# TOTAL IONIZING DOSE TEST REPORT

*No. 07T-RTAX2000S-D2T2A1*
*Sept. 5, 2007*
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## I. SUMMARY TABLE

| Parameter | Tolerance |
|---|---|
| 1. Functionality | Passed 300 krad($SiO_2$) |
| 2. Standby Power Supply Current ($I_{CCA}/I_{CCI}$) | Passed 200 krad($SiO_2$) |
| 3. Input Threshold ($V_{TIL}/V_{IH}$) | Passed 300 krad($SiO_2$) |
| 4. Output Threshold ($V_{OL}/V_{OH}$) | Passed 300 krad($SiO_2$) |
| 5. Propagation Delay | Passed 300 krad($SiO_2$) for ±10% degradation criterion |
| 6. Transition Characteristic | Passed 300 krad($SiO_2$) |

## II. TOTAL IONIZING DOSE (TID) TESTING

The design of the following testing is based on an extensive, published database accumulated from the TID testing of many generations of antifuse-based FPGAs; the link of the database is in below.

http://www.actel.com/products/milaero/hireldata.aspx#tid

### *A. Device-Under-Test (DUT) and Irradiation Parameters*

Table 1 lists the DUT and irradiation parameters. Each input is grounded during irradiation and annealing.

Table 1 DUT and Irradiation Parameters

| | |
|---|---|
| Part Number | RTAX2000S |
| Package | CG624 |
| Foundry | United Microelectronics Corp. |
| Technology | 0.15 µm CMOS |
| DUT Design | rtax2000_CG624_Top |
| Die Lot Number | D2T2A1 |
| Quantity Tested | 6 |
| Serial Number | 300 krad($SiO_2$): 3095, 3124, 3147<br>200 krad($SiO_2$): 3148, 3149, 3176 |
| Radiation Facility | Defense Microelectronics Activity |
| Radiation Source | Co-60 |
| Dose Rate (±5%) | 5 krad($SiO_2$)/min |
| Irradiation Temperature | Room |
| Irradiation and Annealing Bias $V_{CCI}/V_{CCA}$ | Static at 3.3 V/1.5 V |
| IO Configuration | Single ended: LVTTL<br>Differential pair: LVPECL |

## B. *Test Method*

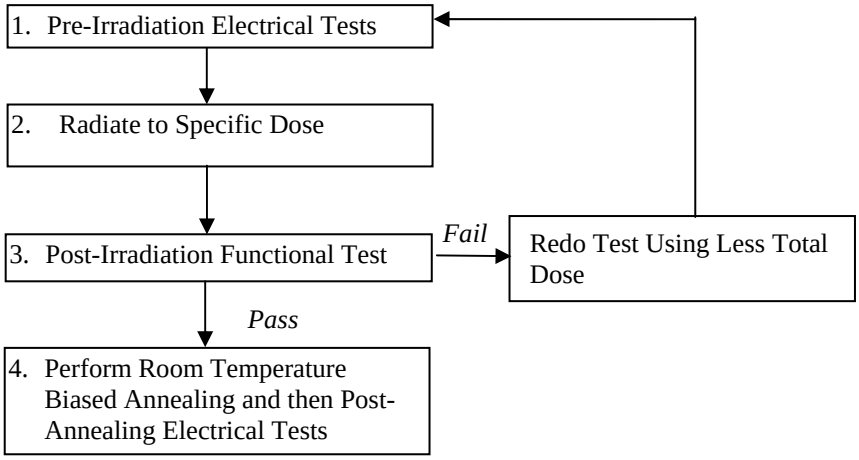


Figure 1 Parametric test flow chart

The test method basically is in compliance with the military standard TM1019.6. Figure 1 is the flow chart of the testing sequence. The accelerated annealing test in section 3.12 is not performed lot-to-lot. This is because for a deep-submicron CMOS technology used by the RTAXS product, the adverse effects due to interface state at the gate $SiO_2$/Si interface are negligible. The function of commercial non-irradiated transistors would be unreliable if the degradation of interface plays an important role. In other words, the $SiO_2$/Si interface in deep submicron CMOS transistors has to be radiation hard for even commercial applications. Thus the dominant annealing effect in RTAXS device is the reduction of trapped holes in the $SiO_2$; this basically alleviates the radiation effects on the DUT. Separate report on the accelerated annealing test will be provided to justify the omission of it in the lot testing; the justification testing will follow section 3.12.1.b.5.

Section 3.11 extended room temperature anneal test is also applied; room temperature annealing for 5 days was done on each device before the final parameter measurements.

## C. *Logic Design and Electrical Parameter Measurements*

The DUT uses a high utilization generic design, rtax2000_CG624_Top, for testing total dose effects. These logic designs are described in the following subsections. Figure 2 shows the block diagram and the Verilog file (rtax2000_CG624_Top.v) is in the link:

http://www.actel.com/products/milaero/hireldata.aspx#tid

Generally, the functional test is performed on every design; most inputs are tested for threshold voltage and leakage current, including global clocks; the standby $I_{CC}$ includes $I_{CCI}$ and $I_{CCA}$. Except propagation delay and the transition characteristic, which is measured on the output O_BS, all other parameter measurements are done on a tester. Also note that, due to logistics limitation, the post-irradiation but pre-room-temperature-annealing functional test is performed on bench; the tested designs are shift registers and long buffer string, which are design 5 and 6 described in the following.

### 1. Embedded SRAM

This design is to test the function of the embedded SRAM. It uses all the RAM blocks available in the DUT. This design enables an automatic testing sequence that every bit is written and then read. Any error will be reported as a signal in the output.

### 2. Unidirectional LVTTL Input and Output

This is for testing radiation effects on unidirectional input and output threshold, leakage, and buffer fan-out. There are 3 sub-designs: a) a logic-core buffer with 8 fan-outs; b) a logic-core buffer with 3 fan-outs; c) 6 channels of input buffer directly connected to output buffer without core logic. LVTTL is used because it is the worst case among all the single-ended standards.

3. Bidirectional LVTTL IO

This design is for testing the radiation effects on the input/output characteristic of the bidirectional IO. There are 7 channels of bidirectional IO for radiation effects testing.

4. LVPECL Input

This design is for testing the radiation effects on the LVPECL differential inputs. 3.3V-LVPECL is considered the worst case differential input standard in the DUT. There are 7 channels.

5. Shift Registers

This design is to test the radiation effects on the function of flip-flops, which are configured R-Cells. There are 4 shift registers and each using a different global clock; one has 3,584 bits and the other three each has 2,048 bits.

6. Long Buffer String

This design is to measure the radiation effects on the propagation delay. The input of the design using a clock feeding a toggle flip-flop to generate a checkerboard signal; this signal is then fed into a buffer string with 10,000 stages. The time delay between the input clock edge at CLOCK_IN and the output switching due to this clock edge at O_BS is defined as propagation delay high to low ($T_{pdhl}$) or low to high ($T_{pdlh}$); the percentage change of the average of $T_{pdhl}$ and $T_{pdlh}$ is used to determine the radiation effects. A more than 10% of propagation change is considered as failure.

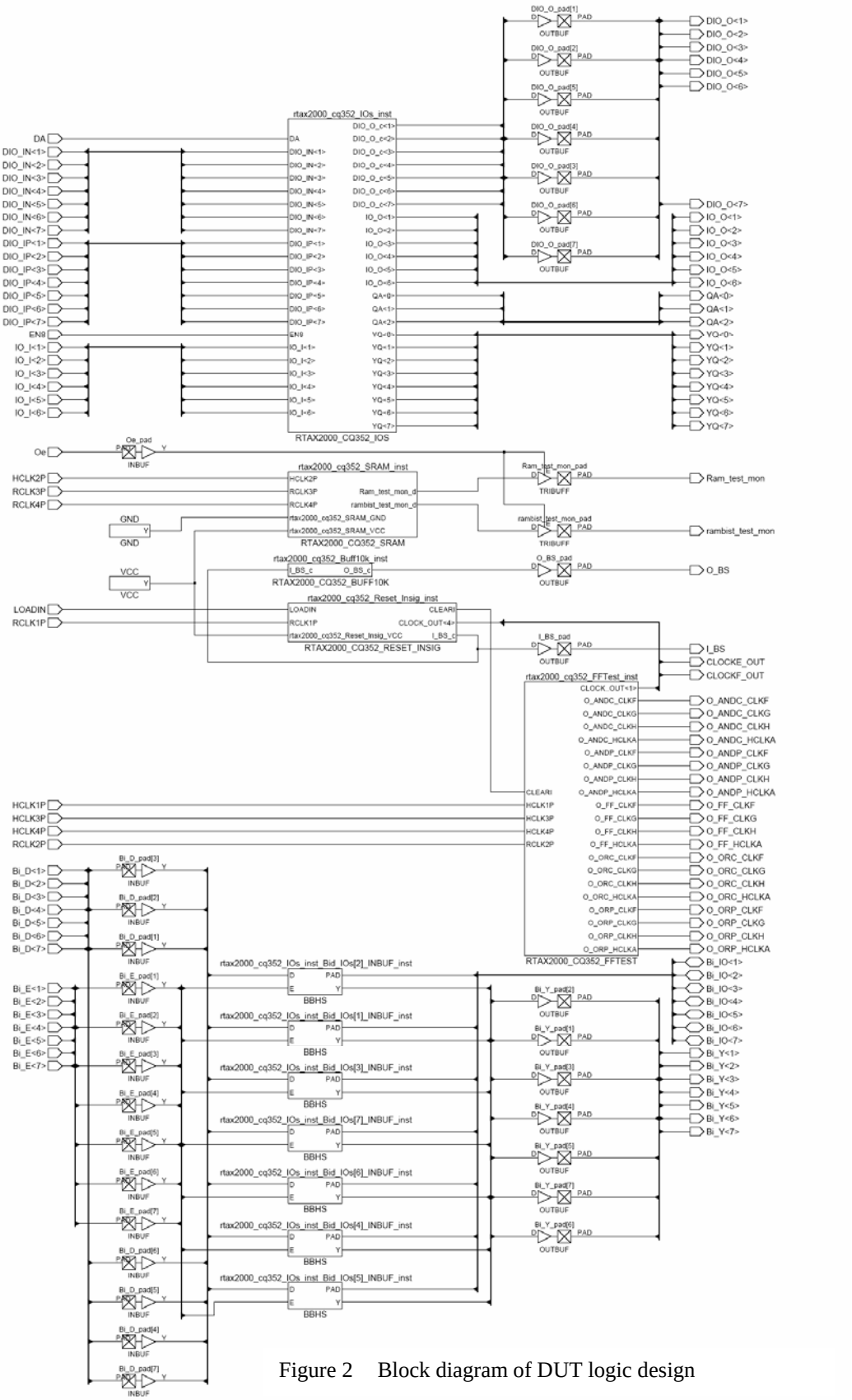


Figure 2 Block diagram of DUT logic design

## III. TEST RESULTS

### A. *Functional Test*

Every DUT passed the pre-irradiation and post-annealing functional tests on the tester; it also passed post-irradiation test on-bench.

### B. *Standby Power Supply Current ($I_{CCA}$ and $I_{CCI}$)*

Figure 3-8 show the in-flux standby $I_{CCA}$ and $I_{CCI}$ versus total dose of every DUT.

In compliance with TM1019.6 subsection 3.11.2.c, the post-irradiation-parametric limit (PIPL) for the post-annealing $I_{CC}$ in this test is defined as the addition of highest $I_{CCI}$, $I_{CCDA}$ and $I_{CCDIFFA}$ values in Table 2-4 of the RTAXS spec sheet:

http://www.actel.com/documents/RTAXS_DS.pdf

Thus for $I_{CCA}$, the PIPL is 500 mA; the PIPL of $I_{CCI}$ equals to 35+10+3.13×7 = 66.91(mA). Note that there are 7 pairs of differential LVPECL inputs in each DUT.

Table 2 summarizes the pre-irradiation, post-irradiation and post-annealing $I_{CC}$ data: the post-annealing $I_{CCA}$ of every DUT pass the PIPL easily; the post-annealing $I_{CCI}$ of DUTs irradiated to 200 krad($SiO_2$) all pass the PIPL, while the $I_{CCI}$ of DUTs irradiated to 300 krad($SiO_2$) all exceed the PIPL.

Table 2 Pre-irradiation, Post Irradiation and Post-Annealing $I_{CC}$

| DUT | Total Dose krad ($SiO_2$) | $I_{CCA}$ (mA) | | | $I_{CCI}$ (mA) | | |
|---|---|---|---|---|---|---|---|
| | | Pre-irrad | Post-irrad | Post-ann | Pre-irrad | Post-irrad | Post-ann |
| 3095 | 300 | 9.6 | 30.2 | 9.1 | 25.6 | 255 | 112 |
| 3124 | 300 | 4.5 | 140 | 12.2 | 25.5 | 289 | 233 |
| 3147 | 300 | 9.0 | 40 | 9.0 | 26.0 | 267 | 136 |
| 3148 | 200 | 7.6 | 7.9 | 7.8 | 25.5 | 80 | 40.1 |
| 3149 | 200 | 2.0 | 2.35 | 1.4 | 24.5 | 139 | 60.0 |
| 3176 | 200 | 7.5 | 7.1 | 8.5 | 25.2 | 94 | 44.1 |

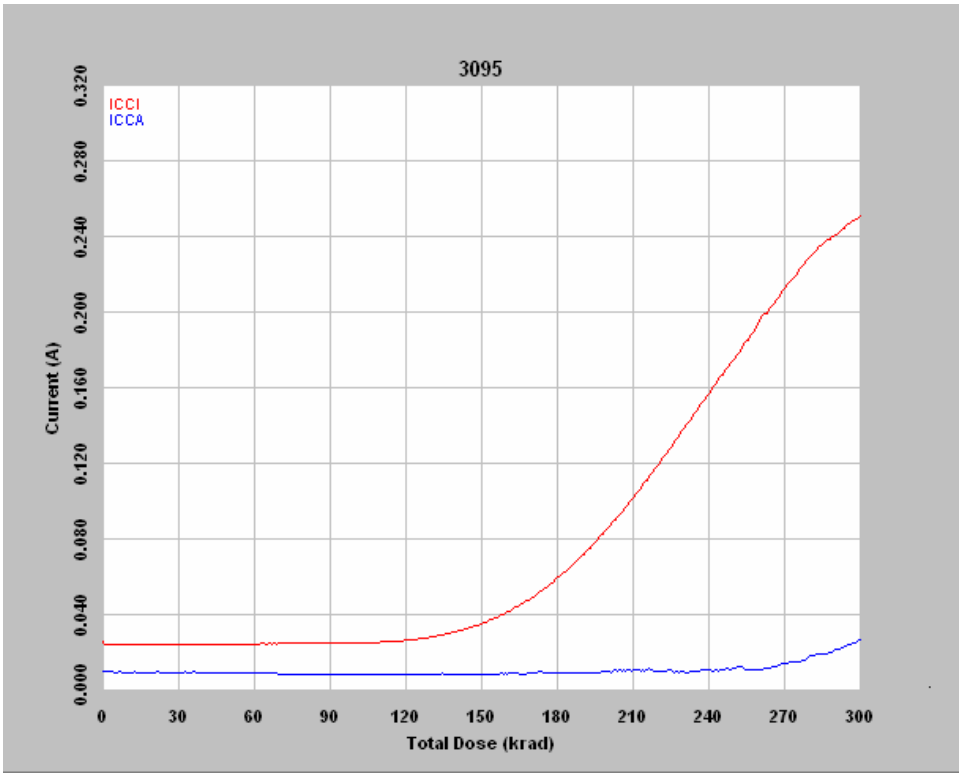


Figure 3 DUT 3095 in-flux $I_{CCA}$ and $I_{CCI}$. The spikes are due to bad contacts.

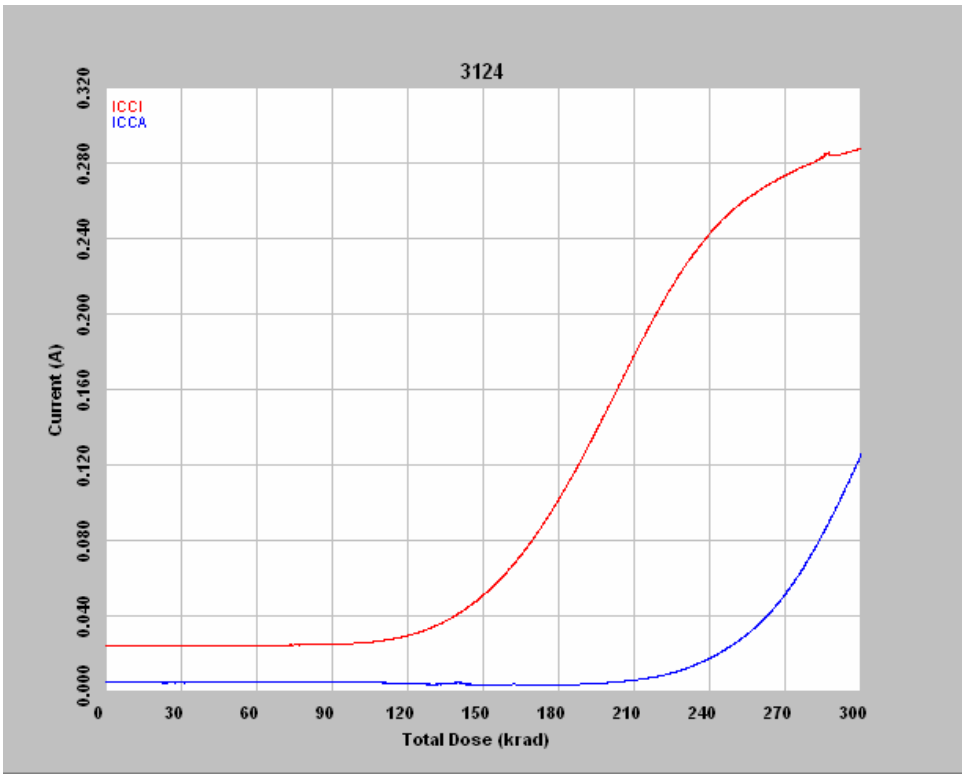


Figure 4 DUT 3124 in-flux $I_{CCA}$ and $I_{CCI}$

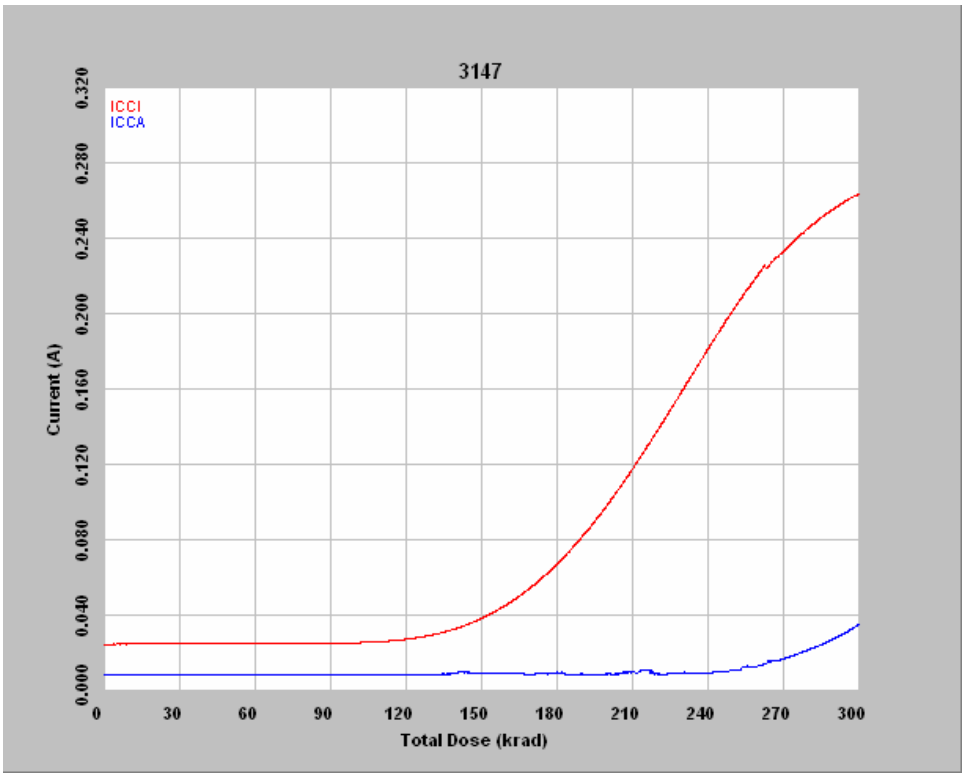


Figure 5 DUT 3147 in-flux $I_{CCA}$ and $I_{CCI}$

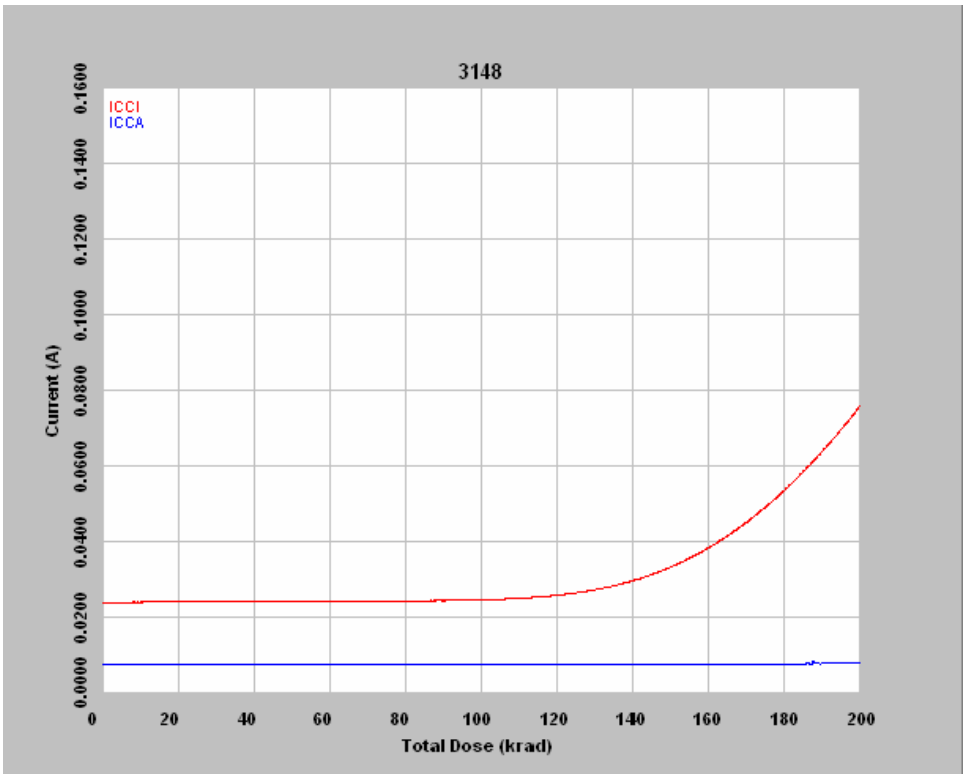


Figure 6 DUT 3148 in-flux $I_{CCA}$ and $I_{CCI}$

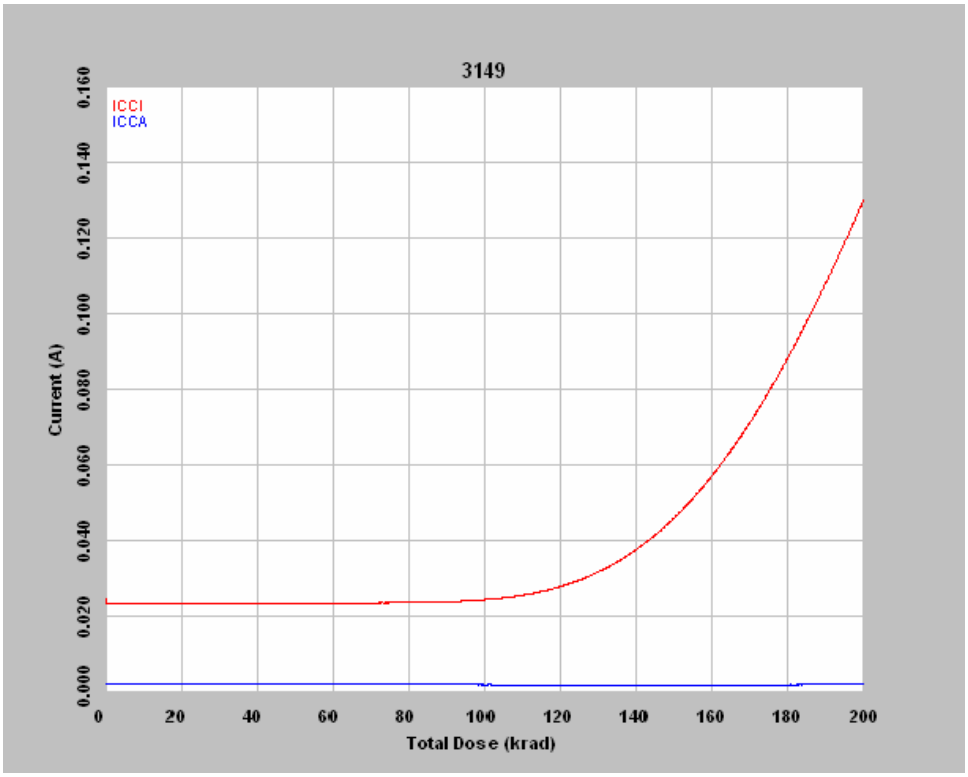


Figure 7 DUT 3149 in-flux $I_{CCA}$ and $I_{CCI}$

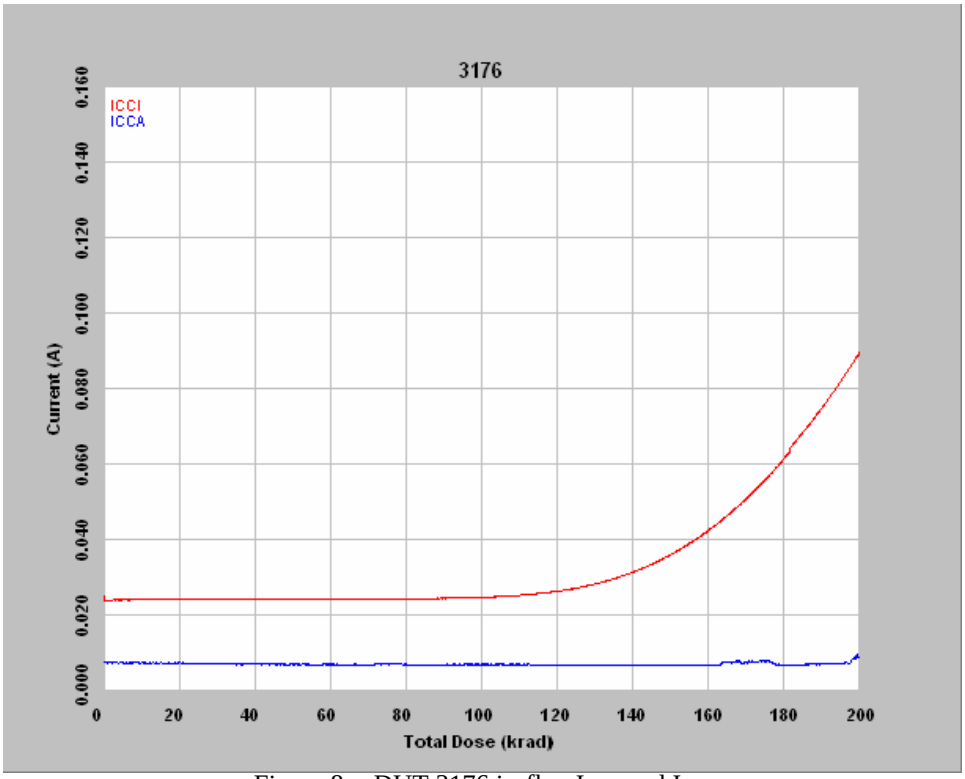


Figure 8 DUT 3176 in-flux $I_{CCA}$ and $I_{CCI}$

### C. *Single-Ended $V_{IL}/V_{IH}$ and $I_{IL}/I_{IH}$*

Table 3 displays the pre-irradiation and post-annealing single-ended $V_{IL}$; every data in this table passes the spec. Table 4 displays the pre-irradiation and post-annealing single-ended $V_{IH}$; every data in this table passes the spec.

Table 5 displays the pre-irradiation and post-annealing single-ended $I_{IL}$; every data in the table passes the spec. Table 6 displays the pre-irradiation and post-annealing single-ended $I_{IH}$; every data in the table passes the spec. The PIPL for both $I_{IL}$ and $I_{IH}$ is 5 µA.

Table 3a

| **DUT** | | **3095** | | **3124** | | **3147** | |
|---|---|---|---|---|---|---|---|
| Parameter (V) | Design | Pre-Irrad | Post-Ann | Pre-Irrad | Post-Ann | Pre-Irrad | Post-Ann |
| bi_levels_vil | Bi_D_7 | 1.38 | 1.37 | 1.385 | 1.375 | 1.375 | 1.37 |
| bi_levels_vil | Bi_D_6 | 1.36 | 1.355 | 1.365 | 1.36 | 1.36 | 1.355 |
| bi_levels_vil | Bi_D_5 | 1.37 | 1.365 | 1.375 | 1.365 | 1.375 | 1.365 |
| bi_levels_vil | Bi_D_4 | 1.38 | 1.37 | 1.38 | 1.37 | 1.375 | 1.365 |
| bi_levels_vil | Bi_D_3 | 1.37 | 1.365 | 1.375 | 1.365 | 1.37 | 1.365 |
| bi_levels_vil | Bi_D_2 | 1.37 | 1.365 | 1.37 | 1.365 | 1.37 | 1.36 |
| bi_levels_vil | Bi_D_1 | 1.365 | 1.36 | 1.37 | 1.36 | 1.365 | 1.355 |
| bi_levels_vil | DA | 1.385 | 1.385 | 1.385 | 1.385 | 1.385 | 1.37 |
| bi_levels_vil | EN8 | 1.355 | 1.355 | 1.355 | 1.345 | 1.345 | 1.335 |
| bi_levels_vil | IO_I_6 | 1.365 | 1.355 | 1.36 | 1.355 | 1.36 | 1.355 |
| bi_levels_vil | IO_I_5 | 1.355 | 1.355 | 1.355 | 1.355 | 1.34 | 1.345 |
| bi_levels_vil | IO_I_4 | 1.405 | 1.395 | 1.4 | 1.39 | 1.395 | 1.39 |
| bi_levels_vil | IO_I_3 | 1.395 | 1.395 | 1.38 | 1.39 | 1.395 | 1.385 |
| bi_levels_vil | IO_I_2 | 1.4 | 1.395 | 1.4 | 1.395 | 1.395 | 1.39 |
| bi_levels_vil | IO_I_1 | 1.395 | 1.39 | 1.4 | 1.39 | 1.39 | 1.395 |
| bi_levels_vil | RCLK1P | 1.445 | 1.44 | 1.445 | 1.44 | 1.44 | 1.435 |
| bi_levels_vil | RCLK2P | 1.445 | 1.44 | 1.445 | 1.44 | 1.44 | 1.435 |

Table 3b

| **DUT** | | **3148** | | **3149** | | **3176** | |
|---|---|---|---|---|---|---|---|
| Parameter (V) | Design | Pre-Irrad | Post-Ann | Pre-Irrad | Post-Ann | Pre-Irrad | Post-Ann |
| bi_levels_vil | Bi_D_7 | 1.38 | 1.37 | 1.38 | 1.37 | 1.38 | 1.37 |
| bi_levels_vil | Bi_D_6 | 1.365 | 1.355 | 1.365 | 1.355 | 1.36 | 1.355 |
| bi_levels_vil | Bi_D_5 | 1.375 | 1.365 | 1.375 | 1.365 | 1.37 | 1.365 |
| bi_levels_vil | Bi_D_4 | 1.38 | 1.375 | 1.375 | 1.37 | 1.375 | 1.37 |
| bi_levels_vil | Bi_D_3 | 1.37 | 1.365 | 1.375 | 1.365 | 1.37 | 1.36 |
| bi_levels_vil | Bi_D_2 | 1.37 | 1.365 | 1.365 | 1.36 | 1.365 | 1.36 |
| bi_levels_vil | Bi_D_1 | 1.37 | 1.36 | 1.365 | 1.36 | 1.365 | 1.36 |
| bi_levels_vil | DA | 1.38 | 1.385 | 1.385 | 1.385 | 1.385 | 1.365 |
| bi_levels_vil | EN8 | 1.345 | 1.34 | 1.345 | 1.34 | 1.355 | 1.335 |
| bi_levels_vil | IO_I_6 | 1.365 | 1.36 | 1.355 | 1.355 | 1.355 | 1.36 |
| bi_levels_vil | IO_I_5 | 1.355 | 1.35 | 1.345 | 1.35 | 1.345 | 1.345 |
| bi_levels_vil | IO_I_4 | 1.4 | 1.395 | 1.39 | 1.39 | 1.39 | 1.39 |
| bi_levels_vil | IO_I_3 | 1.4 | 1.395 | 1.385 | 1.395 | 1.395 | 1.385 |
| bi_levels_vil | IO_I_2 | 1.4 | 1.395 | 1.395 | 1.39 | 1.395 | 1.39 |
| bi_levels_vil | IO_I_1 | 1.405 | 1.395 | 1.395 | 1.395 | 1.395 | 1.385 |
| bi_levels_vil | RCLK1P | 1.445 | 1.44 | 1.44 | 1.435 | 1.445 | 1.44 |
| bi_levels_vil | RCLK2P | 1.445 | 1.44 | 1.44 | 1.435 | 1.445 | 1.44 |

Table 4a

| DUT | | 3095 | | 3124 | | 3147 | |
|---|---|---|---|---|---|---|---|
| Parameter (V) | Design | Pre-Irrad | Post-Ann | Pre-Irrad | Post-Ann | Pre-Irrad | Post-Ann |
| bi_levels_vih | Bi_D_7 | 1.38 | 1.37 | 1.38 | 1.375 | 1.375 | 1.365 |
| bi_levels_vih | Bi_D_6 | 1.385 | 1.38 | 1.385 | 1.38 | 1.385 | 1.38 |
| bi_levels_vih | Bi_D_5 | 1.38 | 1.375 | 1.385 | 1.365 | 1.38 | 1.375 |
| bi_levels_vih | Bi_D_4 | 1.38 | 1.37 | 1.38 | 1.37 | 1.375 | 1.365 |
| bi_levels_vih | Bi_D_3 | 1.385 | 1.38 | 1.385 | 1.38 | 1.385 | 1.38 |
| bi_levels_vih | Bi_D_2 | 1.385 | 1.38 | 1.385 | 1.38 | 1.385 | 1.375 |
| bi_levels_vih | Bi_D_1 | 1.385 | 1.375 | 1.38 | 1.375 | 1.38 | 1.37 |
| bi_levels_vih | DA | 1.4 | 1.395 | 1.4 | 1.39 | 1.39 | 1.39 |
| bi_levels_vih | EN8 | 1.455 | 1.445 | 1.45 | 0 | 1.445 | 1.44 |
| bi_levels_vih | IO_I_6 | 1.415 | 1.41 | 1.42 | 1.45 | 1.415 | 1.41 |
| bi_levels_vih | IO_I_5 | 1.43 | 1.42 | 1.43 | 1.415 | 1.43 | 1.395 |
| bi_levels_vih | IO_I_4 | 1.395 | 1.39 | 1.395 | 1.43 | 1.39 | 1.385 |
| bi_levels_vih | IO_I_3 | 1.405 | 1.4 | 1.405 | 1.385 | 1.4 | 1.395 |
| bi_levels_vih | IO_I_2 | 1.395 | 1.39 | 1.395 | 1.4 | 1.39 | 1.385 |
| bi_levels_vih | IO_I_1 | 1.405 | 1.395 | 1.405 | 1.39 | 1.4 | 1.395 |
| bi_levels_vih | RCLK1P | 1.44 | 1.43 | 1.435 | 1.4 | 1.435 | 1.425 |
| bi_levels_vih | RCLK2P | 1.445 | 1.435 | 1.445 | 1.43 | 1.44 | 1.43 |

Table 4b

| DUT | | 3148 | | 3149 | | 3176 | |
|---|---|---|---|---|---|---|---|
| Parameter (V) | Design | Pre-Irrad | Post-Ann | Pre-Irrad | Post-Ann | Pre-Irrad | Post-Ann |
| bi_levels_vih | Bi_D_7 | 1.38 | 1.37 | 1.38 | 1.37 | 1.38 | 1.37 |
| bi_levels_vih | Bi_D_6 | 1.365 | 1.355 | 1.365 | 1.355 | 1.36 | 1.355 |
| bi_levels_vih | Bi_D_5 | 1.375 | 1.365 | 1.375 | 1.365 | 1.37 | 1.365 |
| bi_levels_vih | Bi_D_4 | 1.38 | 1.375 | 1.375 | 1.37 | 1.375 | 1.37 |
| bi_levels_vih | Bi_D_3 | 1.37 | 1.365 | 1.375 | 1.365 | 1.37 | 1.36 |
| bi_levels_vih | Bi_D_2 | 1.37 | 1.365 | 1.365 | 1.36 | 1.365 | 1.36 |
| bi_levels_vih | Bi_D_1 | 1.37 | 1.36 | 1.365 | 1.36 | 1.365 | 1.36 |
| bi_levels_vih | DA | 1.38 | 1.385 | 1.385 | 1.385 | 1.385 | 1.365 |
| bi_levels_vih | EN8 | 1.345 | 1.34 | 1.345 | 1.34 | 1.355 | 1.335 |
| bi_levels_vih | IO_I_6 | 1.365 | 1.36 | 1.355 | 1.355 | 1.355 | 1.36 |
| bi_levels_vih | IO_I_5 | 1.355 | 1.35 | 1.345 | 1.35 | 1.345 | 1.345 |
| bi_levels_vih | IO_I_4 | 1.4 | 1.395 | 1.39 | 1.39 | 1.39 | 1.39 |
| bi_levels_vih | IO_I_3 | 1.4 | 1.395 | 1.385 | 1.395 | 1.395 | 1.385 |
| bi_levels_vih | IO_I_2 | 1.4 | 1.395 | 1.395 | 1.39 | 1.395 | 1.39 |
| bi_levels_vih | IO_I_1 | 1.405 | 1.395 | 1.395 | 1.395 | 1.395 | 1.385 |
| bi_levels_vih | RCLK1P | 1.445 | 1.44 | 1.44 | 1.435 | 1.445 | 1.44 |
| bi_levels_vih | RCLK2P | 1.445 | 1.44 | 1.44 | 1.435 | 1.445 | 1.44 |

Table 5a

| DUT | | 3095 | | | | 3124 | | | | 3147 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | Design | Pre-Irrad | | Post-Ann | | Pre-Irrad | | Post-Ann | | Pre-Irrad | | Post-Ann | |
| IIL_Inputs_Max_ | Bi_D_1 | 2.0 | nA | -506.2 | pA | -1.3 | nA | -1.6 | nA | -2.4 | nA | -1.3 | nA |
| IIL_Inputs_Max_ | Bi_D_2 | 2.4 | nA | -296.9 | pA | 2.6 | nA | 749.4 | pA | -506.2 | pA | 958.7 | pA |
| IIL_Inputs_Max_ | Bi_D_3 | 3.1 | nA | 330.9 | pA | 1.8 | nA | 3.9 | nA | 3.1 | nA | 2.6 | nA |
| IIL_Inputs_Max_ | Bi_D_4 | -3.0 | nA | -3.4 | nA | -4.1 | nA | -7.0 | nA | -2.6 | nA | -2.4 | nA |
| IIL_Inputs_Max_ | Bi_D_5 | -2.6 | nA | -4.1 | nA | -77.4 | pA | -2.8 | nA | -3.6 | nA | -3.6 | nA |
| IIL_Inputs_Max_ | Bi_D_6 | -3.6 | nA | -5.1 | nA | -4.0 | nA | -3.2 | nA | -4.4 | nA | -4.2 | nA |
| IIL_Inputs_Max_ | Bi_D_7 | -3.0 | nA | -4.3 | nA | -2.8 | nA | -5.1 | nA | -4.1 | nA | -3.9 | nA |
| IIL_Inputs_Max_ | Bi_E_1 | -1.8 | nA | -1.4 | nA | -3.4 | nA | -2.4 | nA | -1.1 | nA | -1.8 | nA |
| IIL_Inputs_Max_ | Bi_E_2 | -97.5 | pA | -2.6 | nA | -1.4 | nA | -1.6 | nA | -2.4 | nA | -3.4 | nA |
| IIL_Inputs_Max_ | Bi_E_3 | -516.4 | pA | -1.6 | nA | -1.8 | nA | -4.1 | nA | -935.2 | pA | -1.4 | nA |
| IIL_Inputs_Max_ | Bi_E_4 | -935.2 | pA | -2.0 | nA | -2.2 | nA | -1.8 | nA | -3.0 | nA | -4.1 | nA |
| IIL_Inputs_Max_ | Bi_E_5 | -2.0 | nA | -2.6 | nA | -2.8 | nA | -2.8 | nA | -1.6 | nA | -2.2 | nA |
| IIL_Inputs_Max_ | Bi_E_6 | -2.6 | nA | -3.7 | nA | -935.2 | pA | -4.1 | nA | -3.4 | nA | -4.3 | nA |
| IIL_Inputs_Max_ | Bi_E_7 | -2.2 | nA | -2.6 | nA | -2.4 | nA | -3.4 | nA | -2.0 | nA | -4.5 | nA |
| IIL_Inputs_Max_ | DA | -4.2 | nA | -3.3 | nA | -5.2 | nA | -4.8 | nA | -4.6 | nA | -4.8 | nA |
| IIL_Inputs_Max_ | DIO_IN_1 | 792.8 | pA | -2.8 | nA | -1.7 | nA | -1.1 | nA | 2.0 | nA | 583.5 | pA |
| IIL_Inputs_Max_ | DIO_IN_2 | -3.9 | nA | -4.8 | nA | -3.9 | nA | -1.4 | nA | -4.6 | nA | -2.7 | nA |
| IIL_Inputs_Max_ | DIO_IN_3 | -3.9 | nA | -2.9 | nA | -1.8 | nA | -2.3 | nA | -3.1 | nA | -2.5 | nA |
| IIL_Inputs_Max_ | DIO_IN_4 | -1.3 | nA | -672.2 | pA | 374.2 | pA | 583.5 | pA | 583.5 | pA | -2.6 | nA |
| IIL_Inputs_Max_ | DIO_IN_5 | -2.9 | nA | -3.1 | nA | -1.8 | nA | -3.1 | nA | -3.1 | nA | -1.8 | nA |
| IIL_Inputs_Max_ | DIO_IN_6 | -3.1 | nA | -5.4 | nA | -2.5 | nA | -2.9 | nA | -3.3 | nA | -1.2 | nA |
| IIL_Inputs_Max_ | DIO_IN_7 | -2.1 | nA | -802.2 | pA | -3.7 | nA | -3.7 | nA | -2.9 | nA | -3.1 | nA |
| IIL_Inputs_Max_ | DIO_IP_1 | -3.2 | nA | -2.1 | nA | 1.4 | nA | -3.0 | nA | 164.9 | pA | -1.7 | nA |
| IIL_Inputs_Max_ | DIO_IP_2 | -3.7 | nA | -1.4 | nA | -3.3 | nA | -2.9 | nA | -4.6 | nA | -174.0 | pA |
| IIL_Inputs_Max_ | DIO_IP_3 | 1.0 | nA | 1.0 | nA | 583.5 | pA | -2.1 | nA | -1.3 | nA | -1.9 | nA |
| IIL_Inputs_Max_ | DIO_IP_4 | -3.5 | nA | -3.1 | nA | -1.4 | nA | -802.2 | pA | -174.0 | pA | -3.5 | nA |
| IIL_Inputs_Max_ | DIO_IP_5 | -2.3 | nA | -3.5 | nA | -1.8 | nA | -1.6 | nA | -2.5 | nA | -802.2 | pA |
| IIL_Inputs_Max_ | DIO_IP_6 | -2.5 | nA | -3.3 | nA | -2.5 | nA | -3.1 | nA | -3.3 | nA | -1.6 | nA |
| IIL_Inputs_Max_ | DIO_IP_7 | -2.3 | nA | -2.3 | nA | -1.6 | nA | -383.4 | pA | -1.4 | nA | -2.1 | nA |
| IIL_Inputs_Max_ | EN8 | -2.7 | nA | -1.6 | nA | 873.1 | pA | -2.5 | nA | -1.0 | nA | -1.4 | nA |
| IIL_Inputs_Max_ | HCLK1P | -3.2 | nA | -3.7 | nA | -4.7 | nA | -3.4 | nA | -2.4 | nA | -4.5 | nA |
| IIL_Inputs_Max_ | HCLK2P | 792.8 | pA | -253.6 | pA | -672.2 | pA | 2.7 | nA | -881.4 | pA | -672.2 | pA |
| IIL_Inputs_Max_ | HCLK3P | 3.5 | nA | 1.4 | nA | 4.3 | nA | 3.9 | nA | 2.2 | nA | 2.4 | nA |
| IIL_Inputs_Max_ | HCLK4P | -1.3 | nA | -2.8 | nA | -705.4 | pA | -2.4 | nA | -1.8 | nA | -914.7 | pA |
| IIL_Inputs_Max_ | IO_I_1 | 1.4 | nA | 583.5 | pA | 1.4 | nA | -2.3 | nA | 792.8 | pA | -2.8 | nA |
| IIL_Inputs_Max_ | IO_I_2 | 3.5 | nA | 1.6 | nA | 2.8 | nA | 3.5 | nA | 3.7 | nA | 2.6 | nA |
| IIL_Inputs_Max_ | IO_I_3 | 1.0 | nA | -462.9 | pA | 164.9 | pA | -253.6 | pA | 374.2 | pA | -462.9 | pA |
| IIL_Inputs_Max_ | IO_I_4 | -296.9 | pA | 1.4 | nA | 3.7 | nA | 2.8 | nA | 2.8 | nA | 1.4 | nA |
| IIL_Inputs_Max_ | IO_I_5 | 1.6 | nA | 164.9 | pA | 164.9 | pA | -1.7 | nA | 2.3 | nA | -3.8 | nA |
| IIL_Inputs_Max_ | IO_I_6 | -2.1 | nA | -802.2 | pA | -2.9 | nA | -2.3 | nA | -2.9 | nA | -1.4 | nA |
| IIL_Inputs_Max_ | LOADIN | -4.0 | nA | -6.3 | nA | -4.5 | nA | -7.6 | nA | -6.1 | nA | -6.1 | nA |
| IIL_Inputs_Max_ | RCLK1P | 1.0 | nA | -672.2 | pA | -253.6 | pA | -4.6 | nA | -1.7 | nA | -881.4 | pA |
| IIL_Inputs_Max_ | RCLK2P | 1.4 | nA | -2.0 | nA | -1.1 | nA | -2.8 | nA | -2.0 | nA | -1.8 | nA |
| IIL_Inputs_Max_ | RCLK3P | 3.3 | nA | 2.8 | nA | 2.4 | nA | 2.2 | nA | 3.1 | nA | 3.9 | nA |
| IIL_Inputs_Max_ | RCLK4P | -1.1 | nA | -3.2 | nA | -1.4 | nA | -2.0 | nA | -2.0 | nA | -3.0 | nA |

Table 5b

| DUT | | 3148 | | 3149 | | 3176 | |
|---|---|---|---|---|---|---|---|
| Parameter | Design | Pre-Irrad | Post-Ann | Pre-Irrad | Post-Ann | Pre-Irrad | Post-Ann |
| IIL_Inputs_Max_ | Bi_D_1 | -87.6 pA | -296.9 pA | -506.2 pA | -506.2 pA | -924.7 pA | -1.6 nA |
| IIL_Inputs_Max_ | Bi_D_2 | 2.6 nA | 121.6 pA | 1.8 nA | 1.8 nA | 958.7 pA | 2.0 nA |
| IIL_Inputs_Max_ | Bi_D_3 | 1.6 nA | 2.2 nA | 958.7 pA | 958.7 pA | 2.0 nA | 958.7 pA |
| IIL_Inputs_Max_ | Bi_D_4 | -2.2 nA | -4.3 nA | -3.6 nA | -3.0 nA | -4.7 nA | -4.3 nA |
| IIL_Inputs_Max_ | Bi_D_5 | -2.6 nA | -2.4 nA | -496.0 pA | -3.6 nA | -77.4 pA | -2.8 nA |
| IIL_Inputs_Max_ | Bi_D_6 | -5.5 nA | -6.7 nA | -3.2 nA | -6.3 nA | -1.7 nA | -5.3 nA |
| IIL_Inputs_Max_ | Bi_D_7 | -6.4 nA | -6.4 nA | -3.2 nA | -5.5 nA | -4.9 nA | -5.3 nA |
| IIL_Inputs_Max_ | Bi_E_1 | -2.0 nA | -2.6 nA | -1.1 nA | -935.2 pA | -1.8 nA | -516.4 pA |
| IIL_Inputs_Max_ | Bi_E_2 | -2.4 nA | -2.8 nA | -2.2 nA | -2.2 nA | -725.8 pA | -3.7 nA |
| IIL_Inputs_Max_ | Bi_E_3 | -1.8 nA | -3.0 nA | -4.3 nA | -1.6 nA | -2.6 nA | -1.8 nA |
| IIL_Inputs_Max_ | Bi_E_4 | -2.0 nA | -2.6 nA | -1.8 nA | -2.0 nA | -2.6 nA | -2.6 nA |
| IIL_Inputs_Max_ | Bi_E_5 | -3.0 nA | -2.8 nA | -2.8 nA | -2.0 nA | -306.9 pA | -97.5 pA |
| IIL_Inputs_Max_ | Bi_E_6 | -1.4 nA | -1.8 nA | -2.6 nA | -935.2 pA | -2.2 nA | -3.7 nA |
| IIL_Inputs_Max_ | Bi_E_7 | -1.8 nA | -2.0 nA | -2.6 nA | -2.2 nA | -2.6 nA | -2.8 nA |
| IIL_Inputs_Max_ | DA | -5.8 nA | -5.0 nA | -5.6 nA | -3.1 nA | -6.5 nA | -4.6 nA |
| IIL_Inputs_Max_ | DIO_IN_1 | -1.5 nA | -1.5 nA | 792.8 pA | -1.1 nA | -1.9 nA | -3.6 nA |
| IIL_Inputs_Max_ | DIO_IN_2 | -3.9 nA | -2.7 nA | -4.6 nA | 454.3 pA | -5.2 nA | -1.6 nA |
| IIL_Inputs_Max_ | DIO_IN_3 | -3.3 nA | -5.2 nA | -4.2 nA | -1.4 nA | -1.8 nA | -1.8 nA |
| IIL_Inputs_Max_ | DIO_IN_4 | 792.8 pA | -1.5 nA | -253.6 pA | 374.2 pA | -672.2 pA | -44.3 pA |
| IIL_Inputs_Max_ | DIO_IN_5 | -2.5 nA | -2.9 nA | -3.9 nA | -2.9 nA | -3.3 nA | -802.2 pA |
| IIL_Inputs_Max_ | DIO_IN_6 | -3.9 nA | -4.6 nA | -4.8 nA | -3.3 nA | -3.1 nA | -1.6 nA |
| IIL_Inputs_Max_ | DIO_IN_7 | -3.3 nA | -4.8 nA | -2.7 nA | -3.5 nA | -2.1 nA | -3.9 nA |
| IIL_Inputs_Max_ | DIO_IP_1 | -1.7 nA | 164.9 pA | -462.9 pA | -1.9 nA | 2.5 nA | -2.1 nA |
| IIL_Inputs_Max_ | DIO_IP_2 | -1.8 nA | -2.5 nA | -2.7 nA | -3.3 nA | -2.7 nA | -2.5 nA |
| IIL_Inputs_Max_ | DIO_IP_3 | 3.9 nA | -462.9 pA | 1.0 nA | -253.6 pA | 1.6 nA | -1.9 nA |
| IIL_Inputs_Max_ | DIO_IP_4 | -1.8 nA | -1.8 nA | -3.3 nA | -2.3 nA | -4.4 nA | -3.1 nA |
| IIL_Inputs_Max_ | DIO_IP_5 | -592.8 pA | -3.1 nA | -3.7 nA | -2.7 nA | -3.1 nA | -2.5 nA |
| IIL_Inputs_Max_ | DIO_IP_6 | -2.5 nA | -4.2 nA | -802.2 pA | -2.7 nA | -2.9 nA | -2.7 nA |
| IIL_Inputs_Max_ | DIO_IP_7 | -2.7 nA | -1.8 nA | -1.0 nA | -2.9 nA | -1.8 nA | -1.4 nA |
| IIL_Inputs_Max_ | EN8 | -3.3 nA | -2.9 nA | -3.5 nA | -2.5 nA | -2.5 nA | -1.8 nA |
| IIL_Inputs_Max_ | HCLK1P | -4.3 nA | -2.4 nA | -3.2 nA | -2.4 nA | -3.4 nA | -2.0 nA |
| IIL_Inputs_Max_ | HCLK2P | -1.3 nA | -672.2 pA | 583.5 pA | 164.9 pA | -881.4 pA | 1.4 nA |
| IIL_Inputs_Max_ | HCLK3P | 3.1 nA | 1.6 nA | 2.8 nA | 2.6 nA | 1.6 nA | 3.5 nA |
| IIL_Inputs_Max_ | HCLK4P | -1.3 nA | -2.2 nA | -914.7 pA | -4.5 nA | -705.4 pA | -2.8 nA |
| IIL_Inputs_Max_ | IO_I_1 | -1.1 nA | -1.5 nA | -253.6 pA | -2.1 nA | 1.4 nA | -1.5 nA |
| IIL_Inputs_Max_ | IO_I_2 | 2.2 nA | 2.8 nA | 3.1 nA | 1.6 nA | 958.7 pA | 4.1 nA |
| IIL_Inputs_Max_ | IO_I_3 | 1.4 nA | 1.4 nA | -462.9 pA | -462.9 pA | -462.9 pA | 164.9 pA |
| IIL_Inputs_Max_ | IO_I_4 | 2.4 nA | 2.0 nA | 3.3 nA | 2.0 nA | 2.4 nA | 2.8 nA |
| IIL_Inputs_Max_ | IO_I_5 | -44.3 pA | -672.2 pA | 2.0 nA | -44.3 pA | -1.3 nA | -672.2 pA |
| IIL_Inputs_Max_ | IO_I_6 | -3.3 nA | -592.8 pA | -1.8 nA | -2.3 nA | -383.4 pA | 454.3 pA |
| IIL_Inputs_Max_ | LOADIN | -5.5 nA | -6.8 nA | -3.6 nA | -4.7 nA | -4.5 nA | -7.6 nA |
| IIL_Inputs_Max_ | RCLK1P | 1.8 nA | -1.7 nA | -1.5 nA | -462.9 pA | -2.6 nA | 374.2 pA |
| IIL_Inputs_Max_ | RCLK2P | 131.9 pA | -3.2 nA | -1.5 nA | -77.4 pA | -286.7 pA | -914.7 pA |
| IIL_Inputs_Max_ | RCLK3P | 2.6 nA | 1.2 nA | 4.1 nA | 1.4 nA | 4.5 nA | 2.4 nA |
| IIL_Inputs_Max_ | RCLK4P | -725.8 pA | -2.2 nA | -2.0 nA | -935.2 pA | -3.9 nA | -2.0 nA |

Table 5c

| DUT | | 3095 | | | | 3124 | | | | 3147 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | Design | Pre-Irrad | | Post-Ann | | Pre-Irrad | | Post-Ann | | Pre-Irrad | | Post-Ann | |
| IIL_BiOuts_Max_ | Bi_IO_1 | -4.0 | nA | -4.6 | nA | -3.6 | nA | -5.7 | nA | -4.9 | nA | -5.3 | nA |
| IIL_BiOuts_Max_ | Bi_IO_2 | -4.5 | nA | -7.0 | nA | -5.3 | nA | -5.1 | nA | -4.1 | nA | -5.3 | nA |
| IIL_BiOuts_Max_ | Bi_IO_3 | -2.4 | nA | -2.6 | nA | -2.6 | nA | -2.0 | nA | -2.2 | nA | -914.7 | pA |
| IIL_BiOuts_Max_ | Bi_IO_4 | -44.3 | pA | -2.3 | nA | -3.2 | nA | -3.2 | nA | -1.5 | nA | -1.7 | nA |
| IIL_BiOuts_Max_ | Bi_IO_5 | -496.0 | pA | -1.1 | nA | -2.8 | nA | -2.2 | nA | -286.7 | pA | -2.2 | nA |
| IIL_BiOuts_Max_ | Bi_IO_6 | -2.6 | nA | -5.3 | nA | -2.4 | nA | -2.2 | nA | -3.4 | nA | -3.4 | nA |
| IIL_BiOuts_Max_ | Bi_IO_7 | -3.0 | nA | -3.0 | nA | -1.1 | nA | -1.9 | nA | -3.0 | nA | -4.5 | nA |

Table 5d

| DUT | | 3148 | | | | 3149 | | | | 3176 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | Design | Pre-Irrad | | Post-Ann | | Pre-Irrad | | Post-Ann | | Pre-Irrad | | Post-Ann | |
| IIL_BiOuts_Max_ | Bi_IO_1 | -1.5 | nA | -4.2 | nA | -2.6 | nA | -3.2 | nA | -1.3 | nA | 280.0 | nA |
| IIL_BiOuts_Max_ | Bi_IO_2 | -4.5 | nA | -4.7 | nA | -4.3 | nA | -6.1 | nA | -2.4 | nA | -366.6 | nA |
| IIL_BiOuts_Max_ | Bi_IO_3 | -705.4 | pA | -3.0 | nA | -2.8 | nA | -2.6 | nA | -77.4 | pA | 218.4 | nA |
| IIL_BiOuts_Max_ | Bi_IO_4 | -3.0 | nA | -44.3 | pA | -2.6 | nA | -1.1 | nA | -1.5 | nA | -19.9 | uA |
| IIL_BiOuts_Max_ | Bi_IO_5 | -914.7 | pA | -1.1 | nA | -1.8 | nA | -4.1 | nA | 969.2 | pA | -12.4 | uA |
| IIL_BiOuts_Max_ | Bi_IO_6 | -2.6 | nA | -3.4 | nA | -4.7 | nA | -2.4 | nA | -2.8 | nA | 28.0 | nA |
| IIL_BiOuts_Max_ | Bi_IO_7 | -3.4 | nA | -5.3 | nA | -4.7 | nA | -3.4 | nA | -1.9 | nA | -3.0 | nA |

Table 6a

| DUT | | 3095 | | | | 3124 | | | | 3147 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | Design | Pre-Irrad | | Post-Ann | | Pre-Irrad | | Post-Ann | | Pre-Irrad | | Post-Ann | |
| IIH_Inputs_Max_ | Bi_D_1 | 8.9 | nA | 9.5 | nA | 7.2 | nA | 8.7 | nA | 7.7 | nA | 8.1 | nA |
| IIH_Inputs_Max_ | Bi_D_2 | 2.6 | nA | 5.8 | nA | 7.7 | nA | 7.7 | nA | 5.8 | nA | 8.3 | nA |
| IIH_Inputs_Max_ | Bi_D_3 | 5.4 | nA | 6.0 | nA | 3.7 | nA | 6.8 | nA | 2.4 | nA | 6.0 | nA |
| IIH_Inputs_Max_ | Bi_D_4 | 3.5 | nA | 550.5 | pA | 3.7 | nA | 3.1 | nA | 2.6 | nA | 1.6 | nA |
| IIH_Inputs_Max_ | Bi_D_5 | -286.7 | pA | 1.6 | nA | 2.0 | nA | 4.1 | nA | -496.0 | pA | 550.5 | pA |
| IIH_Inputs_Max_ | Bi_D_6 | 4.8 | nA | 7.3 | nA | 4.8 | nA | 3.7 | nA | 4.6 | nA | 6.0 | nA |
| IIH_Inputs_Max_ | Bi_D_7 | 530.9 | pA | 2.0 | nA | 3.0 | nA | 2.4 | nA | 2.4 | nA | 2.4 | nA |
| IIH_Inputs_Max_ | Bi_E_1 | 949.7 | pA | 1.8 | nA | 4.9 | nA | 949.7 | pA | 3.0 | nA | 3.0 | nA |
| IIH_Inputs_Max_ | Bi_E_2 | 321.4 | pA | -1.6 | nA | 2.6 | nA | -516.4 | pA | 2.2 | nA | 949.7 | pA |
| IIH_Inputs_Max_ | Bi_E_3 | 2.0 | nA | 112.0 | pA | 1.4 | nA | -306.9 | pA | 321.4 | pA | -1.8 | nA |
| IIH_Inputs_Max_ | Bi_E_4 | -1.1 | nA | 740.3 | pA | 2.2 | nA | -935.2 | pA | -516.4 | pA | -725.8 | pA |
| IIH_Inputs_Max_ | Bi_E_5 | 1.4 | nA | 530.9 | pA | 2.2 | nA | -1.4 | nA | 2.4 | nA | 321.4 | pA |
| IIH_Inputs_Max_ | Bi_E_6 | 949.7 | pA | -516.4 | pA | -935.2 | pA | -516.4 | pA | 530.9 | pA | -2.0 | nA |
| IIH_Inputs_Max_ | Bi_E_7 | 321.4 | pA | 949.7 | pA | -1.8 | nA | -1.1 | nA | 530.9 | pA | -725.8 | pA |
| IIH_Inputs_Max_ | DA | 1.5 | nA | 454.3 | pA | 2.3 | nA | 873.1 | pA | -174.0 | pA | 3.0 | nA |
| IIH_Inputs_Max_ | DIO_IN_1 | 3.7 | nA | 4.8 | nA | 5.0 | nA | 3.9 | nA | 6.0 | nA | 2.0 | nA |
| IIH_Inputs_Max_ | DIO_IN_2 | -174.0 | pA | 873.1 | pA | 2.1 | nA | 1.3 | nA | 873.1 | pA | 2.8 | nA |
| IIH_Inputs_Max_ | DIO_IN_3 | 1.3 | nA | 2.1 | nA | -174.0 | pA | 873.1 | pA | -2.5 | nA | 1.3 | nA |
| IIH_Inputs_Max_ | DIO_IN_4 | 5.6 | nA | 2.0 | nA | 5.0 | nA | 2.0 | nA | 1.6 | nA | 1.6 | nA |
| IIH_Inputs_Max_ | DIO_IN_5 | 2.5 | nA | 1.1 | nA | -1.4 | nA | 1.7 | nA | -174.0 | pA | 1.5 | nA |
| IIH_Inputs_Max_ | DIO_IN_6 | 663.7 | pA | -1.2 | nA | -802.2 | pA | 454.3 | pA | 663.7 | pA | -383.4 | pA |
| IIH_Inputs_Max_ | DIO_IN_7 | 1.9 | nA | 873.1 | pA | 1.5 | nA | 2.1 | nA | 1.5 | nA | -1.2 | nA |
| IIH_Inputs_Max_ | DIO_IP_1 | 3.1 | nA | 1.6 | nA | 2.7 | nA | 164.9 | pA | 1.6 | nA | 792.8 | pA |
| IIH_Inputs_Max_ | DIO_IP_2 | -383.4 | pA | -1.6 | nA | 454.3 | pA | -383.4 | pA | 244.9 | pA | 35.5 | pA |
| IIH_Inputs_Max_ | DIO_IP_3 | 5.4 | nA | 3.7 | nA | 2.5 | nA | 792.8 | pA | 4.4 | nA | 1.8 | nA |
| IIH_Inputs_Max_ | DIO_IP_4 | 873.1 | pA | -802.2 | pA | 244.9 | pA | 1.5 | nA | -383.4 | pA | -1.0 | nA |
| IIH_Inputs_Max_ | DIO_IP_5 | -174.0 | pA | -1.6 | nA | 35.5 | pA | 244.9 | pA | -174.0 | pA | 35.5 | pA |
| IIH_Inputs_Max_ | DIO_IP_6 | 35.5 | pA | -592.8 | pA | 35.5 | pA | 454.3 | pA | 244.9 | pA | 663.7 | pA |
| IIH_Inputs_Max_ | DIO_IP_7 | -2.3 | nA | 244.9 | pA | -1.4 | nA | 2.1 | nA | 1.1 | nA | -174.0 | pA |
| IIH_Inputs_Max_ | EN8 | 244.9 | pA | 873.1 | pA | -383.4 | pA | 2.5 | nA | 873.1 | pA | 873.1 | pA |
| IIH_Inputs_Max_ | HCLK1P | -1.6 | nA | -725.8 | pA | -3.2 | nA | -1.4 | nA | -1.6 | nA | -97.5 | pA |
| IIH_Inputs_Max_ | HCLK2P | 1.2 | nA | 583.5 | pA | 4.4 | nA | 1.6 | nA | 2.7 | nA | -462.9 | pA |
| IIH_Inputs_Max_ | HCLK3P | 3.3 | nA | 3.7 | nA | 4.1 | nA | 4.5 | nA | 5.1 | nA | 2.8 | nA |
| IIH_Inputs_Max_ | HCLK4P | 1.4 | nA | 341.2 | pA | -77.4 | pA | -496.0 | pA | -496.0 | pA | -914.7 | pA |
| IIH_Inputs_Max_ | IO_I_1 | 2.7 | nA | 2.9 | nA | 1.6 | nA | -44.3 | pA | 2.9 | nA | 583.5 | pA |
| IIH_Inputs_Max_ | IO_I_2 | 4.7 | nA | 2.8 | nA | 3.1 | nA | 4.1 | nA | 6.2 | nA | 4.7 | nA |
| IIH_Inputs_Max_ | IO_I_3 | 792.8 | pA | 1.4 | nA | 2.5 | nA | -44.3 | pA | 1.0 | nA | 2.3 | nA |
| IIH_Inputs_Max_ | IO_I_4 | 4.3 | nA | 4.5 | nA | 6.0 | nA | 5.6 | nA | 5.1 | nA | 3.3 | nA |
| IIH_Inputs_Max_ | IO_I_5 | 2.9 | nA | 1.4 | nA | 3.9 | nA | 3.9 | nA | 2.7 | nA | 2.3 | nA |
| IIH_Inputs_Max_ | IO_I_6 | -1.6 | nA | -1.6 | nA | -802.2 | pA | 2.3 | nA | -592.8 | pA | 244.9 | pA |
| IIH_Inputs_Max_ | LOADIN | 2.0 | nA | 2.0 | nA | 3.7 | nA | 3.1 | nA | 2.9 | nA | 2.0 | nA |
| IIH_Inputs_Max_ | RCLK1P | 2.7 | nA | 2.0 | nA | 2.5 | nA | -44.3 | pA | 3.7 | nA | 164.9 | pA |
| IIH_Inputs_Max_ | RCLK2P | -1.1 | nA | -77.4 | pA | 341.2 | pA | 969.2 | pA | -1.5 | nA | 550.5 | pA |
| IIH_Inputs_Max_ | RCLK3P | 4.7 | nA | 3.5 | nA | 7.7 | nA | 3.3 | nA | 3.3 | nA | 4.3 | nA |
| IIH_Inputs_Max_ | RCLK4P | -3.2 | nA | -2.4 | nA | -1.4 | nA | -1.4 | nA | -1.1 | nA | -2.2 | nA |

Table 6b

| DUT | | 3148 | | | | 3149 | | | | 3176 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | Design | Pre-Irrad | | Post-Ann | | Pre-Irrad | | Post-Ann | | Pre-Irrad | | Post-Ann | |
| IIH_Inputs_Max_ | Bi_D_1 | 6.6 | nA | 7.2 | nA | 8.7 | nA | 8.1 | nA | 9.5 | nA | 9.7 | nA |
| IIH_Inputs_Max_ | Bi_D_2 | 7.2 | nA | 6.6 | nA | 7.7 | nA | 7.0 | nA | 5.6 | nA | 8.9 | nA |
| IIH_Inputs_Max_ | Bi_D_3 | 5.8 | nA | 6.6 | nA | 6.6 | nA | 5.4 | nA | 5.8 | nA | 5.1 | nA |
| IIH_Inputs_Max_ | Bi_D_4 | 2.0 | nA | 3.3 | nA | 3.1 | nA | 3.1 | nA | 4.3 | nA | 1.8 | nA |
| IIH_Inputs_Max_ | Bi_D_5 | 1.8 | nA | 969.2 | pA | 1.8 | nA | 1.2 | nA | 1.6 | nA | 550.5 | pA |
| IIH_Inputs_Max_ | Bi_D_6 | 3.3 | nA | 3.7 | nA | 7.3 | nA | 4.6 | nA | 6.2 | nA | 3.1 | nA |
| IIH_Inputs_Max_ | Bi_D_7 | 1.8 | nA | 2.4 | nA | 1.2 | nA | 1.6 | nA | 3.9 | nA | -97.5 | pA |
| IIH_Inputs_Max_ | Bi_E_1 | 1.8 | nA | 1.4 | nA | 1.2 | nA | 949.7 | pA | 2.8 | nA | 530.9 | pA |
| IIH_Inputs_Max_ | Bi_E_2 | -516.4 | pA | -2.6 | nA | 3.5 | nA | -1.4 | nA | 112.0 | pA | 1.4 | nA |
| IIH_Inputs_Max_ | Bi_E_3 | 1.2 | nA | 2.0 | nA | -1.6 | nA | 112.0 | pA | 2.6 | nA | 1.8 | nA |
| IIH_Inputs_Max_ | Bi_E_4 | 3.3 | nA | -2.8 | nA | -306.9 | pA | 321.4 | pA | 1.8 | nA | 1.8 | nA |
| IIH_Inputs_Max_ | Bi_E_5 | -1.1 | nA | -725.8 | pA | 1.4 | nA | 112.0 | pA | 740.3 | pA | 740.3 | pA |
| IIH_Inputs_Max_ | Bi_E_6 | 321.4 | pA | -306.9 | pA | -1.8 | nA | -725.8 | pA | 1.4 | nA | 239.1 | nA |
| IIH_Inputs_Max_ | Bi_E_7 | 1.4 | nA | -935.2 | pA | -725.8 | pA | -1.1 | nA | -306.9 | pA | -935.2 | pA |
| IIH_Inputs_Max_ | DA | 454.3 | pA | 3.2 | nA | 1.9 | nA | 2.5 | nA | 1.1 | nA | 2.8 | nA |
| IIH_Inputs_Max_ | DIO_IN_1 | 3.1 | nA | 5.6 | nA | 1.2 | nA | 2.0 | nA | 6.7 | nA | 2.0 | nA |
| IIH_Inputs_Max_ | DIO_IN_2 | 1.1 | nA | 3.8 | nA | 1.5 | nA | 2.8 | nA | 1.7 | nA | 1.5 | nA |
| IIH_Inputs_Max_ | DIO_IN_3 | 2.1 | nA | 35.5 | pA | -1.0 | nA | 244.9 | pA | -174.0 | pA | 1.1 | nA |
| IIH_Inputs_Max_ | DIO_IN_4 | 3.9 | nA | 583.5 | pA | 1.4 | nA | 2.3 | nA | 1.6 | nA | -462.9 | pA |
| IIH_Inputs_Max_ | DIO_IN_5 | -1.0 | nA | 1.3 | nA | -2.5 | nA | 454.3 | pA | -1.8 | nA | 1.1 | nA |
| IIH_Inputs_Max_ | DIO_IN_6 | 35.5 | pA | -1.2 | nA | -1.6 | nA | -174.0 | pA | 873.1 | pA | -1.0 | nA |
| IIH_Inputs_Max_ | DIO_IN_7 | 2.1 | nA | 873.1 | pA | 1.3 | nA | 244.9 | pA | 244.9 | pA | -592.8 | pA |
| IIH_Inputs_Max_ | DIO_IP_1 | 2.7 | nA | 2.0 | nA | 3.5 | nA | 1.0 | nA | 3.1 | nA | 1.6 | nA |
| IIH_Inputs_Max_ | DIO_IP_2 | 663.7 | pA | -2.3 | nA | -174.0 | pA | -592.8 | pA | -1.6 | nA | -592.8 | pA |
| IIH_Inputs_Max_ | DIO_IP_3 | 4.4 | nA | 1.4 | nA | 2.7 | nA | 583.5 | pA | 1.8 | nA | 3.1 | nA |
| IIH_Inputs_Max_ | DIO_IP_4 | 663.7 | pA | -592.8 | pA | -802.2 | pA | -1.6 | nA | 1.7 | nA | 1.5 | nA |
| IIH_Inputs_Max_ | DIO_IP_5 | 663.7 | pA | -802.2 | pA | -1.0 | nA | -592.8 | pA | -383.4 | pA | -174.0 | pA |
| IIH_Inputs_Max_ | DIO_IP_6 | 35.5 | pA | -802.2 | pA | 454.3 | pA | 1.1 | nA | 35.5 | pA | -1.2 | nA |
| IIH_Inputs_Max_ | DIO_IP_7 | 244.9 | pA | 1.5 | nA | 454.3 | pA | 454.3 | pA | 2.8 | nA | 2.5 | nA |
| IIH_Inputs_Max_ | EN8 | 1.9 | nA | -592.8 | pA | 663.7 | pA | 1.1 | nA | 1.5 | nA | 2.3 | nA |
| IIH_Inputs_Max_ | HCLK1P | -306.9 | pA | -1.8 | nA | -2.2 | nA | -97.5 | pA | -1.6 | nA | -306.9 | pA |
| IIH_Inputs_Max_ | HCLK2P | 2.9 | nA | 1.0 | nA | 2.5 | nA | -672.2 | pA | 1.6 | nA | 164.9 | pA |
| IIH_Inputs_Max_ | HCLK3P | 3.3 | nA | 5.8 | nA | 5.1 | nA | 4.3 | nA | 2.4 | nA | 4.9 | nA |
| IIH_Inputs_Max_ | HCLK4P | 1.8 | nA | -2.6 | nA | 131.9 | pA | -705.4 | pA | 759.8 | pA | 550.5 | pA |
| IIH_Inputs_Max_ | IO_I_1 | 2.9 | nA | 1.2 | nA | 1.4 | nA | 1.2 | nA | 2.9 | nA | 164.9 | pA |
| IIH_Inputs_Max_ | IO_I_2 | 4.7 | nA | 3.5 | nA | 3.9 | nA | 4.3 | nA | 2.8 | nA | 3.7 | nA |
| IIH_Inputs_Max_ | IO_I_3 | 1.0 | nA | 3.9 | nA | 583.5 | pA | 3.3 | nA | 2.3 | nA | 2.7 | nA |
| IIH_Inputs_Max_ | IO_I_4 | 4.5 | nA | 4.7 | nA | 4.9 | nA | 5.1 | nA | 4.9 | nA | 4.3 | nA |
| IIH_Inputs_Max_ | IO_I_5 | 3.5 | nA | 1.8 | nA | 3.7 | nA | -462.9 | pA | 2.0 | nA | 2.5 | nA |
| IIH_Inputs_Max_ | IO_I_6 | 873.1 | pA | -383.4 | pA | -802.2 | pA | 1.1 | nA | -1.4 | nA | 1.5 | nA |
| IIH_Inputs_Max_ | LOADIN | 3.3 | nA | 3.5 | nA | 2.7 | nA | 2.2 | nA | 1.6 | nA | 2.5 | nA |
| IIH_Inputs_Max_ | RCLK1P | 1.8 | nA | 583.5 | pA | 374.2 | pA | 2.5 | nA | -462.9 | pA | 771.1 | nA |
| IIH_Inputs_Max_ | RCLK2P | -286.7 | pA | -496.0 | pA | -914.7 | pA | 131.9 | pA | 2.0 | nA | -496.0 | pA |
| IIH_Inputs_Max_ | RCLK3P | 4.5 | nA | 3.7 | nA | 2.8 | nA | 3.9 | nA | 5.1 | nA | 4.3 | nA |
| IIH_Inputs_Max_ | RCLK4P | -97.5 | pA | -1.8 | nA | 1.8 | nA | -2.2 | nA | 112.0 | pA | 1.6 | nA |

Table 6c

| DUT | | 3095 | | 3124 | | 3147 | |
|---|---|---|---|---|---|---|---|
| Parameter | Design | Pre-Irrad | Post-Ann | Pre-Irrad | Post-Ann | Pre-Irrad | Post-Ann |
| IIH_BiOuts_Max_ | Bi_IO_1 | -253.6 pA | 1.2 nA | 1.6 nA | 1.6 nA | 3.1 nA | 374.2 pA |
| IIH_BiOuts_Max_ | Bi_IO_2 | -3.2 nA | -2.0 nA | 131.9 pA | 550.5 pA | -1.5 nA | -2.0 nA |
| IIH_BiOuts_Max_ | Bi_IO_3 | 1.2 nA | -1.1 nA | 1.6 nA | -2.6 nA | -496.0 pA | -2.6 nA |
| IIH_BiOuts_Max_ | Bi_IO_4 | 792.8 pA | 1.0 nA | 2.9 nA | -881.4 pA | -253.6 pA | -1.3 nA |
| IIH_BiOuts_Max_ | Bi_IO_5 | -496.0 pA | 20.6 uA | 550.5 pA | 20.6 uA | -1.8 nA | 1.2 nA |
| IIH_BiOuts_Max_ | Bi_IO_6 | -56.5 pA | 1.7 uA | -1.3 nA | 3.4 uA | -894.9 pA | -3.6 nA |
| IIH_BiOuts_Max_ | Bi_IO_7 | -894.9 pA | -1.5 nA | -4.0 nA | -2.4 nA | -266.1 pA | -1.1 nA |

Table 6d

| DUT | | 3148 | | 3149 | | 3176 | |
|---|---|---|---|---|---|---|---|
| Parameter | Design | Pre-Irrad | Post-Ann | Pre-Irrad | Post-Ann | Pre-Irrad | Post-Ann |
| IIH_BiOuts_Max_ | Bi_IO_1 | 2.0 nA | -881.4 pA | 2.0 nA | 1.8 nA | -44.3 pA | 164.9 pA |
| IIH_BiOuts_Max_ | Bi_IO_2 | -1.3 nA | -914.7 pA | 759.8 pA | -705.4 pA | -914.7 pA | -286.7 pA |
| IIH_BiOuts_Max_ | Bi_IO_3 | 1.6 nA | -1.5 nA | 550.5 pA | -496.0 pA | 341.2 pA | -1.8 nA |
| IIH_BiOuts_Max_ | Bi_IO_4 | 2.0 nA | 792.8 pA | 1.6 nA | 583.5 pA | 1.4 nA | 1.4 nA |
| IIH_BiOuts_Max_ | Bi_IO_5 | 969.2 pA | -77.4 pA | -1.8 nA | 20.6 uA | 2.2 nA | 20.6 uA |
| IIH_BiOuts_Max_ | Bi_IO_6 | -266.1 pA | -894.9 pA | -1.5 nA | 8.2 uA | -475.7 pA | 1.9 uA |
| IIH_BiOuts_Max_ | Bi_IO_7 | -266.1 pA | -1.9 nA | -1.7 nA | -2.4 nA | -1.3 nA | 153.0 pA |

### *D. Differential Input (LVPECL) Threshold Voltage ($V_{IL}/V_{IH}$)*

Table 7 and 8 show the pre-irradiation and post-annealing threshold-voltages of the LVPECL input. Every data passes the spec.

Table 7a

| DUT | | 3095 | | 3124 | | 3147 | |
|---|---|---|---|---|---|---|---|
| Parameter (mV) | Design | Pre-Irrad | Post-Ann | Pre-Irrad | Post-Ann | Pre-Irrad | Post-Ann |
| bi_levels_vil | DIO_IP_7 | 95 | 65 | 115 | 90 | 110 | 80 |
| bi_levels_vil | DIO_IP_6 | 100 | 75 | 100 | 70 | 115 | 90 |
| bi_levels_vil | DIO_IP_5 | 115 | 90 | 100 | 70 | 100 | 75 |
| bi_levels_vil | DIO_IP_4 | 80 | 60 | 80 | 55 | 95 | 75 |
| bi_levels_vil | DIO_IP_3 | 75 | 55 | 80 | 50 | 75 | 55 |
| bi_levels_vil | DIO_IP_2 | 80 | 55 | 80 | 50 | 75 | 50 |
| bi_levels_vil | DIO_IP_1 | 65 | 45 | 55 | 30 | 70 | 50 |

Table7b

| **DUT** | | **3148** | | **3149** | | **3176** | |
|---|---|---|---|---|---|---|---|
| Parameter (mV) | Design | Pre-Irrad | Post-Ann | Pre-Irrad | Post-Ann | Pre-Irrad | Post-Ann |
| bi_levels_vil | DIO_IP_7 | 115 | 100 | 100 | 90 | 105 | 90 |
| bi_levels_vil | DIO_IP_6 | 110 | 95 | 110 | 100 | 95 | 85 |
| bi_levels_vil | DIO_IP_5 | 110 | 95 | 110 | 95 | 115 | 100 |
| bi_levels_vil | DIO_IP_4 | 85 | 70 | 95 | 85 | 90 | 80 |
| bi_levels_vil | DIO_IP_3 | 70 | 60 | 75 | 65 | 65 | 55 |
| bi_levels_vil | DIO_IP_2 | 80 | 70 | 90 | 80 | 80 | 70 |
| bi_levels_vil | DIO_IP_1 | 70 | 55 | 70 | 60 | 60 | 50 |

Table 8a

| **DUT** | | **3095** | | **3124** | | **3147** | |
|---|---|---|---|---|---|---|---|
| Parameter (mV) | Design | Pre-Irrad | Post-Ann | Pre-Irrad | Post-Ann | Pre-Irrad | Post-Ann |
| bi_levels_vih | DIO_IP_7 | 95 | 65 | 115 | 85 | 105 | 80 |
| bi_levels_vih | DIO_IP_6 | 100 | 70 | 95 | 70 | 110 | 85 |
| bi_levels_vih | DIO_IP_5 | 115 | 90 | 95 | 70 | 100 | 70 |
| bi_levels_vih | DIO_IP_4 | 80 | 55 | 75 | 50 | 90 | 70 |
| bi_levels_vih | DIO_IP_3 | 75 | 50 | 75 | 50 | 70 | 50 |
| bi_levels_vih | DIO_IP_2 | 80 | 55 | 75 | 45 | 70 | 45 |
| bi_levels_vih | DIO_IP_1 | 70 | 50 | 55 | 0 | 75 | 55 |

Table 8b

| **DUT** | | **3148** | | **3149** | | **3176** | |
|---|---|---|---|---|---|---|---|
| Parameter (mV) | Design | Pre-Irrad | Post-Ann | Pre-Irrad | Post-Ann | Pre-Irrad | Post-Ann |
| bi_levels_vih | DIO_IP_7 | 115 | 95 | 100 | 90 | 100 | 85 |
| bi_levels_vih | DIO_IP_6 | 105 | 95 | 110 | 100 | 95 | 80 |
| bi_levels_vih | DIO_IP_5 | 110 | 95 | 105 | 95 | 110 | 100 |
| bi_levels_vih | DIO_IP_4 | 85 | 70 | 95 | 80 | 90 | 75 |
| bi_levels_vih | DIO_IP_3 | 70 | 60 | 75 | 65 | 65 | 55 |
| bi_levels_vih | DIO_IP_2 | 80 | 65 | 85 | 75 | 75 | 65 |
| bi_levels_vih | DIO_IP_1 | 70 | 55 | 70 | 60 | 65 | 50 |

## *E. Output-Drive Voltage ($V_{OL}/V_{OH}$)*

The pre-irradiation and post-annealing $V_{OL}/V_{OH}$ are listed in Tables 9 and 10. Every post-annealing data passes the spec.

Table 9a

| **DUT** | | **3095** | | **3124** | | **3147** | |
|---|---|---|---|---|---|---|---|
| Parameter (mV) | Design | Pre-Irrad | Post-Ann | Pre-Irrad | Post-Ann | Pre-Irrad | Post-Ann |
| bi_levels_vol | Bi_IO_7 | 35 | 35 | 35 | 35 | 35 | 35 |
| bi_levels_vol | Bi_IO_6 | 30 | 30 | 35 | 35 | 35 | 30 |
| bi_levels_vol | Bi_IO_5 | 35 | 35 | 35 | 35 | 35 | 35 |
| bi_levels_vol | Bi_IO_4 | 35 | 35 | 35 | 35 | 35 | 35 |
| bi_levels_vol | Bi_IO_3 | 35 | 35 | 35 | 35 | 35 | 35 |
| bi_levels_vol | Bi_IO_2 | 30 | 30 | 30 | 35 | 35 | 35 |
| bi_levels_vol | Bi_IO_1 | 35 | 35 | 35 | 35 | 35 | 35 |
| bi_levels_vol | Bi_Y_7 | 25 | 25 | 25 | 25 | 25 | 25 |
| bi_levels_vol | Bi_Y_6 | 25 | 25 | 25 | 25 | 25 | 25 |
| bi_levels_vol | Bi_Y_5 | 25 | 25 | 25 | 25 | 25 | 25 |
| bi_levels_vol | Bi_Y_4 | 25 | 25 | 25 | 25 | 25 | 25 |
| bi_levels_vol | Bi_Y_3 | 30 | 25 | 30 | 30 | 30 | 30 |
| bi_levels_vol | Bi_Y_2 | 25 | 25 | 25 | 25 | 25 | 25 |
| bi_levels_vol | Bi_Y_1 | 25 | 25 | 25 | 25 | 30 | 25 |
| bi_levels_vol | CLOCKE_OUT | 20 | 20 | 20 | 20 | 20 | 20 |
| bi_levels_vol | CLOCKF_OUT | 25 | 25 | 20 | 25 | 25 | 25 |
| bi_levels_vol | QA_2 | 20 | 20 | 20 | 20 | 20 | 20 |
| bi_levels_vol | QA_1 | 20 | 20 | 20 | 20 | 20 | 20 |
| bi_levels_vol | QA_0 | 20 | 20 | 20 | 20 | 20 | 20 |

Table 9b

| **DUT** | | **3148** | | **3149** | | **3176** | |
|---|---|---|---|---|---|---|---|
| Parameter (mV) | Design | Pre-Irrad | Post-Ann | Pre-Irrad | Post-Ann | Pre-Irrad | Post-Ann |
| bi_levels_vol | Bi_IO_7 | 35 | 35 | 35 | 35 | 35 | 35 |
| bi_levels_vol | Bi_IO_6 | 30 | 30 | 35 | 30 | 30 | 30 |
| bi_levels_vol | Bi_IO_5 | 35 | 35 | 35 | 35 | 35 | 35 |
| bi_levels_vol | Bi_IO_4 | 35 | 35 | 35 | 35 | 35 | 35 |
| bi_levels_vol | Bi_IO_3 | 35 | 35 | 35 | 35 | 35 | 35 |
| bi_levels_vol | Bi_IO_2 | 30 | 30 | 30 | 35 | 30 | 30 |
| bi_levels_vol | Bi_IO_1 | 35 | 35 | 35 | 35 | 35 | 35 |
| bi_levels_vol | Bi_Y_7 | 25 | 25 | 25 | 25 | 25 | 25 |
| bi_levels_vol | Bi_Y_6 | 25 | 25 | 25 | 25 | 25 | 25 |
| bi_levels_vol | Bi_Y_5 | 25 | 25 | 25 | 25 | 25 | 25 |
| bi_levels_vol | Bi_Y_4 | 25 | 25 | 25 | 25 | 25 | 25 |
| bi_levels_vol | Bi_Y_3 | 30 | 25 | 25 | 25 | 25 | 25 |
| bi_levels_vol | Bi_Y_2 | 25 | 25 | 25 | 25 | 25 | 25 |
| bi_levels_vol | Bi_Y_1 | 25 | 25 | 30 | 25 | 30 | 25 |
| bi_levels_vol | CLOCKE_OUT | 20 | 20 | 20 | 20 | 20 | 20 |
| bi_levels_vol | CLOCKF_OUT | 25 | 25 | 20 | 25 | 25 | 20 |
| bi_levels_vol | QA_2 | 20 | 20 | 20 | 20 | 20 | 20 |
| bi_levels_vol | QA_1 | 20 | 20 | 20 | 20 | 20 | 20 |
| bi_levels_vol | QA_0 | 20 | 20 | 20 | 20 | 20 | 20 |

Table 10a

| DUT | | 3095 | | 3124 | | 3147 | |
|---|---|---|---|---|---|---|---|
| Parameter (V) | Design | Pre-Irrad | Post-Ann | Pre-Irrad | Post-Ann | Pre-Irrad | Post-Ann |
| bi_levels_voh | Bi_IO_7 | 2.97 | 2.97 | 2.97 | 2.97 | 2.97 | 2.97 |
| bi_levels_voh | Bi_IO_6 | 2.965 | 2.965 | 2.965 | 2.965 | 2.965 | 2.965 |
| bi_levels_voh | Bi_IO_5 | 2.965 | 2.965 | 2.965 | 2.965 | 2.965 | 2.965 |
| bi_levels_voh | Bi_IO_4 | 2.965 | 2.965 | 2.965 | 2.965 | 2.965 | 2.965 |
| bi_levels_voh | Bi_IO_3 | 2.965 | 2.965 | 2.965 | 2.965 | 2.965 | 2.965 |
| bi_levels_voh | Bi_IO_2 | 2.965 | 2.965 | 2.965 | 2.965 | 2.965 | 2.965 |
| bi_levels_voh | Bi_IO_1 | 2.965 | 2.965 | 2.965 | 2.965 | 2.965 | 2.965 |
| bi_levels_voh | Bi_Y_7 | 2.98 | 2.98 | 2.98 | 2.98 | 2.985 | 2.98 |
| bi_levels_voh | Bi_Y_6 | 2.98 | 2.98 | 2.98 | 2.98 | 2.98 | 2.98 |
| bi_levels_voh | Bi_Y_5 | 2.985 | 2.98 | 2.98 | 2.98 | 2.985 | 2.98 |
| bi_levels_voh | Bi_Y_4 | 2.98 | 2.98 | 2.98 | 2.98 | 2.98 | 2.98 |
| bi_levels_voh | Bi_Y_3 | 2.98 | 2.98 | 2.98 | 2.98 | 2.98 | 2.98 |
| bi_levels_voh | Bi_Y_2 | 2.98 | 2.98 | 2.98 | 2.98 | 2.98 | 2.98 |
| bi_levels_voh | Bi_Y_1 | 2.98 | 2.98 | 2.98 | 2.98 | 2.98 | 2.98 |
| bi_levels_voh | CLOCKE_OUT | 2.975 | 2.97 | 2.97 | 2.965 | 2.975 | 2.97 |
| bi_levels_voh | CLOCKF_OUT | 2.975 | 2.97 | 2.975 | 2.97 | 2.975 | 2.97 |
| bi_levels_voh | QA_2 | 2.97 | 2.965 | 2.97 | 2.965 | 2.97 | 2.965 |
| bi_levels_voh | QA_1 | 2.97 | 2.965 | 2.97 | 2.965 | 2.97 | 2.965 |
| bi_levels_voh | QA_0 | 2.975 | 2.97 | 2.97 | 2.97 | 2.97 | 2.97 |

Table 10b

| DUT | | 3148 | | 3149 | | 3176 | |
|---|---|---|---|---|---|---|---|
| Parameter (V) | Design | Pre-Irrad | Post-Ann | Pre-Irrad | Post-Ann | Pre-Irrad | Post-Ann |
| bi_levels_voh | Bi_IO_7 | 2.97 | 2.97 | 2.97 | 2.97 | 2.97 | 2.97 |
| bi_levels_voh | Bi_IO_6 | 2.965 | 2.965 | 2.965 | 2.965 | 2.965 | 2.97 |
| bi_levels_voh | Bi_IO_5 | 2.965 | 2.965 | 2.965 | 2.965 | 2.965 | 2.965 |
| bi_levels_voh | Bi_IO_4 | 2.965 | 2.965 | 2.965 | 2.965 | 2.965 | 2.965 |
| bi_levels_voh | Bi_IO_3 | 2.965 | 2.965 | 2.965 | 2.965 | 2.965 | 2.965 |
| bi_levels_voh | Bi_IO_2 | 2.965 | 2.965 | 2.965 | 2.965 | 2.965 | 2.965 |
| bi_levels_voh | Bi_IO_1 | 2.965 | 2.965 | 2.965 | 2.965 | 2.965 | 2.965 |
| bi_levels_voh | Bi_Y_7 | 2.985 | 2.98 | 2.98 | 2.98 | 2.985 | 2.98 |
| bi_levels_voh | Bi_Y_6 | 2.98 | 2.98 | 2.98 | 2.98 | 2.98 | 2.98 |
| bi_levels_voh | Bi_Y_5 | 2.985 | 2.98 | 2.98 | 2.98 | 2.98 | 2.98 |
| bi_levels_voh | Bi_Y_4 | 2.98 | 2.98 | 2.98 | 2.98 | 2.98 | 2.98 |
| bi_levels_voh | Bi_Y_3 | 2.98 | 2.98 | 2.98 | 2.98 | 2.98 | 2.98 |
| bi_levels_voh | Bi_Y_2 | 2.98 | 2.98 | 2.98 | 2.98 | 2.98 | 2.98 |
| bi_levels_voh | Bi_Y_1 | 2.98 | 2.98 | 2.98 | 2.98 | 2.98 | 2.98 |
| bi_levels_voh | CLOCKE_OUT | 2.97 | 2.97 | 2.975 | 2.97 | 2.975 | 2.97 |
| bi_levels_voh | CLOCKF_OUT | 2.975 | 2.97 | 2.975 | 2.97 | 2.975 | 2.97 |
| bi_levels_voh | QA_2 | 2.97 | 2.97 | 2.97 | 2.965 | 2.97 | 2.97 |
| bi_levels_voh | QA_1 | 2.97 | 2.97 | 2.97 | 2.97 | 2.97 | 2.97 |
| bi_levels_voh | QA_0 | 2.97 | 2.97 | 2.97 | 2.97 | 2.97 | 2.97 |

## *F. Propagation Delay*

Table 11 lists the pre-irradiation and post-annealing propagation delays. The results show small radiation effects; in any case the percentage change is well below ±10%.

Table 11 Radiation-Induced Propagation Delay Degradations

| DUT | Total Dose krad($SiO_2$) | Pre-Irradiation (µs) | Post-Annealing (µs) | Degradation |
|---|---|---|---|---|
| 3095 | 300 | 6.794 | 6.757 | -0.54% |
| 3124 | 300 | 7.135 | 7.266 | 1.84% |
| 3147 | 300 | 6.784 | 6.775 | -0.13% |
| 3148 | 200 | 6.837 | 6.743 | -1.37% |
| 3149 | 200 | 7.340 | 7.273 | -0.92% |
| 3176 | 200 | 6.806 | 6.719 | -1.29% |

## *G. Transition Characteristic*

Figures 9 to 20 show the pre-irradiation and post-annealing transition edges. In each case, the radiation-induced transition-time degradation is not observable.

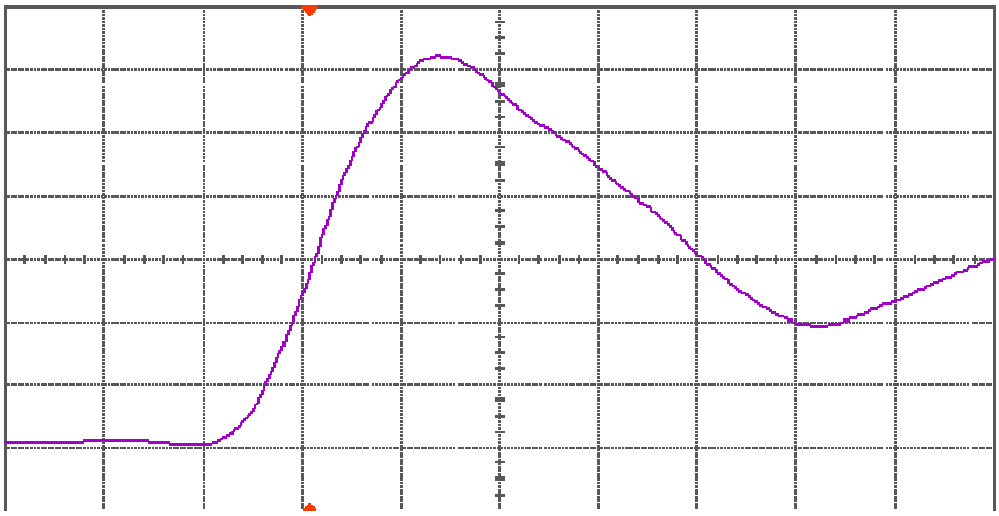

Figure 9(a) DUT 3095 pre-irradiation rising edge, abscissa scale is 1 V/div and ordinate scale is 1 ns/div.

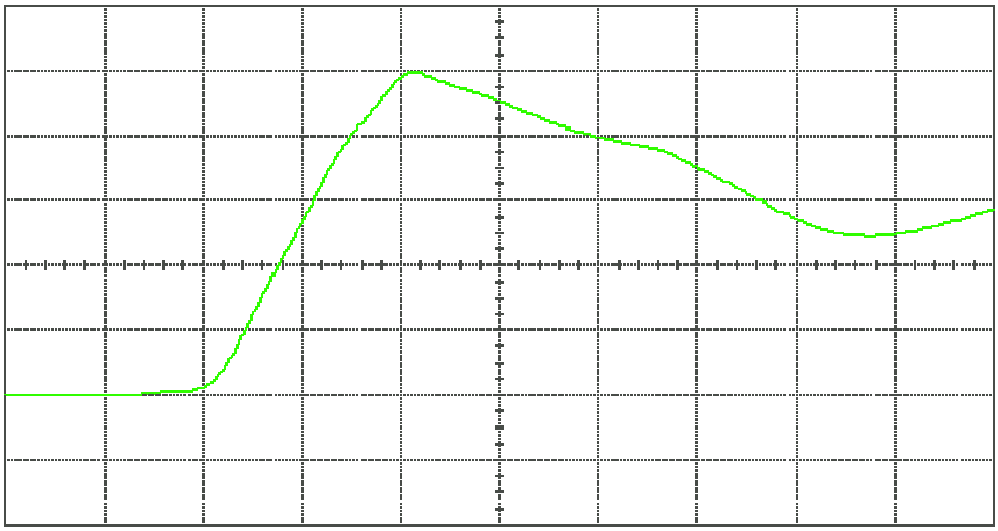

Figure 9(b) DUT 3095 post-annealing rising edge, abscissa scale is 1 V/div and ordinate scale is 1 ns/div.

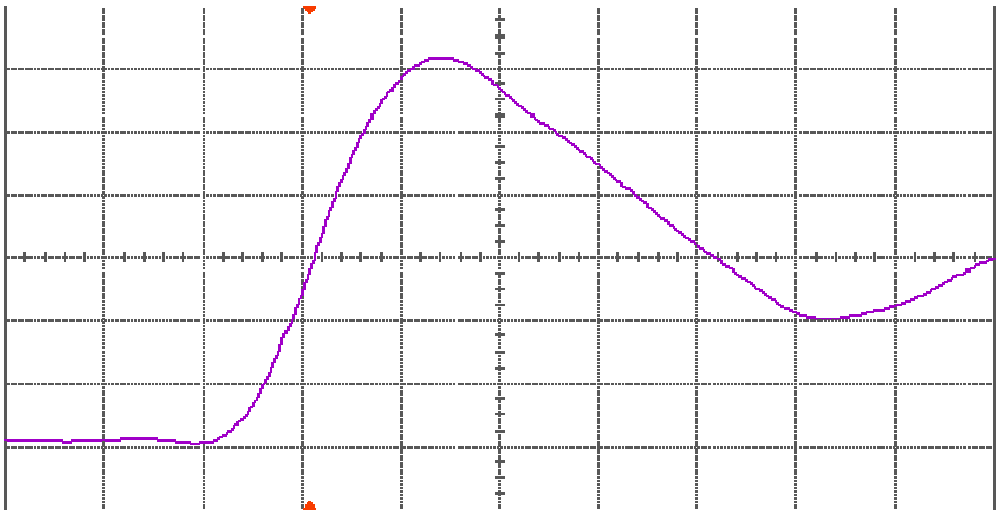

Figure 10(a) DUT 3124 pre-irradiation rising edge, abscissa scale is 1 V/div and ordinate scale is 1 ns/div.

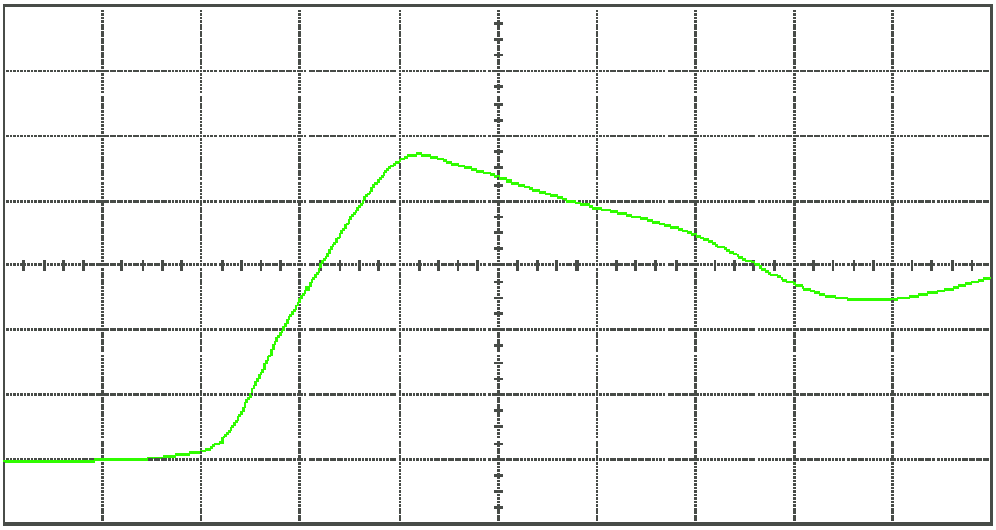

Figure 10(b) DUT 3124 post-annealing rising edge, abscissa scale is 1 V/div and ordinate scale is 1 ns/div.

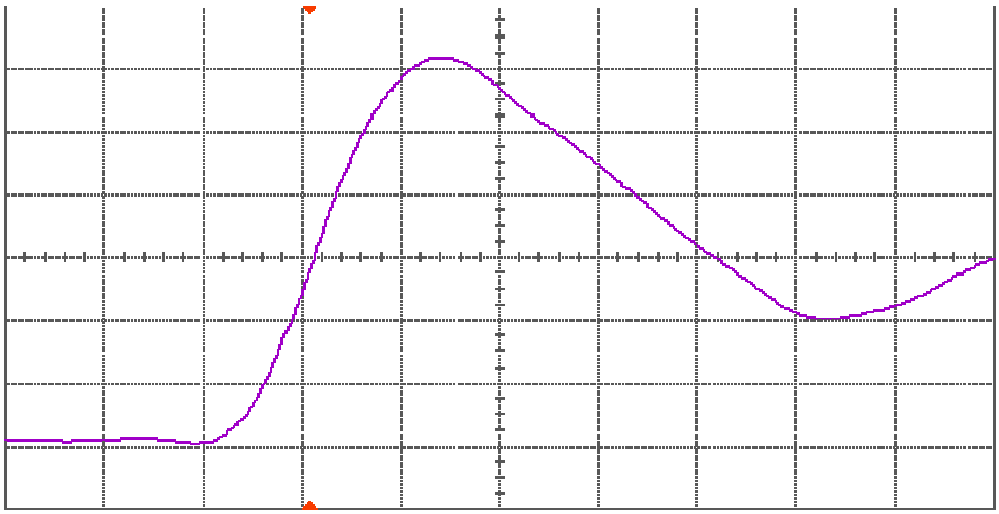

Figure 11(a) DUT 3147 pre-radiation rising edge, abscissa scale is 1 V/div and ordinate scale is 1 ns/div.

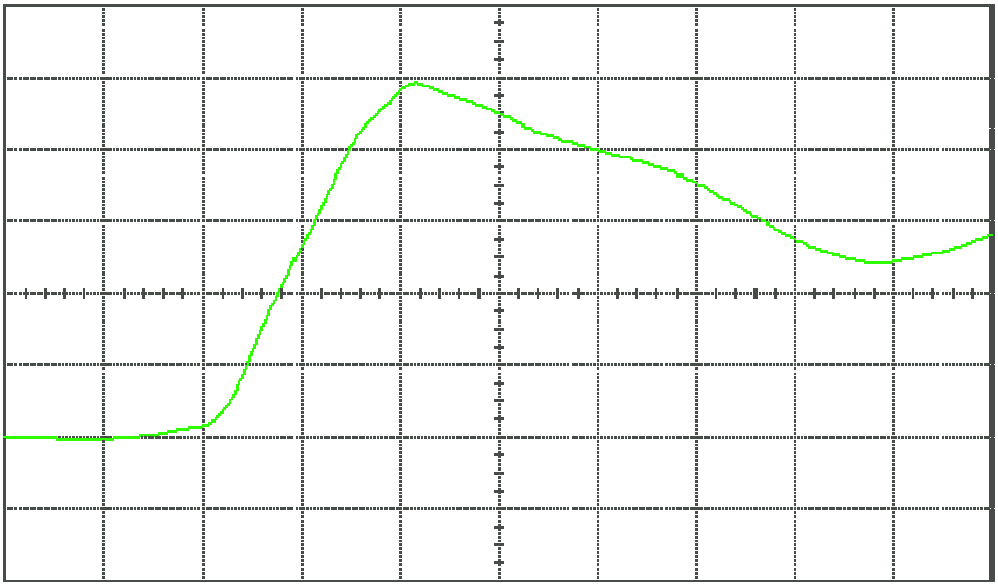

Figure 11(b) DUT 3147 post-annealing rising edge, abscissa scale is 1 V/div and ordinate scale is 1 ns/div.

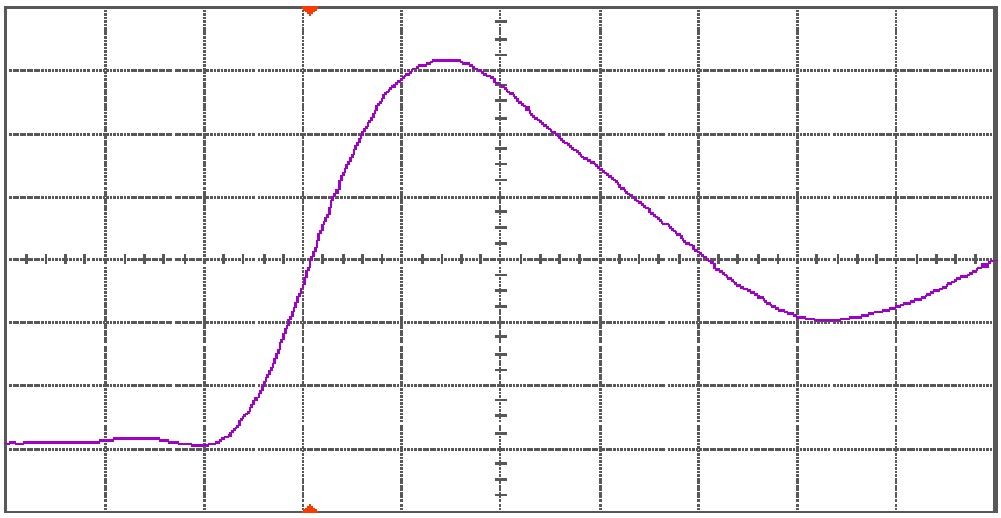

Figure 12(a) DUT 3148 pre-irradiation rising edge, abscissa scale is 1 V/div and ordinate scale is 1 ns/div.

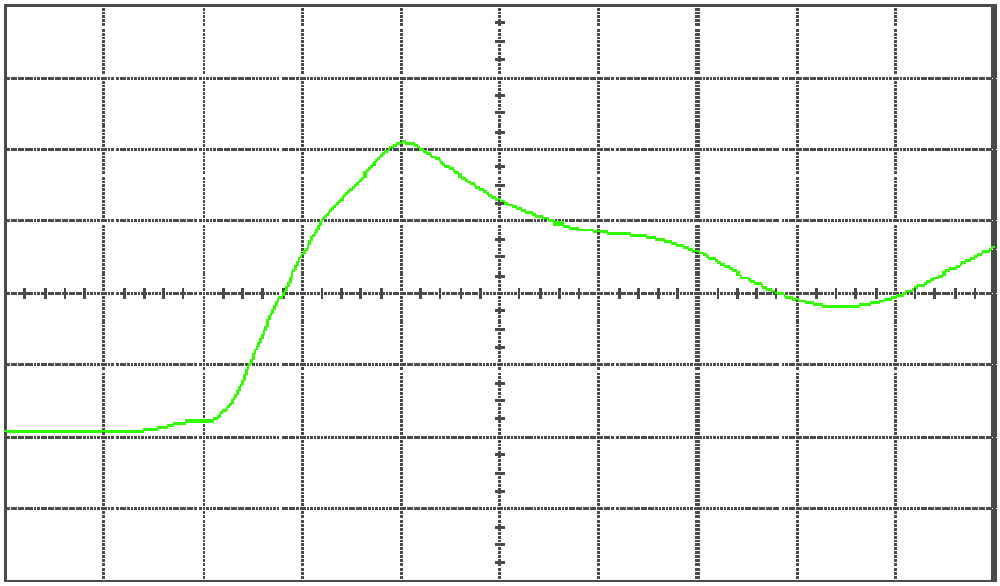

Figure 12(b) DUT 3148 post-annealing rising edge, abscissa scale is 1 V/div and ordinate scale is 1 ns/div.

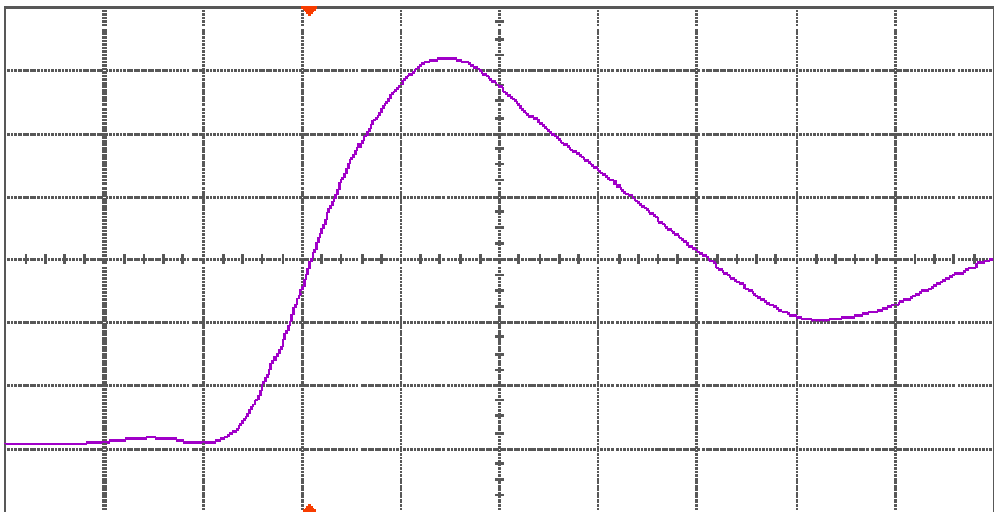

Figure 13(a) DUT 3149 pre-irradiation rising edge, abscissa scale is 1 V/div and ordinate scale is 1 ns/div.

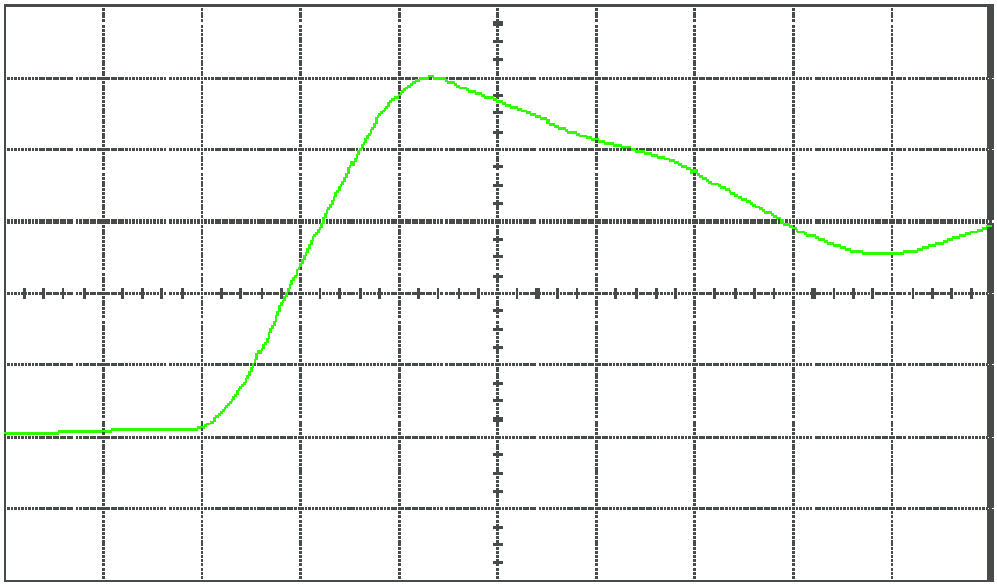

Figure 13(b) DUT 3149 post-annealing rising edge, abscissa scale is 1 V/div and ordinate scale is 1 ns/div.

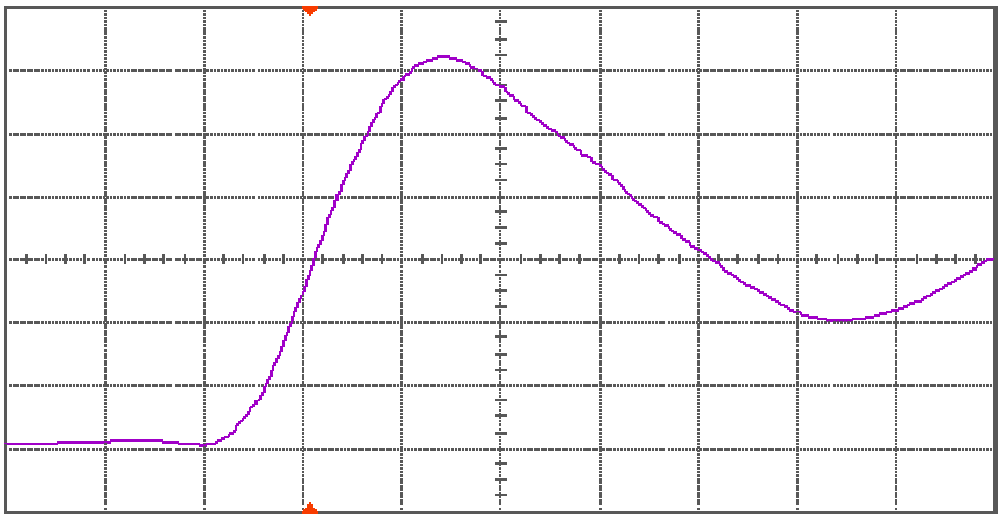

Figure 14(a) DUT 3176 pre-irradiation rising edge, abscissa scale is 1 V/div and ordinate scale is 1 ns/div.

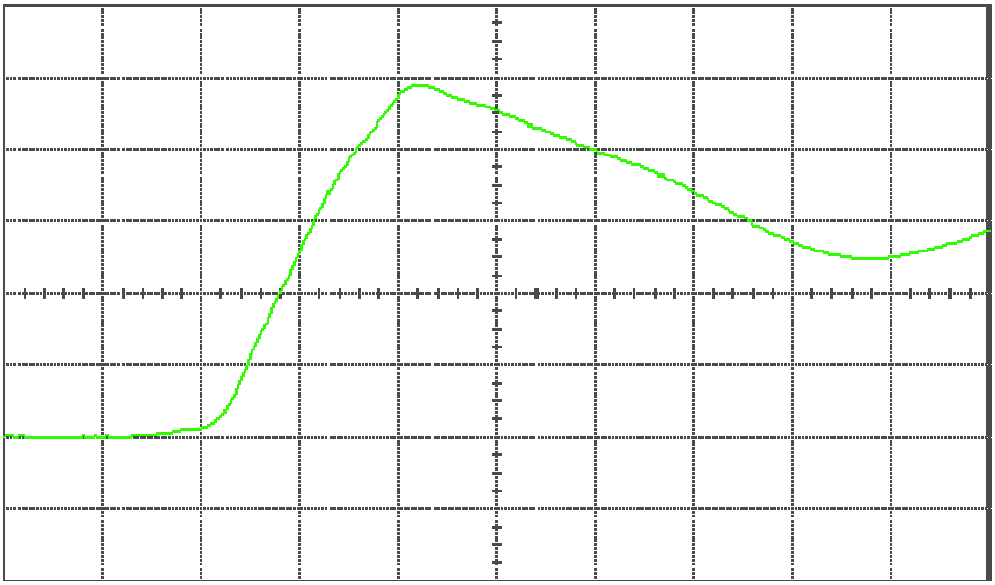

Figure 14(b) DUT 3176 post-annealing rising edge, abscissa scale is 1 V/div and ordinate scale is 1 ns/div.

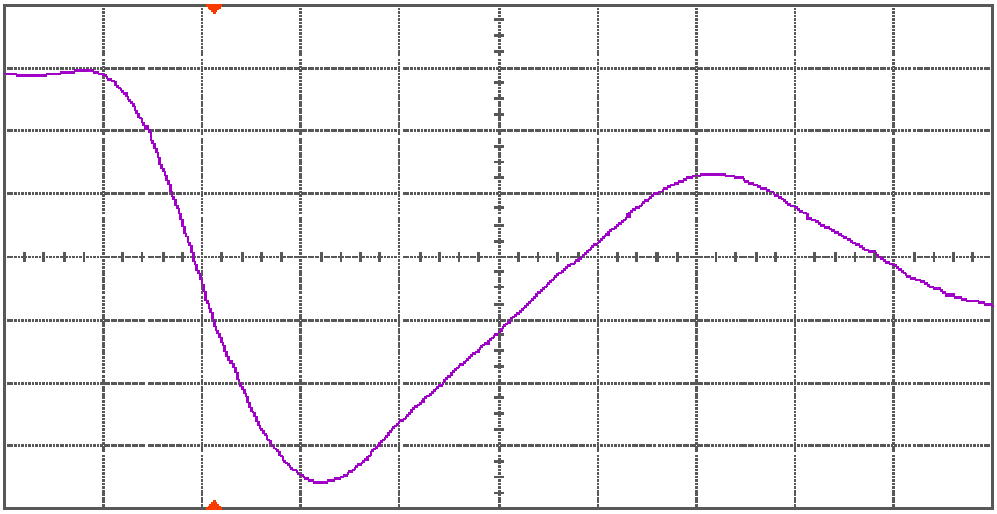

Figure 15(a) DUT 3095 pre-irradiation falling edge, abscissa scale is 1 V/div and ordinate scale is 1 ns/div.

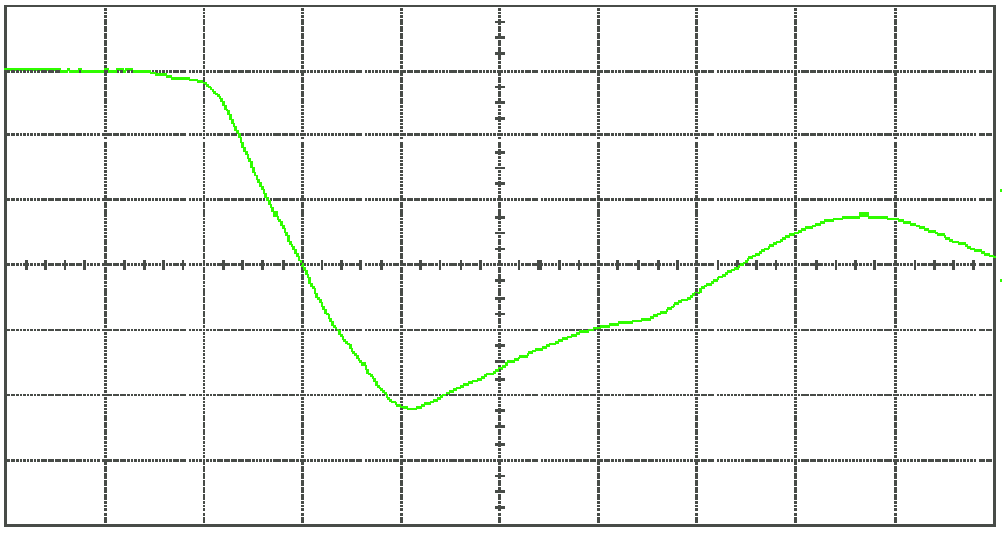

Figure 15(b) DUT 3095 post-annealing falling edge, abscissa scale is 1 V/div and ordinate scale is 1 ns/div.

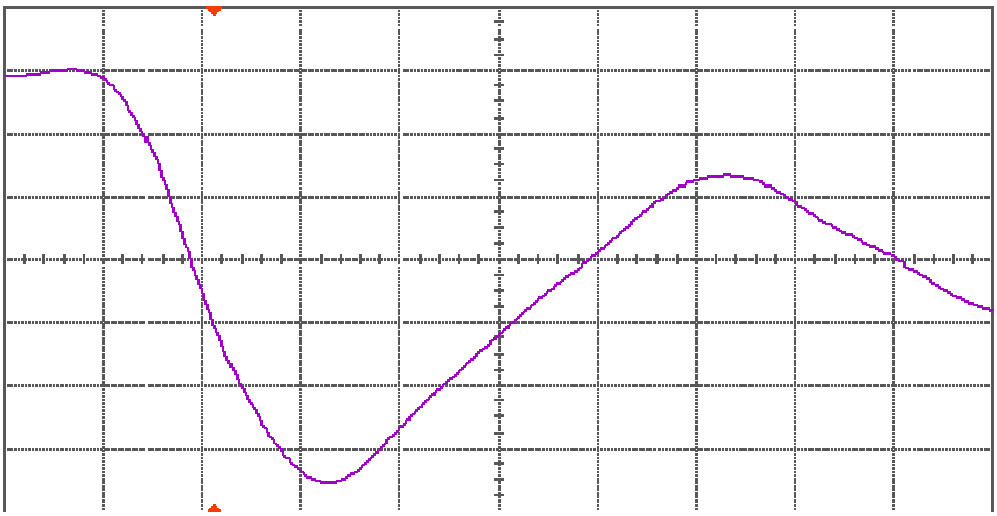

Figure 16(a) DUT 3124 pre-irradiation falling edge, abscissa scale is 1 V/div and ordinate scale is 1 ns/div.

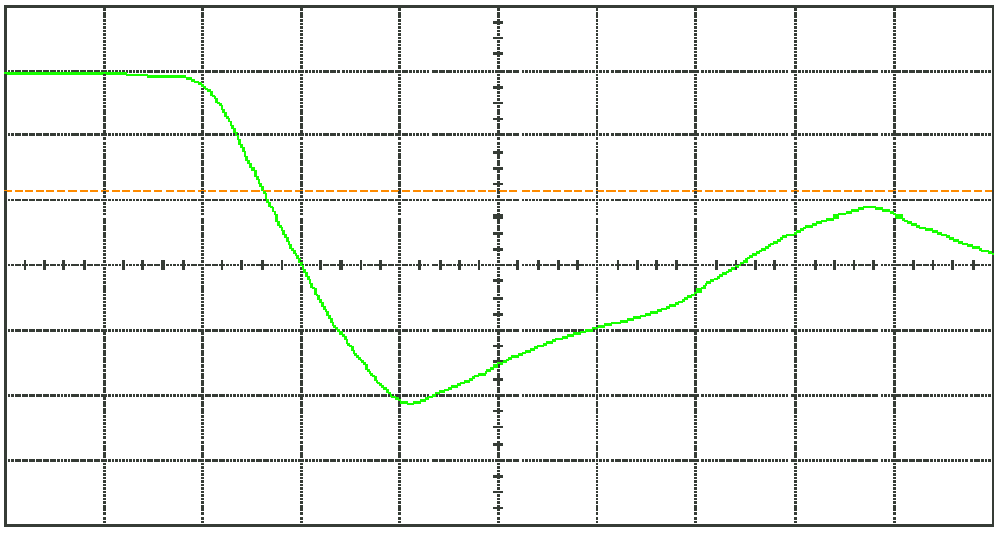

Figure 16(b) DUT 3124 post-annealing falling edge, abscissa scale is 1 V/div and ordinate scale is 1 ns/div.

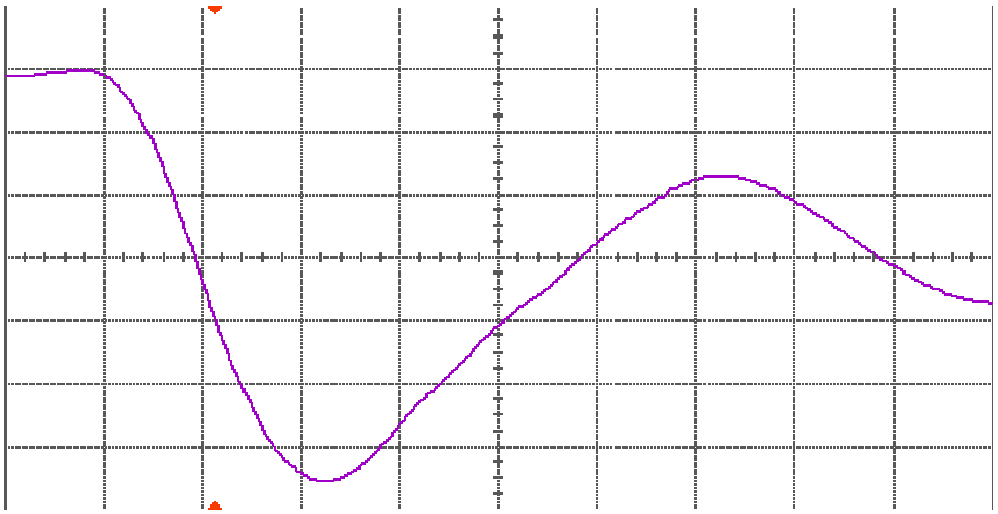

Figure 17(a) DUT 3147 pre-irradiation falling edge, abscissa scale is 1 V/div and ordinate scale is 1 ns/div.

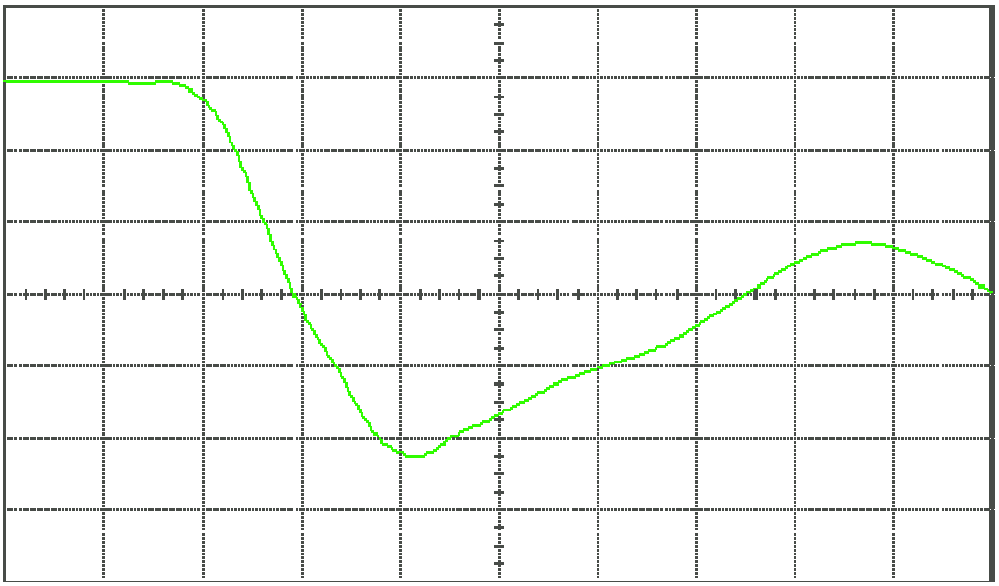

Figure 17(b) DUT 3147 post-annealing falling edge, abscissa scale is 1 V/div and ordinate scale is 1 ns/div.

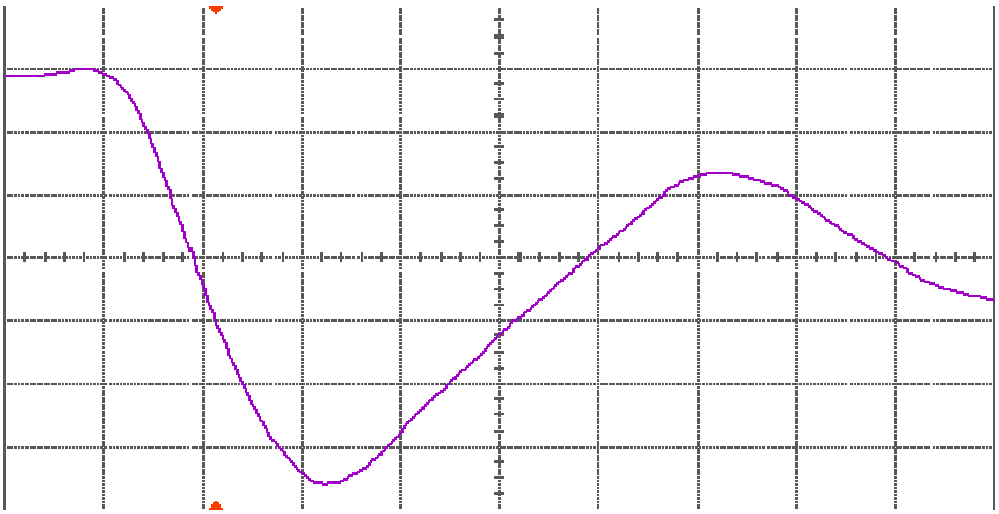

Figure 18(a) DUT 3148 pre-irradiation falling edge, abscissa scale is 1 V/div and ordinate scale is 1 ns/div.

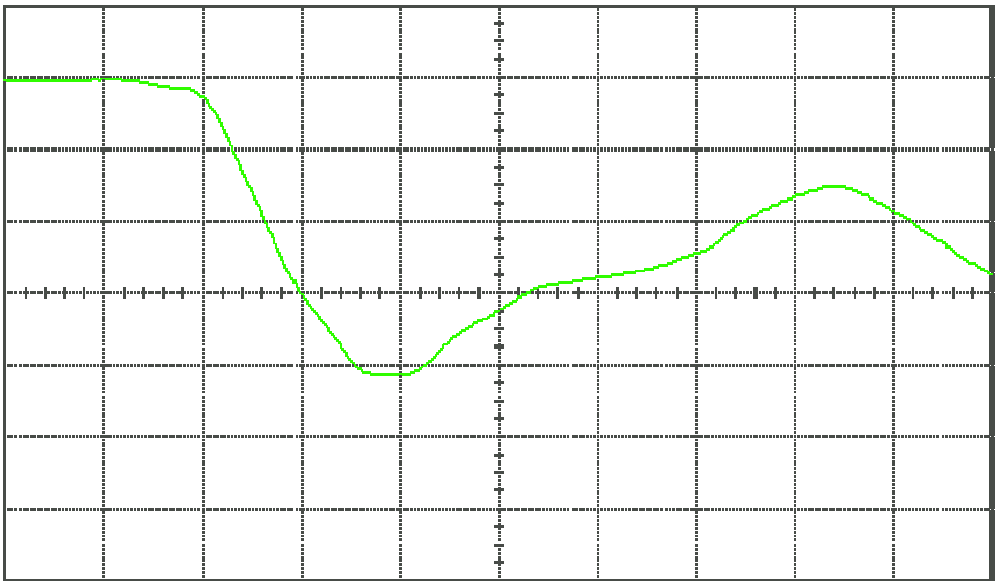

Figure 18(b) DUT 3148 post-annealing falling edge, abscissa scale is 1 V/div and ordinate scale is 1 ns/div.

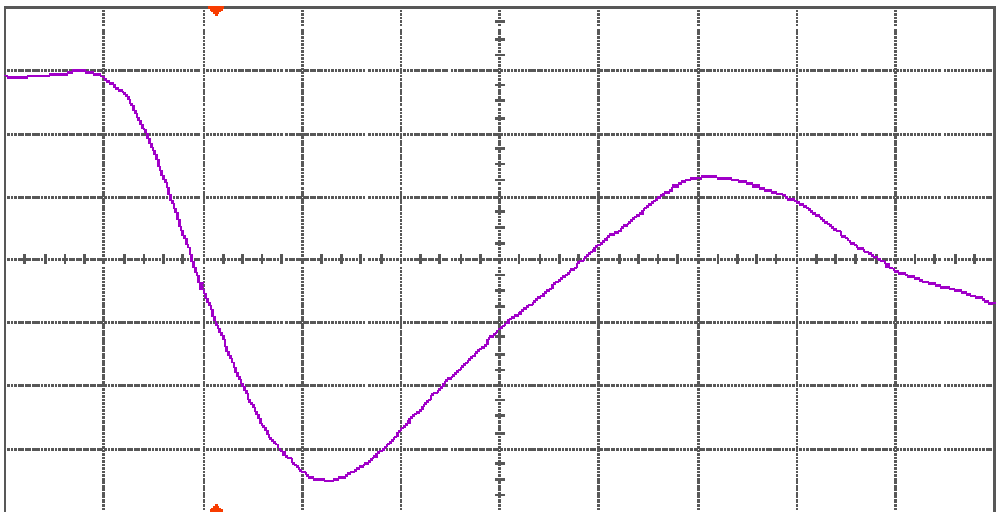

Figure 19(a) DUT 3149 post-annealing falling edge, abscissa scale is 1 V/div and ordinate scale is 1 ns/div.

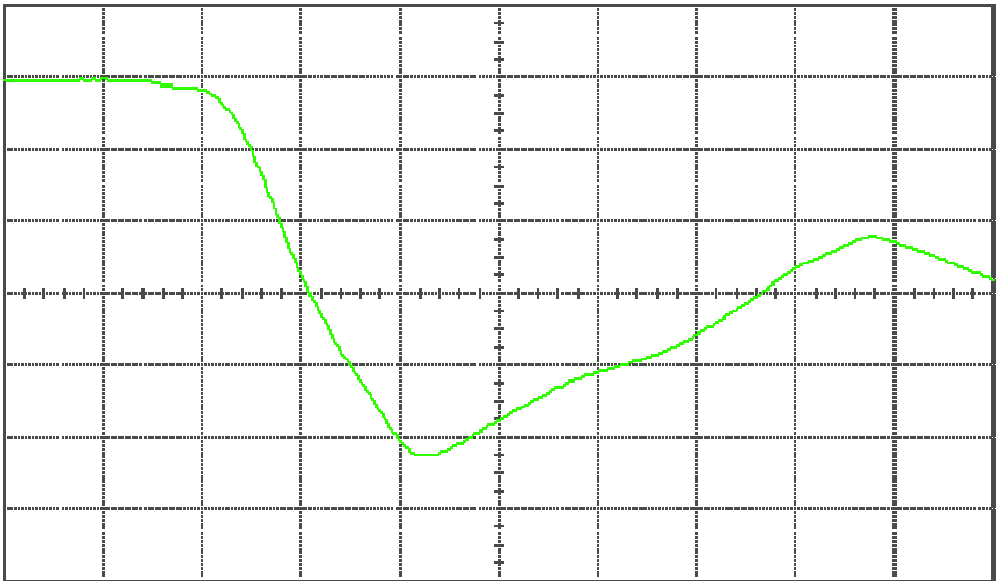

Figure 19(b) DUT 3149 post-annealing falling edge, abscissa scale is 1 V/div and ordinate scale is 1 ns/div.

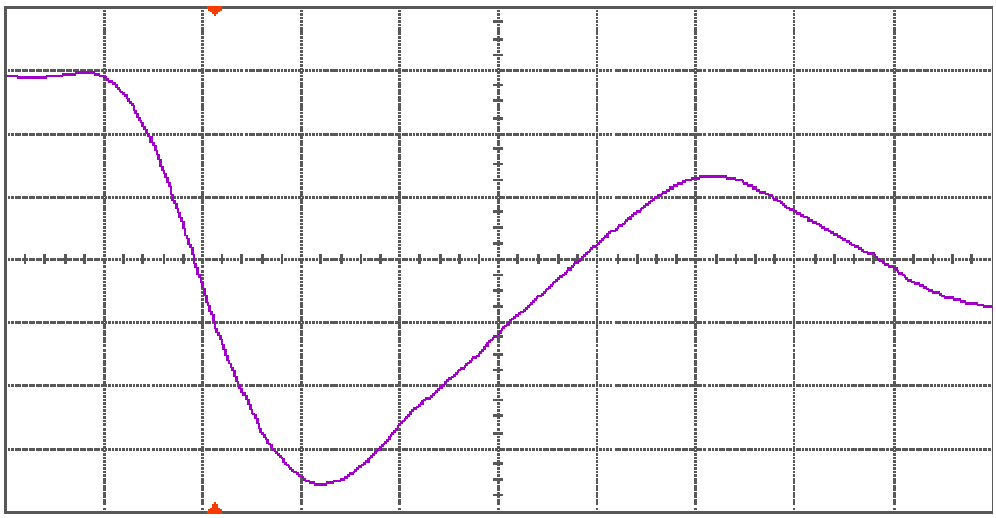

Figure 20(a) DUT 3176 pre-irradiation falling edge, abscissa scale is 1 V/div and ordinate scale is 1 ns/div.

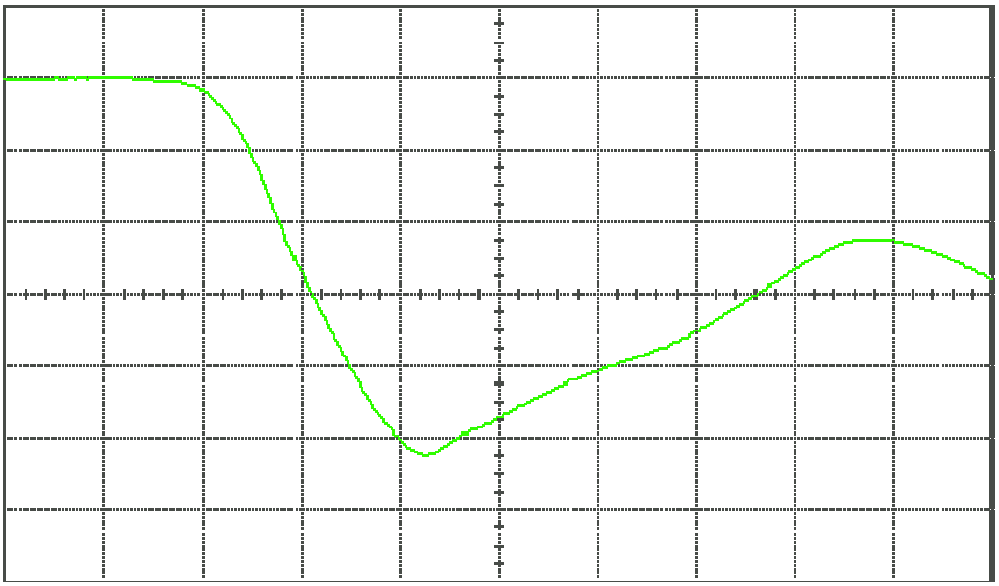

Figure 20(b) DUT 3176 post-annealing falling edge, abscissa scale is 1 V/div and ordinate scale is 1 ns/div.