRADIATED AND ANNEALED UNDER BIAS, SEE FIGURE 1.

Table III. Electrical Characteristics of HI300 /1

Test #	Parameter	Units	Test Conditions /2	Spec. Lim. min	Spec. Lim. max
1	Functional_100kHz	P/F	f = 100kHz, V_{IN} = V_D = +5V, I_{LOAD} = ±10mA	V_{OH}>3V	V_{OL}<1V
10	IDD_vil	mA	V_{IN} = 0.8V	-1.0	10.0
11	ISS_vil	mA	V_{IN} = 0.8V	-10.0	1.0
12	IDD_vih	mA	V_{IN} = 4.0V	0	1.00
13	ISS_vih	mA	V_{IN} = 4.0V	-10.0	0
20	A1_Iil_0V	nA	V_{IN1} = 0V	-1000	1000
21	A2_Iil_0V	nA	V_{IN2} = 0V	-1000	1000
22	A1_Iil_5V	nA	V_{IN1} = 5V	-1000	1000
23	A2_Iil_5V	nA	V_{IN2} = 5V	-1000	1000
24	A1_Iil_15V	nA	V_{IN1} = 15V	-1000	1000
25	A2_Iil_15V	nA	V_{IN2} = 15V	-1000	1000
30	S1_Isoff_1	nA	V_{IN1} = 0.8V, V_D = +14V, V_S = -5V, see Note 3	-10.0	10.0
31	S2_Isoff_1	nA	V_{IN2} = 0.8V, V_D = +14V, V_S = -5V, see Note 3	-10.0	10.0
32	S1_Isoff_2	nA	V_{IN1} = 0.8V, V_D = -5V, V_S = +14V, see Note 3	-10.0	10.0
33	S2_Isoff_2	nA	V_{IN2} = 0.8V, V_D = -5V, V_S = +14V, see Note 3	-10.0	10.0
40	D1_Idoff_1	nA	V_{IN1} = 0.8V, V_D = +14V, V_S = -5V, see Note 3	-10.0	10.0
41	D2_Idoff_1	nA	V_{IN2} = 0.8V, V_D = +14V, V_S = -5V, see Note 3	-10.0	10.0
42	D1_Idoff_2	nA	V_{IN1} = 0.8V, V_D = -5V, V_S = +14V, see Note 3	-10.0	10.0
43	D2_Idoff_2	nA	V_{IN2} = 0.8V, V_D = -5V, V_S = +14V, see Note 3	-10.0	10.0
50	D1_Idon_1	nA	V_{IN1} = 4.0V, V_S = V_D = +14V	-10.0	10.0
51	D2_Idon_1	nA	V_{IN2} = 4.0V, V_S = V_D = +14V	-10.0	10.0
52	D1_Idon_2	nA	V_{IN1} = 4.0V, V_S = V_D = -5V, see Note 3	-10.0	10.0
53	D2_Idon_2	nA	V_{IN2} = 4.0V, V_S = V_D = -5V, see Note 3	-10.0	10.0
60	Rds_1P_10V	W	V_{IN1} = 4.0V, V_D = +7.5V, V_{SS} = -10V, V_{DD} = +10V		70
61	Rds_2P_10V	W	V_{IN2} = 4.0V, V_D = +7.5V, V_{SS} = -10V, V_{DD} = +10V		70
62	Rds_1N_10V	W	V_{IN1} = 4.0V, V_D = -7.5V, V_{SS} = -10V, V_{DD} = +10V		70
63	Rds_2N_10V	W	V_{IN2} = 4.0V, V_D = -7.5V, V_{SS} = -10V, V_{DD} = +10V		70
70	Rds_1P_15V	W	V_{IN1} = 4.0V, V_D = +10V, V_{SS} = -15V, V_{DD} = +15V		50
71	Rds_2P_15V	W	V_{IN2} = 4.0V, V_D = +10V, V_{SS} = -15V, V_{DD} = +15V		50
72	Rds_1N_15V	W	V_{IN1} = 4.0V, V_D = -10V, V_{SS} = -15V, V_{DD} = +15V		50
73	Rds_2N_15V	W	V_{IN2} = 4.0V, V_D = -10V, V_{SS} = -15V, V_{DD} = +15V		50

Notes:

1/ These are the manufacturer's non-irradiated data sheet specification limits. The manufacturer provided no post-irradiation limits at the time the tests were performed.

2/ Supplies = +15V, -15V; V_{IN} = Logic Input. V_{IN} for Logic "1" = 4V, for Logic "0" = 0.8V, unless otherwise specified.

3/ The Digital Voltage Level range of the ATE is from -5.2V to 15.0V. Because of this limitation, Isoff, Idoff and Idon2 are performed at V_S and V_D of -5V instead of -14V. In addition, the test limits for Isoff, Idoff and Idon1 are changed from ±1nA to ±10nA and the test limits for Idon2 are changed from ±2nA to ±10nA because the "open socket leakage current" for these tests was greater than ±1nA on the ATE (A540).

TABLE IV: Summary of Electrical Measurements after Total Dose Exposures and Annealing for HI300 /1

					Total Dose Exposure (kRads Si)						Annealing		Total Dose Exposure (kRads Si)										Annealing	
					Initial		2.5		5.0		168 hours @25°C		10.0		15.0		20.0		30.0		50.0		168 hours @25°C	
Test #	Parameters	Units	Spec. Lim. /2 min	max	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
1	Functional_100kHz	P/F			P		P		P		P		P		P		P		P		P		P	
10	IDD_vil	?A	-1.0	10.0	-0.3	0.2	1.7	0.7	3.4	1.4	2.2	0.7	3.4	0.6	6.6	1.5	7.3	2.2	8.8	2.7	30	11	3.6	0.9
11	ISS_vil	?A	-10.0	1.0	-0.3	0.1	-0.3	0.1	-0.3	0.1	-0.3	0.1	-1.7	0.2	-7.0	1.4	-6.9	1.9	-8.7	2.5	-35	12	-4.7	1.1
12	IDD_vih	mA	0	1.00	0.76	0.02	0.69	0.02	0.62	0.03	0.58	0.02	0.51	0.02	0.42	0.02	0.35	0.02	0.29	0.02	0.13	0.03	0.11	0.02
13	ISS_vih	?A	-10.0	0	-0.3	0.1	-1.2	0.7	-3.6	2.3	-0.3	0.1	-2.3	1.4	-3.5	1.4	-5.8	1.8	-7.6	2.2	-23	9	-2.1	0.7
20	A1_Iil_0V	nA	-1000	1000	-1	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	A2_Iil_0V	nA	-1000	1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	A1_Iil_5V	nA	-1000	1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	A2_Iil_5V	nA	-1000	1000	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
24	A1_Iil_15V	nA	-1000	1000	6	0	6	0	6	0	6	0	6	0	6	0	6	0	6	0	6	0	6	0
25	A2_Iil_15V	nA	-1000	1000	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0
30	S1_Isoff_1	nA	-10.0	10.0	1.4	0	2.0	0.1	2.8	0.6	2.3	0.4	165	26	825	150	78	5	20	2	1819	414	483	58
31	S2_Isoff_1	nA	-10.0	10.0	1.3	0	1.3	0.1	2.8	0.5	2.4	0.2	180	31	866	152	82	7	22	2	1880	412	501	57
32	S1_Isoff_2	nA	-10.0	10.0	1.3	0.1	1.4	0.1	1.4	0	1.4	0	1.5	0.1	1.7	0.2	1.4	0.2	1.5	0.1	4.6	0.8	1.8	0.4
33	S2_Isoff_2	nA	-10.0	10.0	-0.5	0	-0.5	0.1	-0.3	0.1	-0.4	0.1	0.3	0.3	0.5	0.1	0.1	0.1	0.5	0.4	4.0	0.9	0.2	0.1
40	D1_Idoff_1	nA	-10.0	10.0	-0.5	0	-0.2	0.1	0.3	0.1	-0.3	0.1	5.8	1.4	37	11.8	101	32	140	46	437	192	27	12
41	D2_Idoff_1	nA	-10.0	10.0	1.1	0.1	1.9	0.1	2.2	0.1	2.1	0.1	8.0	1.5	40	11.8	103	32	143	46	437	191	29	12
42	D1_Idoff_2	nA	-10.0	10.0	1.2	0.1	1.3	0	1.3	0	1.3	0	1.3	0.1	1.8	0.3	2.3	0.3	1.9	0.4	3.8	1.4	2.5	0
43	D2_Idoff_2	nA	-10.0	10.0	-0.6	0.1	-0.6	0.1	-0.4	0.1	-0.4	0.1	-0.1	0.1	-0.3	0.1	0.0	0.3	-0.1	0.1	2.3	1.3	0.6	0.2
50	D1_Idon_1	nA	-10.0	10.0	-0.3	0	223	151	805	536	3.3	2.9	395	331	148	86	26	14	23	15	522	658	7.6	4.3
51	D2_Idon_1	nA	-10.0	10.0	1.6	0.1	225	149	827	558	5.4	3.0	402	333	238	172	52	48	38	30	433	191	12.9	8.0
52	D1_Idon_2	nA	-10.0	10.0	1.4	0	217	144	767	501	4.9	2.8	360	294	130	69	22	11	20	12	26	32	7.5	3.4
53	D2_Idon_2	nA	-10.0	10.0	-0.6	0	218	145	789	529	2.9	2.9	357	292	161	99	28	22	23	18	2.0	1.3	6.1	4.2
60	Rds_1P_10V	?		70	35	0.5	37	0.6	40	1.6	38	0.5	43	1.2	48	1.1	55	1.8	62	2.4	105	6	94	5
61	Rds_2P_10V	?		70	35	0.5	37	0.7	40	1.7	37	0.5	42	1.2	47	0.9	53	1.6	61	2.1	102	5	92	4
62	Rds_1N_10V	?		70	40	0.5	42	0.6	42	1.6	44	0.6	47	1.3	54	1.4	62	2.1	71	2.9	105	4	100	4
63	Rds_2N_10V	?		70	40	0.5	42	0.5	43	1.4	44	0.6	47	1.1	54	1.2	62	1.8	71	2.5	104	3	99	3
70	Rds_1P_15V	?		50	26	0.3	27	0.4	29	1.3	27	0.3	30	0.9	32	0.5	34	0.7	37	0.8	615	470	45	1.3
71	Rds_2P_15V	?		50	26	0.3	26	0.5	29	1.4	27	0.3	29	0.9	37	0.6	33	0.6	36	0.7	955	0.1	44	1.1
72	Rds_1N_15V	?		50	31	0.3	32	0.4	32	1.2	33	0.4	34	0.8	37	0.6	40	0.8	43	0.9	416	451	52	1.4
73	Rds_2N_15V	?		50	31	0.3	32	0.4	32	1.2	34	0.3	34	0.8	37	0.6	40	0.7	43	0.8	955	0	52	1.3

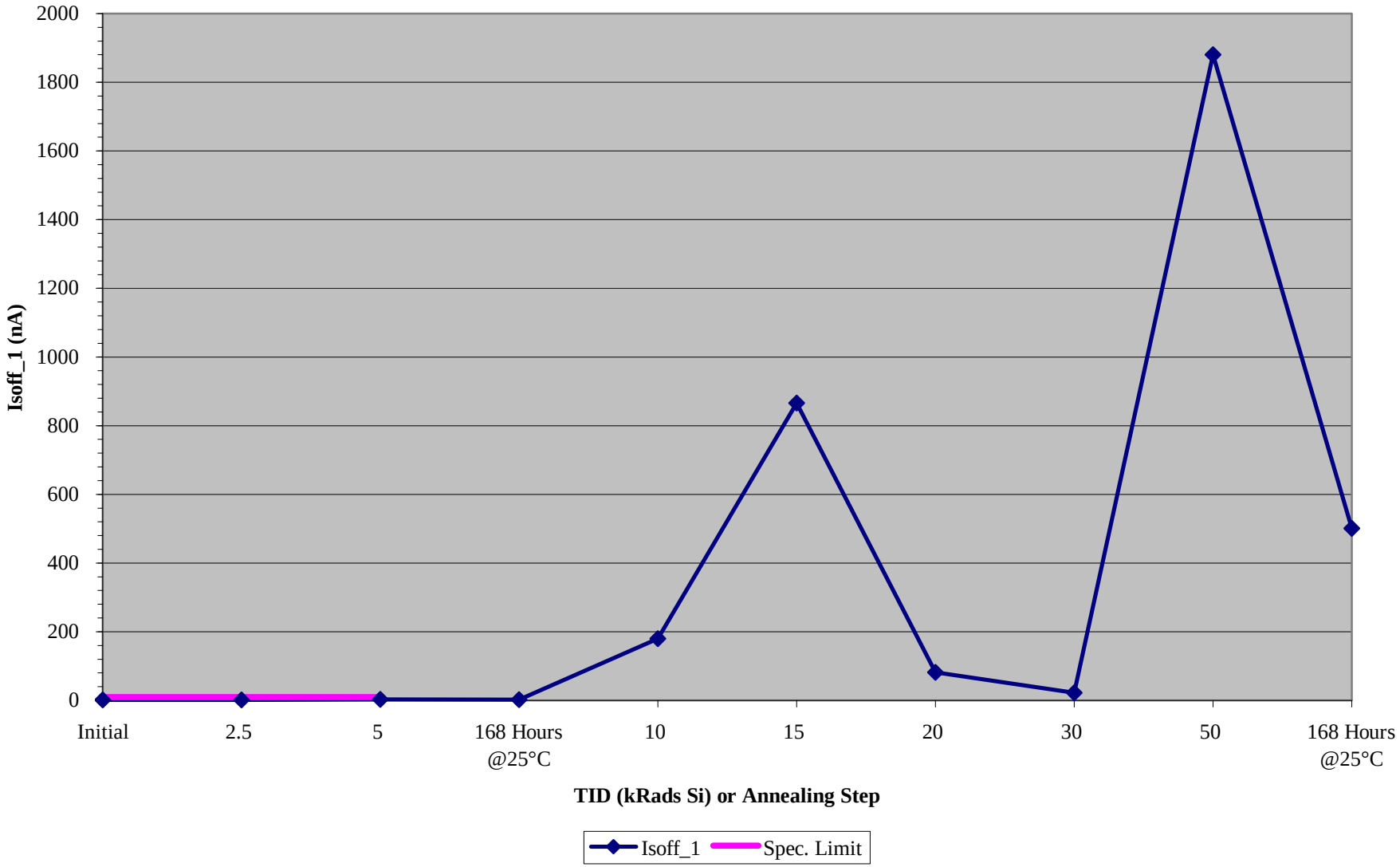
Notes:

1/ The mean and standard deviation values were calculated over the eight parts irradiated in this testing. The control samples remained constant throughout testing and are not included in this table.

2/ These are manufacturer's pre-irradiation data sheet specification limits. No post-irradiation limits were provided by the manufacturer at the time the tests were performed.

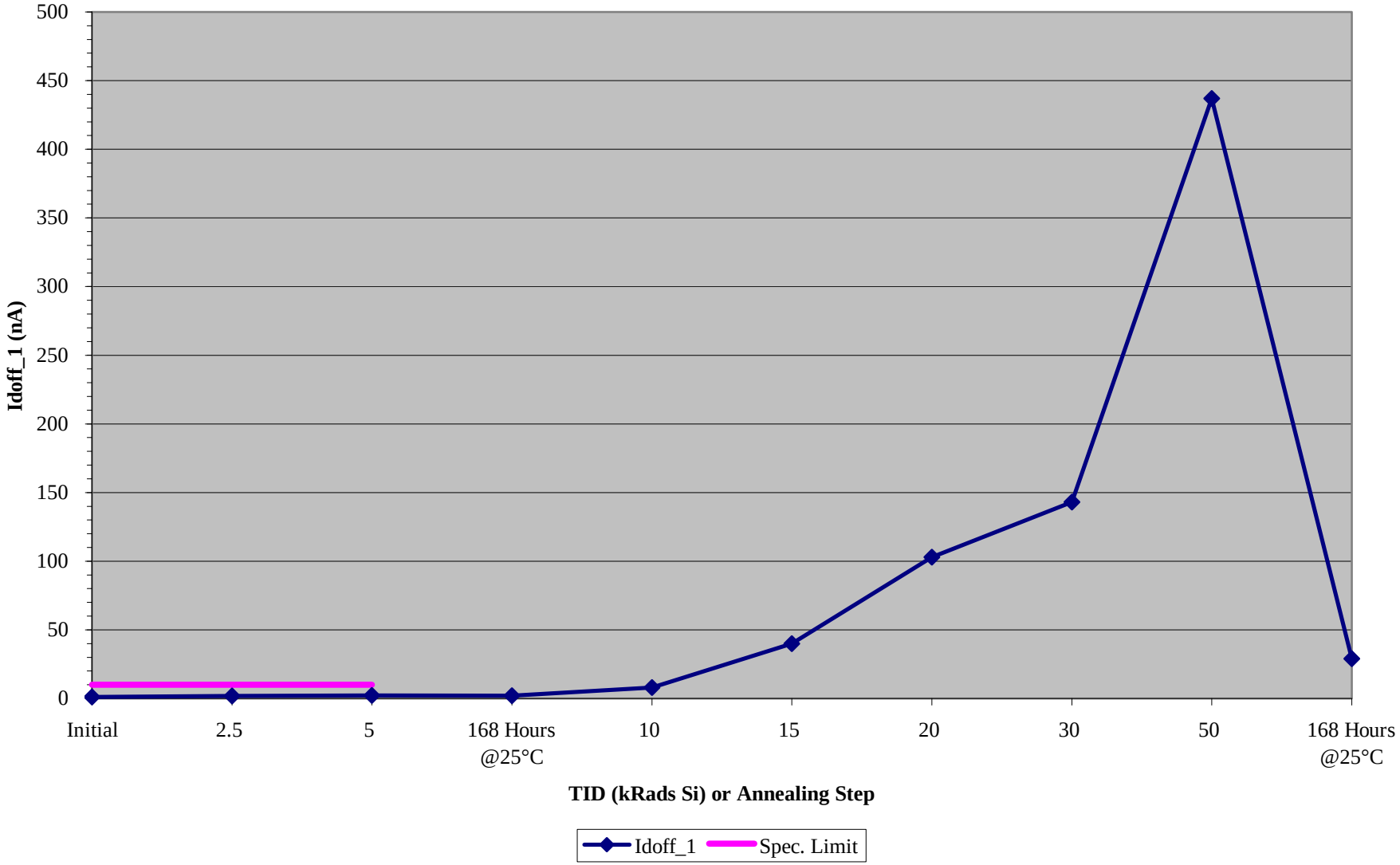
Radiation sensitive parameters: IDD_vil, ISS_vil, ISS_vih, Isoff1, Idoff1, Idon1, Idon2, Rds_10V, Rds_15V.

Figure 2: Isoff_1 vs Total Ionizing Dose (kRads Si) for HI300



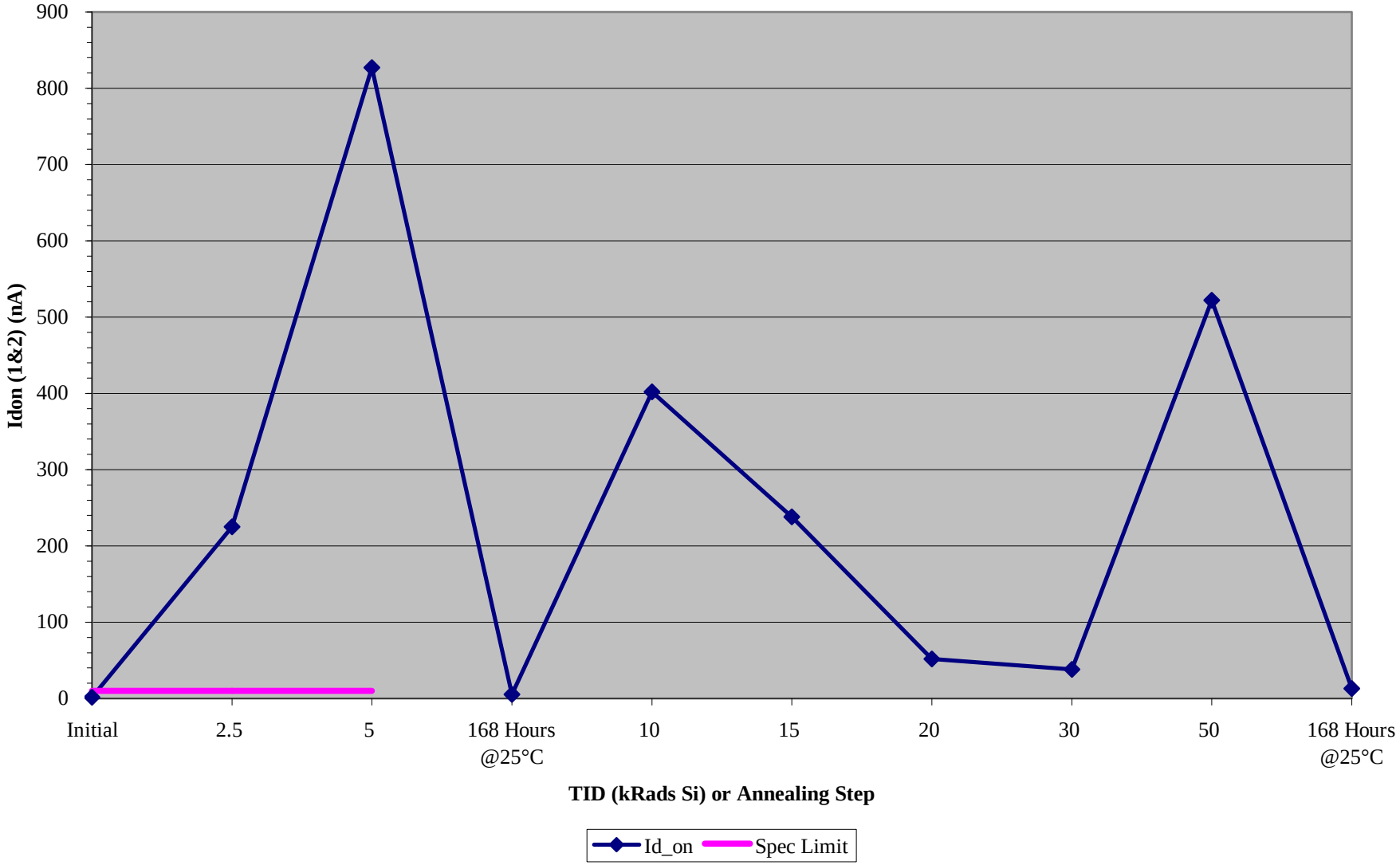
The values of Isoff_1 shown correspond to the one of the two measurements that had the most degradation at that TID or annealing step.

Figure 3: Idoff_1 vs Total Ionizing Dose (kRads Si) for HI300



The values of Idoff_1 shown correspond to the one of the two measurements that had the most degradation at that TID or annealing step.

Figure 4: Idon (1&2) vs Total Ionizing Dose (kRads Si) for HI300



The values of Idon shown correspond to the one of the four measurements that had the most degradation at that TID or annealing step.