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Total Ionizing Dose Test Report

No. 21T-RT4G150-LG1657- K0SN3

March 2021

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I. SUMMARY TABLE

Table. 1. Summary

Parameter	Tolerance
1. Gross Functionality	Passed 125 krad(SiO_2)
2. Power Supply Current	Passed 125 krad(SiO_2)
3. Input Threshold (VIL/VIH)	Passed 125 krad(SiO_2)
4. Output Drive (VOL/VOH)	Passed 125 krad(SiO_2)
5. Propagation Delay	Passed 125 krad(SiO_2) for 10% degradation criterion
6. Transition Time	Passed 125 krad(SiO_2)

II. TOTAL IONIZING DOSE (TID) TESTING

This testing is designed on the basis of an extensive database of TID testing for Radiation-Tolerant FPGAs including flash-based FPGAs. Microsemi TID reports can be found at http://www.microsemi.com/products/fpga-soc/radtolerant-fpgas/military-aerospace-radiation-reliability-data#tid-reports

Electrical parameters are measured pre-irradiation and post-irradiation using the burn in design and the Automatic Test Equipment (ATE) program. The report summarizes sample pins.

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

Table 1 lists the DUT and irradiation parameters.

Table. 2. DUT and Irradiation Parameters

Part Number	RT4G150
Package	LG1657
Foundry	United Microelectronics Corp.
Technology	65 nm
DUT Design	Burn in design with inverter string
Die Lot Number	K0SN3
Quantity Tested	6
Serial Number (Dose)	11675 (125 krad), 11677 (125 krad), 11684 (125 krad), 11744 (125 krad), 11772 (125 krad), 11817 (125 krad)
Radiation Facility	Defense Microelectronics Activity
Radiation Source	Co-60
Dose Rate	5 krad (SiO_2)/min
Irradiation Temperature	Room
Irradiation and Measurement Bias	Static at 1.2V/2.5V/3.3V/3.3V
IO Configuration	Single ended Differential Pair

B. Test Method

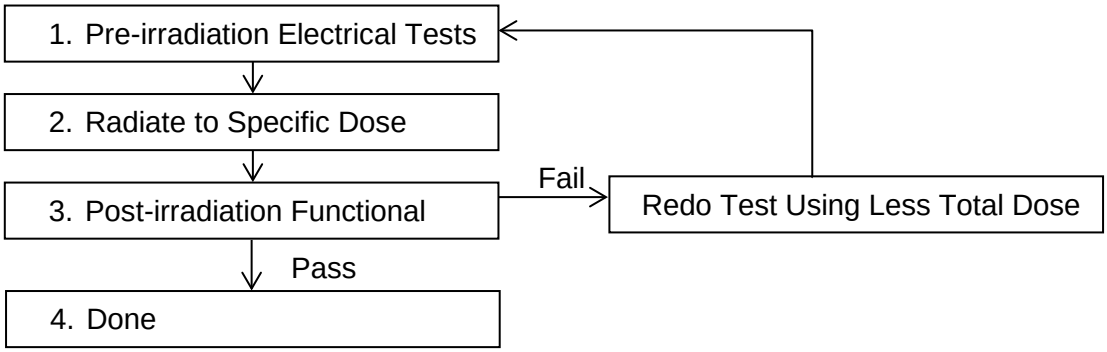

Fig. 1. Parametric test flow chart

The test method generally follows the guidelines in the military standard TM1019. Figure 1 shows the flow chart describing the steps for the functional and parametric tests.

C. Design and Parametric Measurements

RTG4 FPGA devices have different types of I/Os, such as MSIO and MSIOD, double data rate I/Os (DDRIO), and dedicated I/Os based on functional usage. For more information on I/O naming conventions and I/O description, refer to the RTG4 FPGA Pin Description. All I/Os are tested pre and post-irradiation.

Fabric functionality coverage performed by the burn in design is summarized in table 2 below. In addition to the fabric coverage the supplemental test of propagation delay is also used to determine DUT functionality. These tests are performed pre and post-irradiation and recorded as a pass/fail.

Refer to appendix A for a graphical representation of fabric functional coverage blocks used to perform the functional tests.

Table. 3. Fabric Functional Coverage

Block	Coverage
Combo Block	combinatorial macros available in the RTG4 library
Register Block	sequential macros available in the RTG4 library
UPROM	Maximum output toggle rate(checker board) compared to reference
Embedded SRAM Blocks	full toggle coverage on 209 fabric LSRAM & 210 µRAM blocks using dual port/ two port configurations (x18 width)
Shift Register Block	core utilization
I/O Block	I/O utilization
Math Block	full toggle coverage on 462 fabric math blocks with maximum width configuration

The core power supply current IDD, the I/Os power supply currents (IDDI_2.5/IDDI_3.3) and the charge pump and PLL power supply current (IPP_PLL) are also monitored during irradiation in real time.

The input logic threshold (VIL/VIH) is measured on all single-ended inputs as well as all differential inputs, and is reported as a pass or fail, as part of the ATE test program. The output-drive voltage (VOL/VOH) is also measured on all pins on the MSIO MSIOD and DDRIO. This report contains the output-drive voltage measurements on selected IO pins used in the burn in design. LVTTL and LVCMOS 2.5V standard at different sourcing and sinking currents are reported.

A 2000 stage inverter string is used to measure the propagation delay. The propagation delay is defined as the time delay from the triggering edge at the Clock input to the switching edge at the output. The propagation delay is monitored real time during irradiation and the time difference between positive switching edges of the clock and output are reported. Additionally, the transition characteristics (rise and fall) at the output of the inverter chain are measured pre and post-irradiation. Oscilloscope screen captures are shown in section III. F.

III. TEST RESULTS

A. Functionality

Every DUT passed the pre-irradiation and post-irradiation functional tests mentioned in section II.C.

B. Power Supply Current

The core power supply current (IDD) is 1.2 V, the I/O bank power supply currents (IDDI) are 2.5 V (IDDI_2.5) and 3.3 V (IDDI_3.3). The charge pump and PLL power supply current (IPP_PLL) is 3.3 V. Figures 2-25 illustrate the plot of in-flux standby IDD, IDDI_2.5, IDDI_3.3 and IPP_PLL versus total dose for every DUT. Tables 3-6 summarize the pre-irradiation and post-irradiation total current (static & dynamic) IDD, IDDI_2.5, IDDI_3.3 and IPP_PLL.

Table. 4. Pre-irradiation and Post-irradiation I_{DD}

DUT	Total Dose	Pre-irradiation (A)	Post-irradiation (A)	Increase (%)
11675	125 krad	0.4139	0.4271	3.19
11677	125 krad	0.4021	0.4182	4.00
11684	125 krad	0.4251	0.4430	4.21
11744	125 krad	0.3649	0.3773	3.40
11772	125 krad	0.4125	0.4300	4.24
11817	125 krad	0.3985	0.4222	5.95

Table. 5. Pre-irradiation and Post-irradiation $I_{DDI\_2.5}$

DUT	Total Dose	Pre-irradiation (A)	Post-irradiation (A)	Increase (%)
11675	125 krad	0.0089	0.0110	23.60
11677	125 krad	0.0115	0.0138	20.00
11684	125 krad	0.0105	0.0128	21.90
11744	125 krad	0.0091	0.0114	25.27
11772	125 krad	0.0102	0.0125	22.55
11817	125 krad	0.0096	0.0120	25.00

Table. 6. Pre-irradiation and Post-irradiation $I_{DDI\_3.3}$

DUT	Total Dose	Pre-irradiation (A)	Post-irradiation (A)	Increase (%)
11675	125 krad	0.0335	0.0366	9.25
11677	125 krad	0.0330	0.0366	10.91
11684	125 krad	0.0348	0.0375	7.76
11744	125 krad	0.0335	0.0363	8.36
11772	125 krad	0.0341	0.0371	8.80
11817	125 krad	0.0334	0.0361	8.08

Table. 7. Pre-irradiation and Post-irradiation I_{PP_PLL}

DUT	Total Dose	Pre-irradiation (A)	Post-irradiation (A)	Increase (%)
11675	125 krad	0.0153	0.0153	0.00
11677	125 krad	0.0152	0.0153	0.66
11684	125 krad	0.0153	0.0167	9.15
11744	125 krad	0.0154	0.0158	2.60
11772	125 krad	0.0153	0.0157	2.61
11817	125 krad	0.0153	0.0163	6.54

The following figures (2-25) show the in-beam monitoring of the currents mentioned above as a function of TID for the available DUTs.

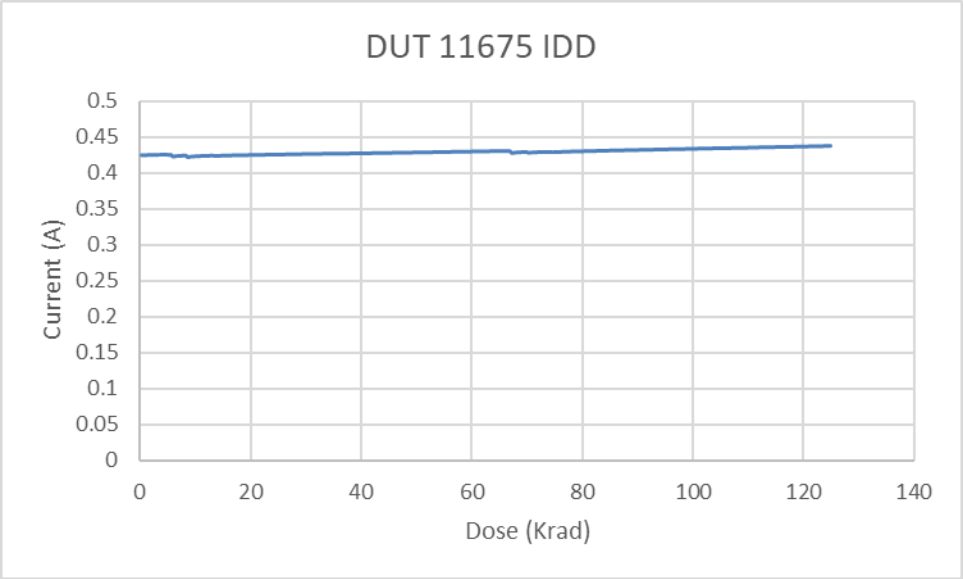

Fig. 2. DUT 11675 core power supply current (I_{DD}) versus TID

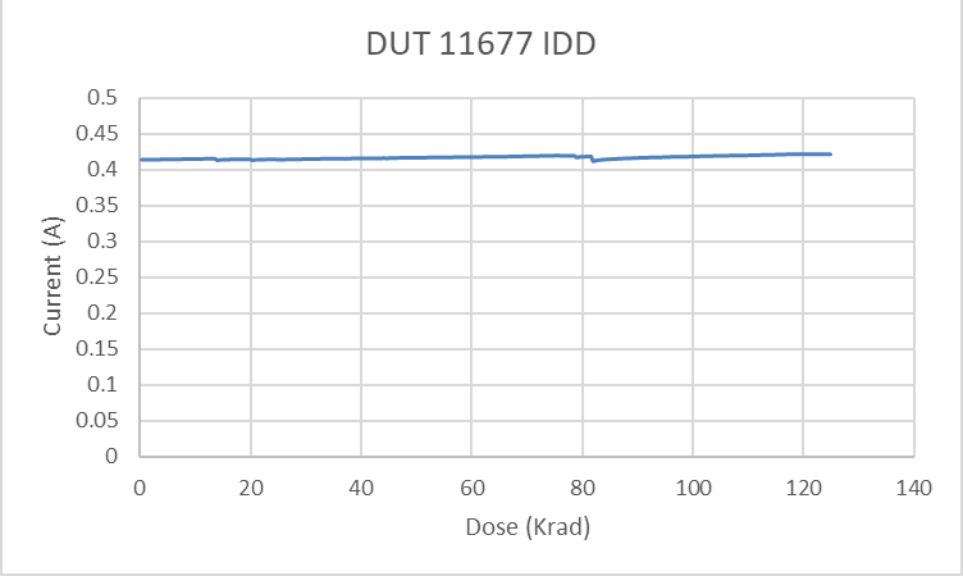

Fig. 3. DUT 11677 core power supply current (I_{DD}) versus TID

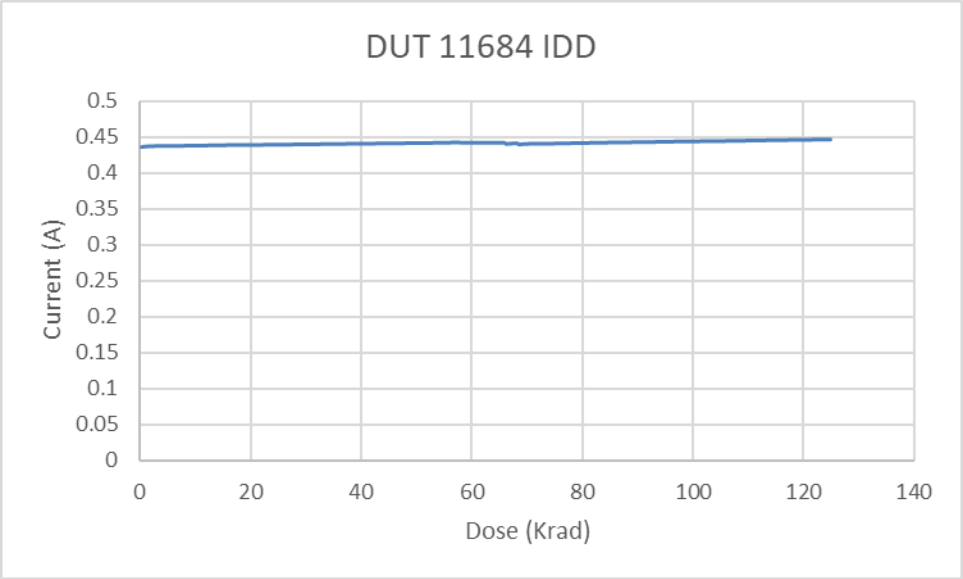

Fig. 4. DUT 11684 core power supply current (I_{DD}) versus TID

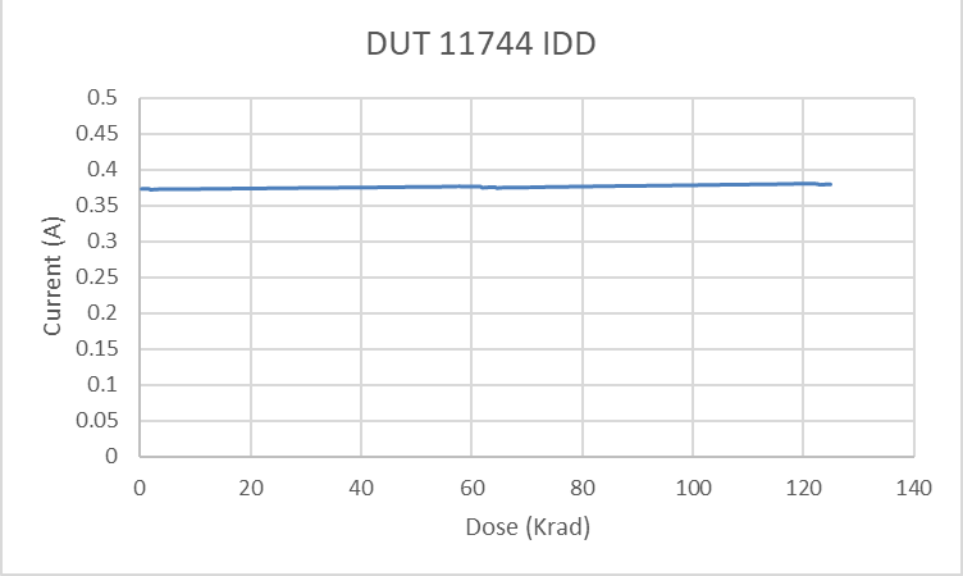

Fig. 5. DUT 11744 core power supply current (I_{DD}) versus TID

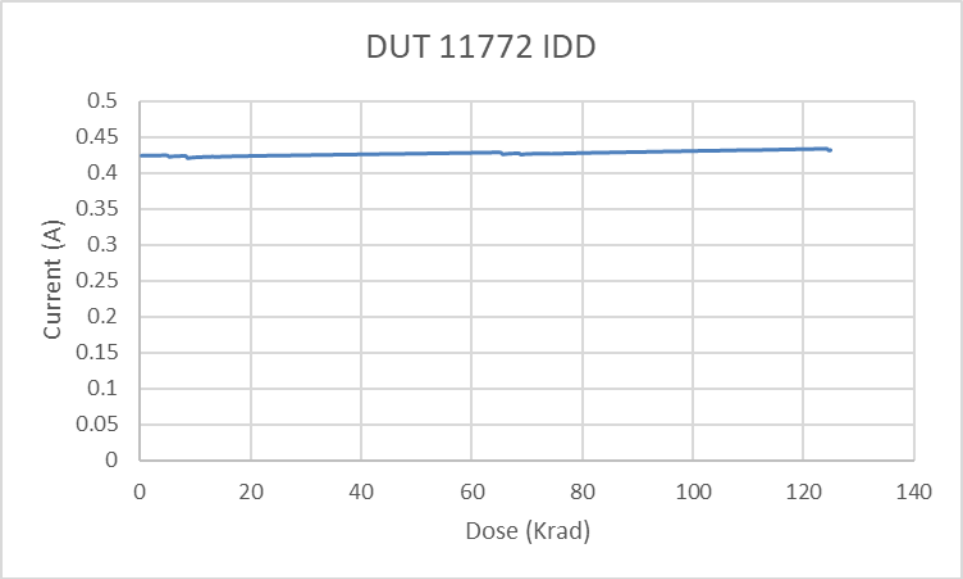

Fig. 6. DUT 11772 core power supply current (I_{DD}) versus TID

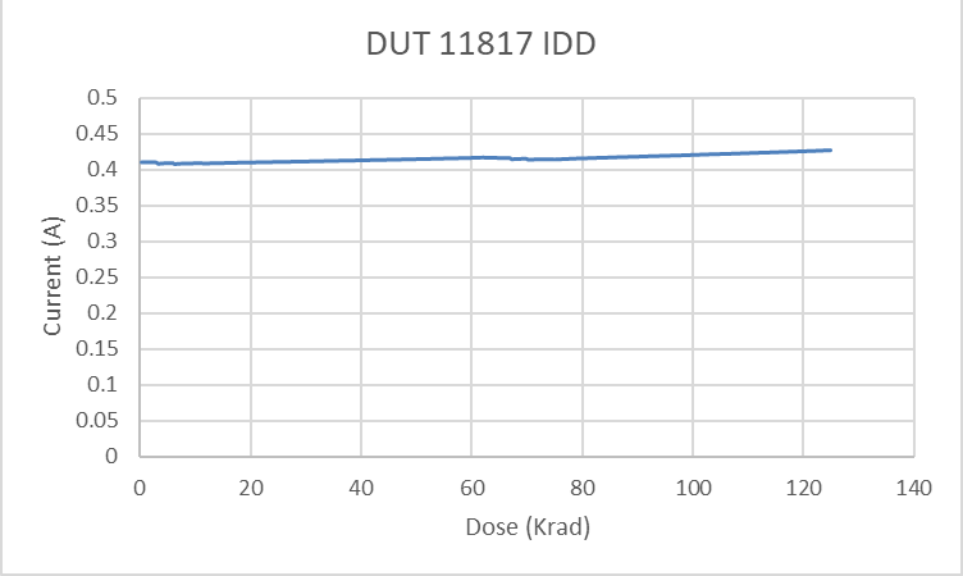

Fig. 7. DUT 11817 core power supply current (I_{DD}) versus TID

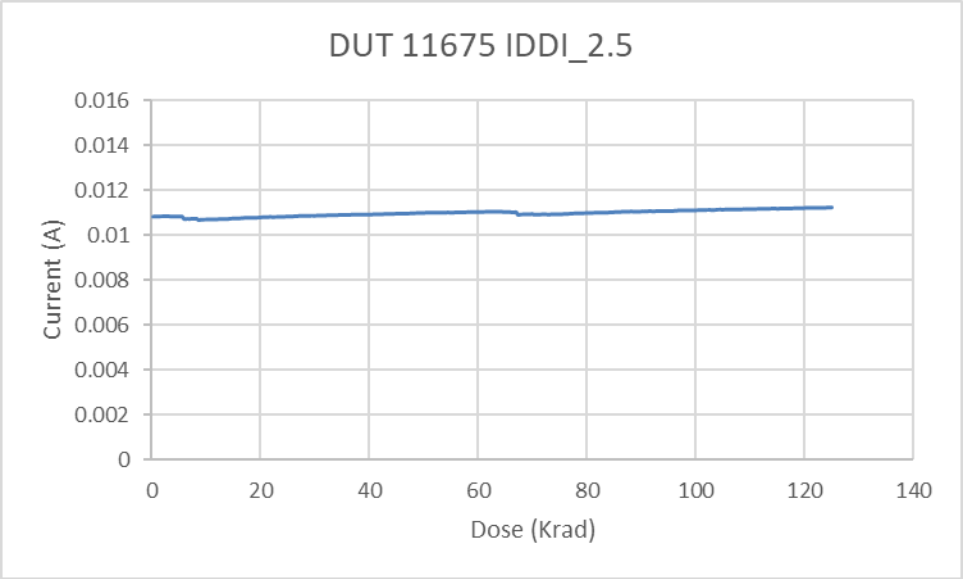

Fig. 8. DUT 11675 I/O bank 2.5V power supply current ($I_{DDI\_2.5}$) versus TID

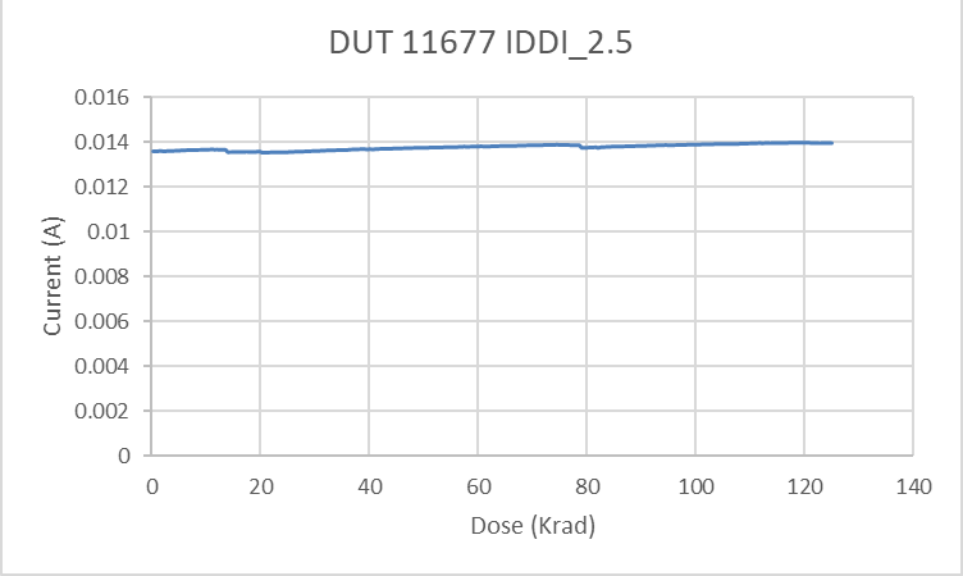

Fig. 9. DUT 11677 I/O bank 2.5V power supply current ($I_{DDI\_2.5}$) versus TID

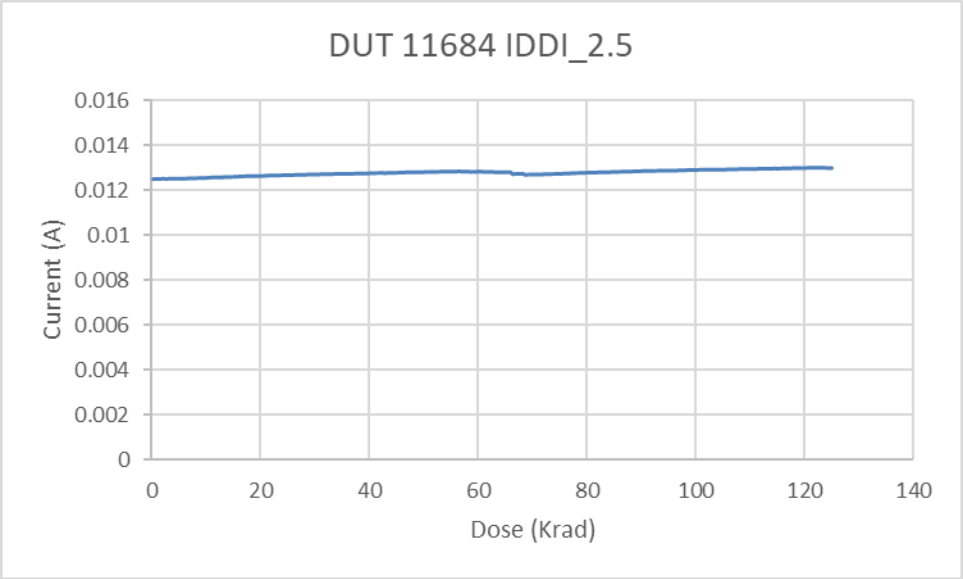

Fig. 10. DUT 11684 I/O bank 2.5V power supply current ($I_{DDI\_2.5}$) versus TID

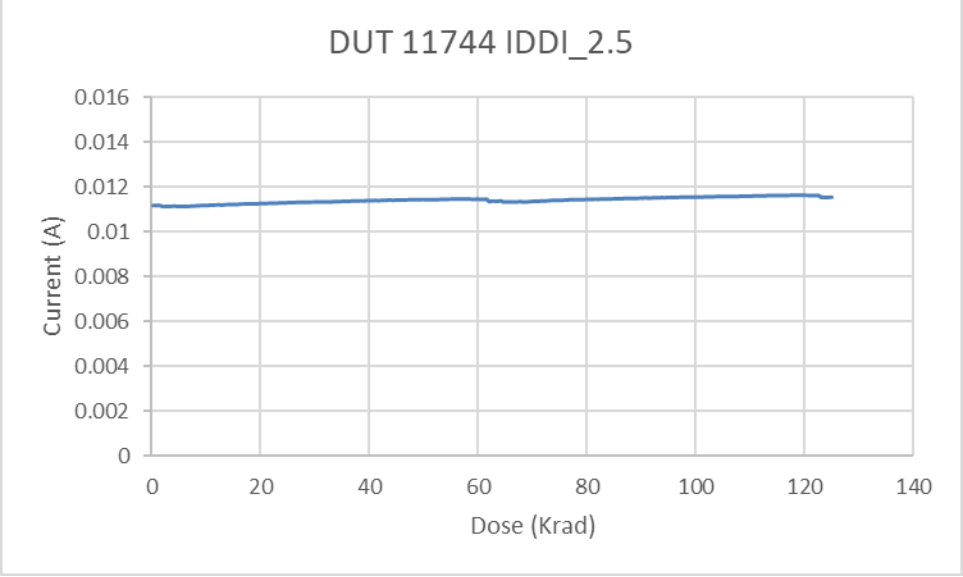

Fig. 11. DUT 11744 I/O bank 2.5V power supply current ($I_{DDI\_2.5}$) versus TID

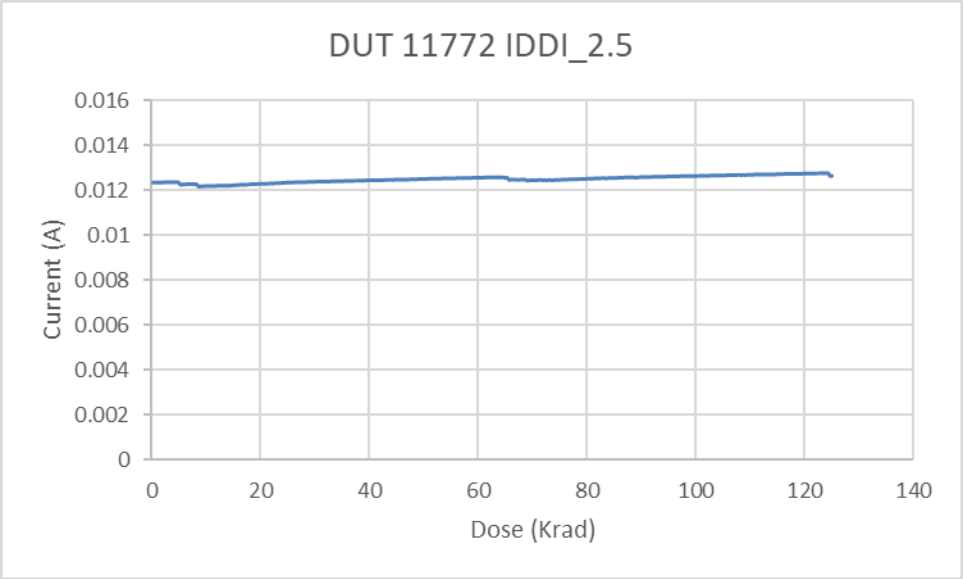

Fig. 12. DUT 11772 I/O bank 2.5V power supply current ($I_{DDI\_2.5}$) versus TID

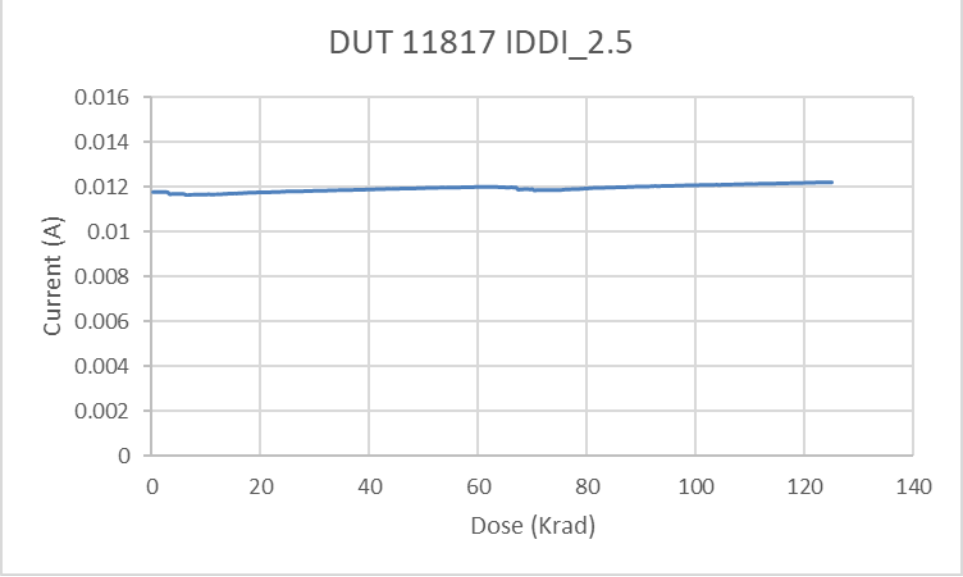

Fig. 13. DUT 11817 I/O bank 2.5V power supply current ($I_{DDI\_2.5}$) versus TID

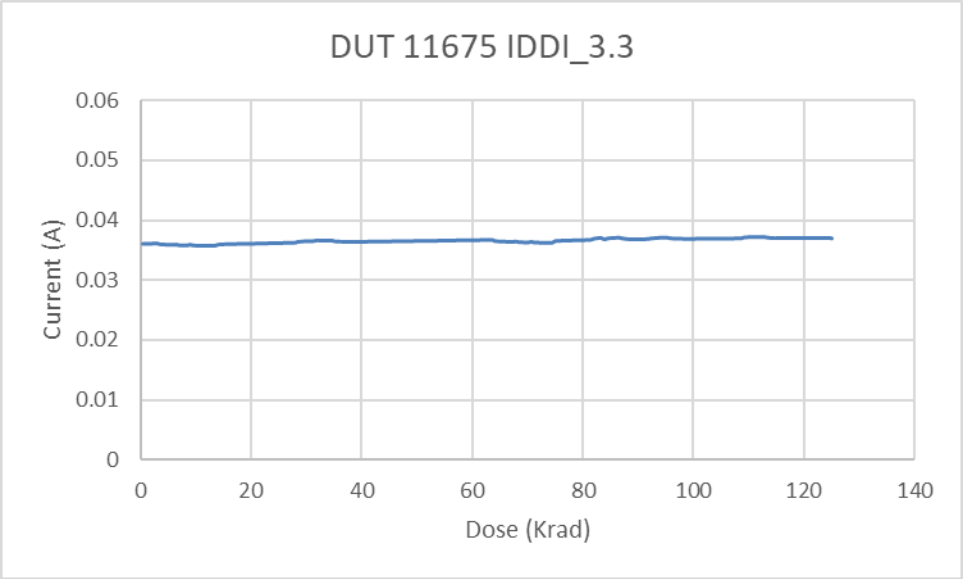

Fig. 14. DUT 11675 I/O bank 3.3V power supply current ($I_{DDI\_3.3}$) versus TID

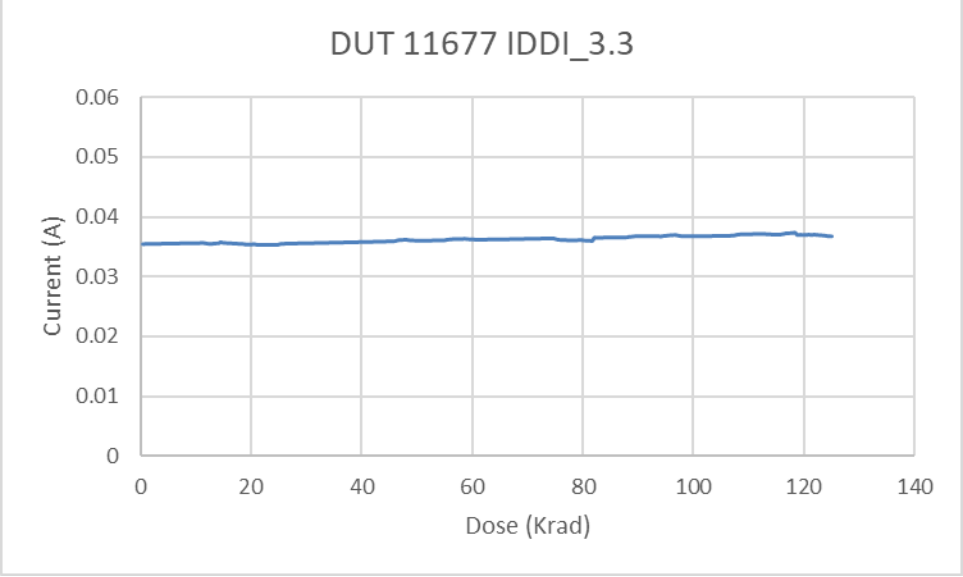

Fig. 15. DUT 11677 I/O bank 3.3V power supply current ($I_{DDI\_3.3}$) versus TID

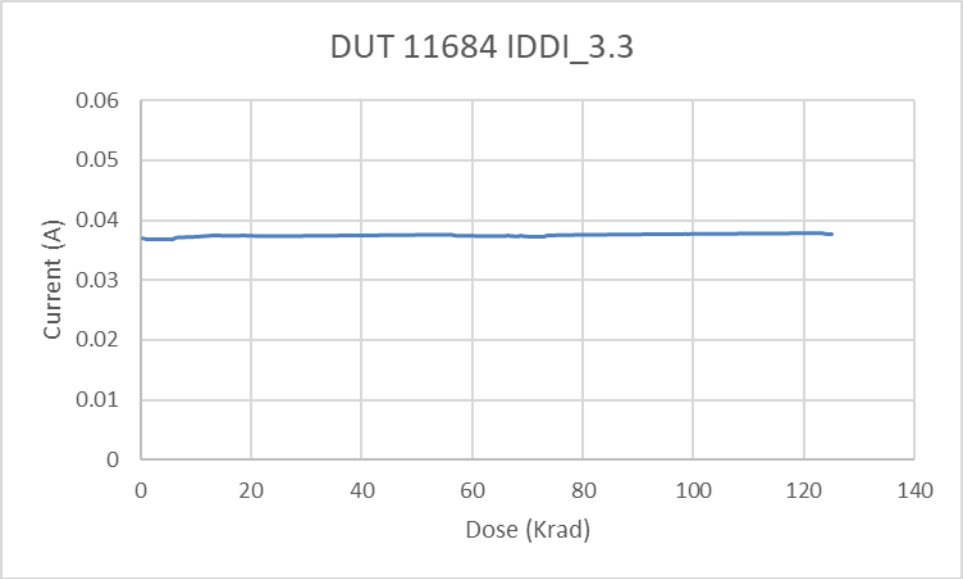

Fig. 16. DUT 11684 I/O bank 3.3V power supply current ($I_{DDI\_3.3}$) versus TID

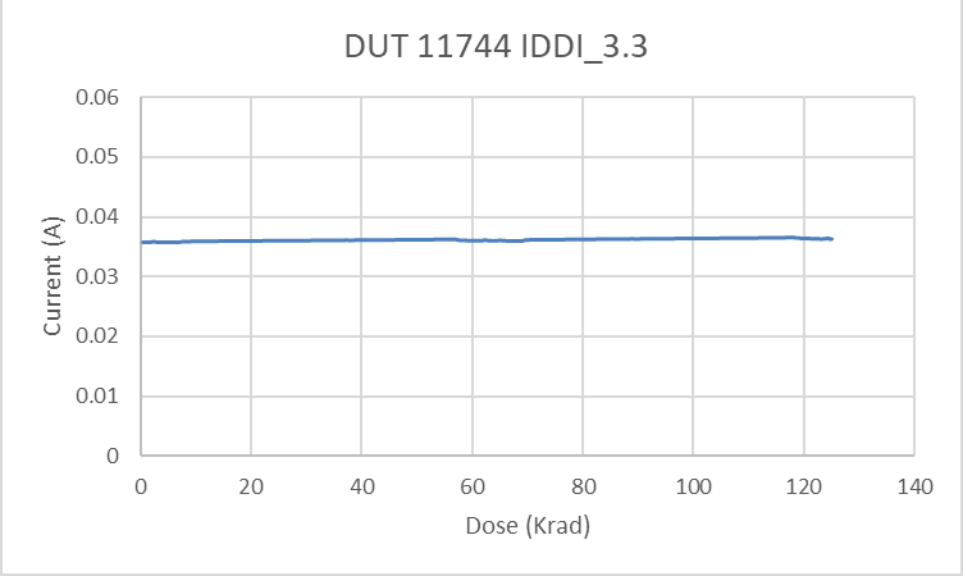

Fig. 17. DUT 11744 I/O bank 3.3V power supply current ($I_{DDI\_3.3}$) versus TID

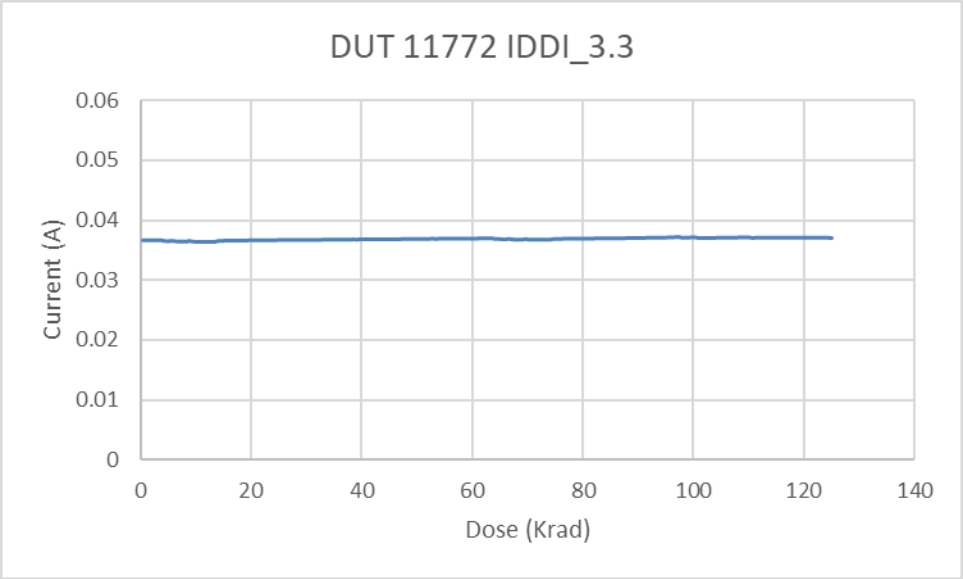

Fig. 18. DUT 11772 I/O bank 3.3V power supply current ($I_{DDI\_3.3}$) versus TID

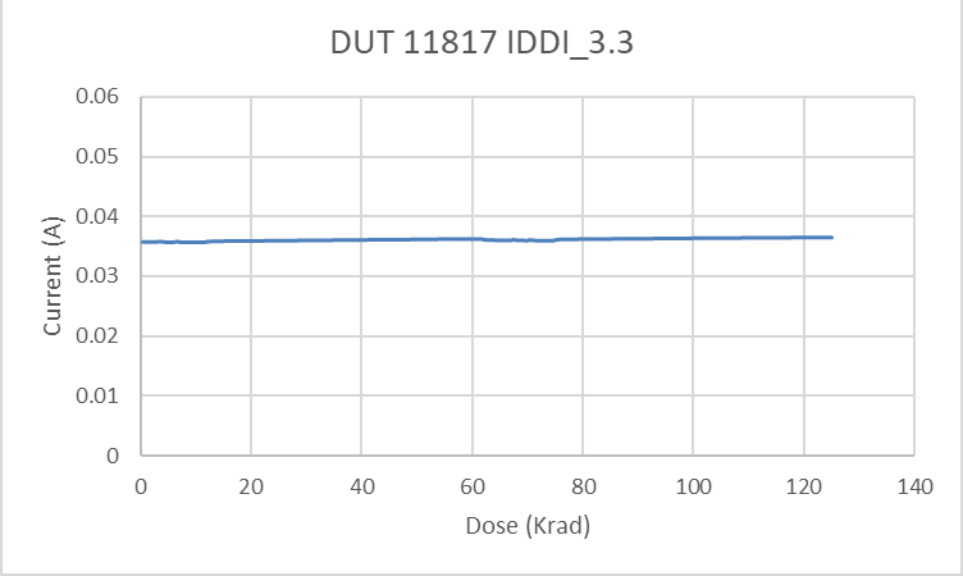

Fig. 19. DUT 11817 I/O bank 3.3V power supply current ($I_{DDI\_3.3}$) versus TID

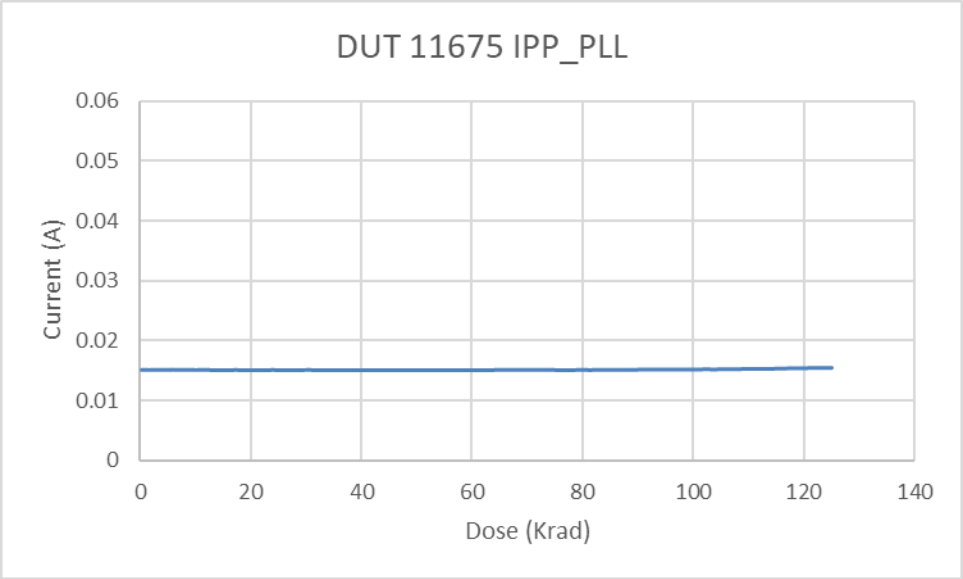

Fig. 20. DUT 11675 charge pump and PLL power supply current (I_{PP_PLL}) versus TID

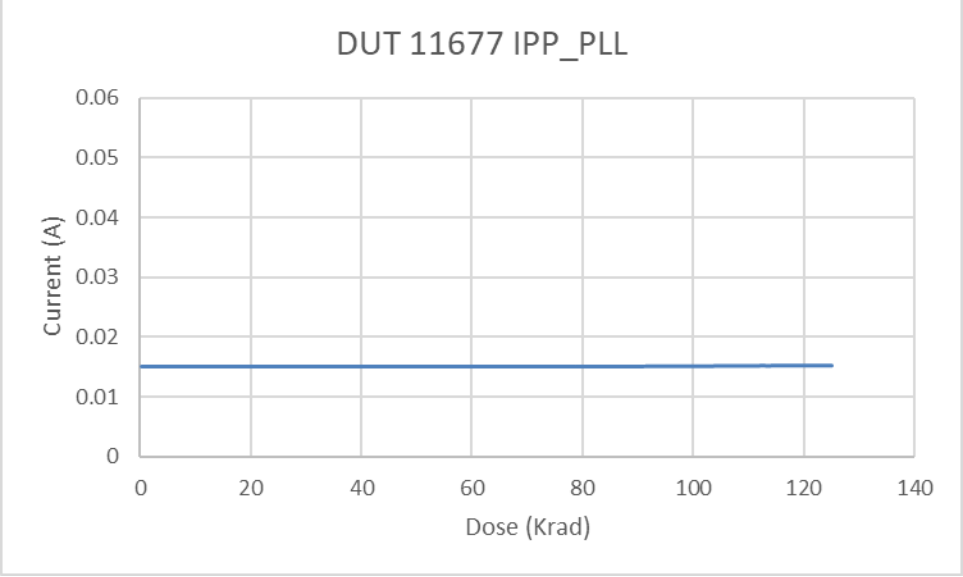

Fig. 21. DUT 11677 charge pump and PLL power supply current (I_{PP_PLL}) versus TID

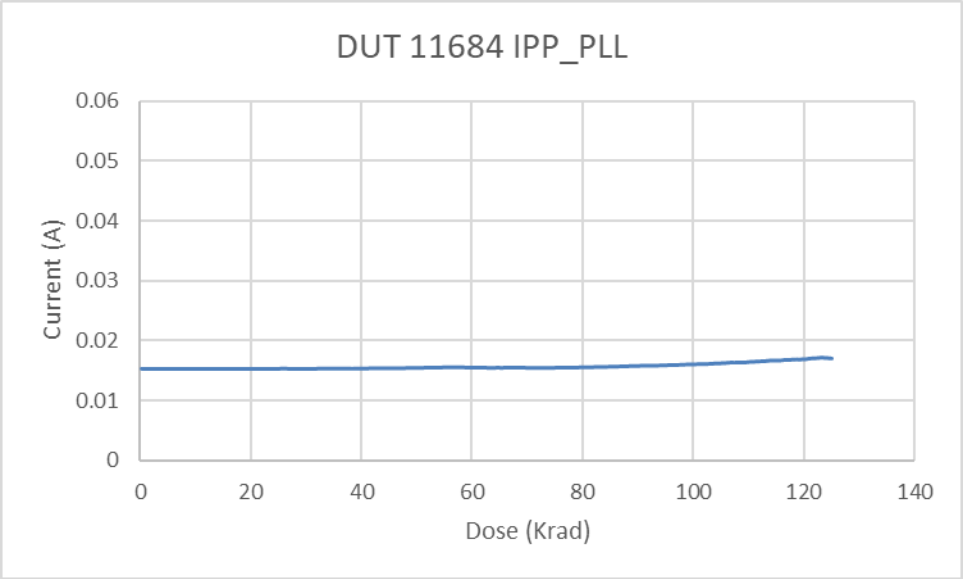

Fig. 22. DUT 11684 charge pump and PLL power supply current (I_{PP_PLL}) versus TID

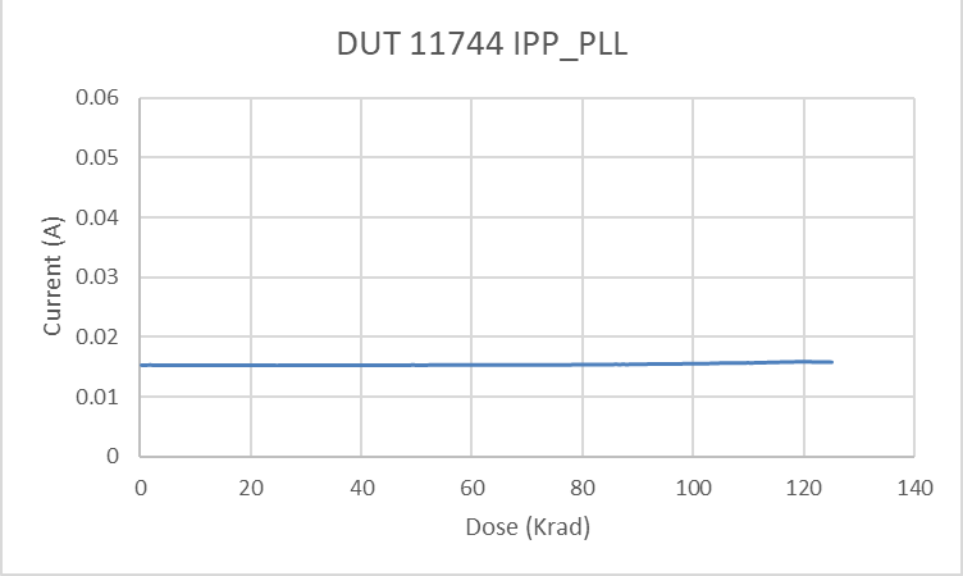

Fig. 23. DUT 11744 charge pump and PLL power supply current (I_{PP_PLL}) versus TID

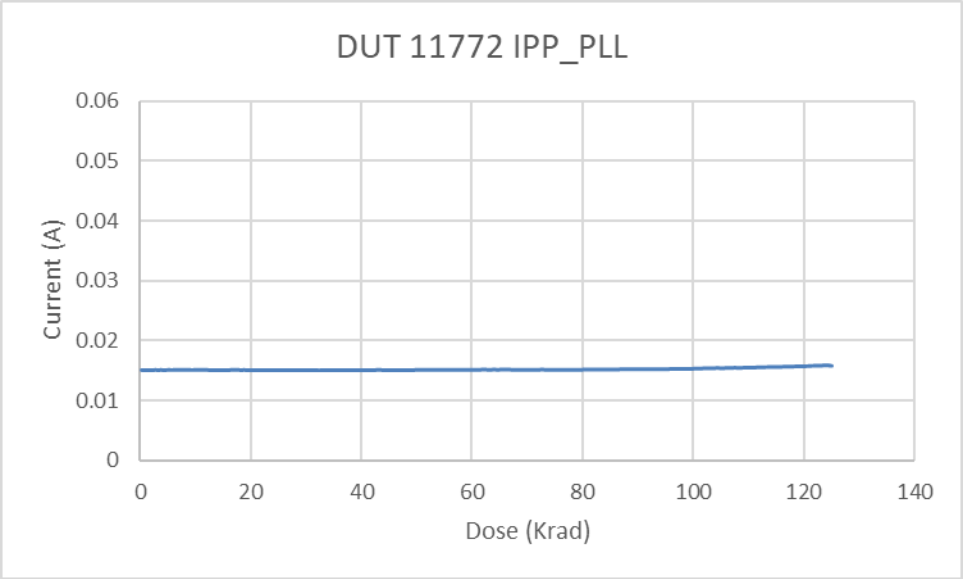

Fig. 24. DUT 11772 charge pump and PLL power supply current (I_{PP_PLL}) versus TID

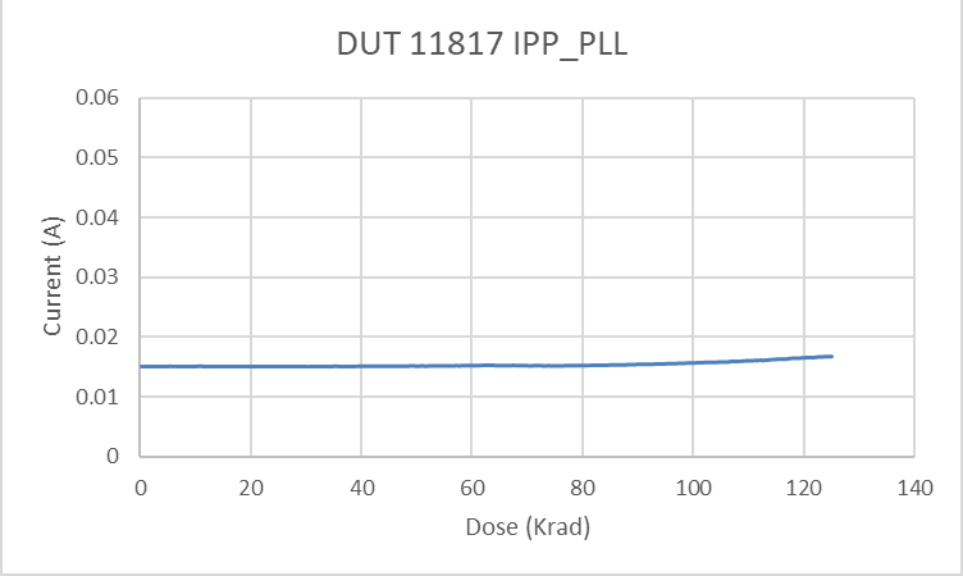

Fig. 25. DUT 11817 charge pump and PLL power supply current (I_{PP_PLL}) versus TID

C. Single-Ended Input Logic Threshold (VIL/VIH)

The input switching threshold, or trip point, is defined as the applied input voltage at which the output of the design starts to switch. VIH is the input trip point when the input is going high to low and VIL is the input trip point when the input is going low to high. The input logic threshold (VIL/VIH) is measured on all single-ended inputs as well as all differential input and recorded as pass or fail. All I/Os are tested at their respective I/O standards and are compliant to the JEDEC specs. Refer to http://www.microsemi.com/document-portal/doc_view/135193-ds0131-rtg4-fpga-datasheet for more information.

The 3 DUTs tested passed with respect to the testing specification pre and post-irradiation. This pass/fail is determined as part of the ATE test program used to perform pre and post-irradiation electrical parametric measurements.

Table. 8. VIH Summary

DUT	Pre-irradiation	Post-irradiation
11675	Passed	Passed
11677	Passed	Passed
11684	Passed	Passed
11744	Passed	Passed
11772	Passed	Passed
11817	Passed	Passed

Table. 9. VIL Summary

DUT	Pre-irradiation	Post-irradiation
11675	Passed	Passed
11677	Passed	Passed
11684	Passed	Passed
11744	Passed	Passed
11772	Passed	Passed
11817	Passed	Passed

D. Output-Drive Voltage (VOL/VOH)

The pre-irradiation and post-irradiation output-drive voltages (VOL/VOH) are performed on all available IOs. The measurements performed pre and post irradiation are within the specification limits; in each case, the radiation-induced degradation is within 10%. For the purpose of this report, the measurements presented below in tables 10 through 33 are sampled on several pins used in the burn in design.

Table. 10. LVCMOS 25 VOH – DUT 11675

		2mA		4mA		6mA		8mA		12mA		14mA	
Pin Name	Pin#	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad
TID_BUF_OUT	A33	2.134	2.129	2.204	2.197	2.175	2.166	2.156	2.146	2.124	2.110	2.111	2.094
EPCSRST_N_0	B31	2.135	2.130	2.204	2.197	2.175	2.167	2.156	2.146	2.124	2.110	2.110	2.095
EPCSRST_N_1	B32	2.135	2.130	2.204	2.198	2.175	2.168	2.155	2.145	2.124	2.111	2.111	2.096
EPCSRST_N_2	B34	2.134	2.127	2.203	2.193	2.174	2.160	2.153	2.136	2.120	2.096	2.106	2.079
EPCSRST_N_3	B35	2.135	2.131	2.204	2.200	2.176	2.170	2.156	2.149	2.125	2.117	2.112	2.103
EPCSRST_N_4	B36	2.134	2.130	2.202	2.198	2.172	2.168	2.151	2.146	2.118	2.112	2.103	2.097
EPCSRST_N_5	B37	2.134	2.131	2.203	2.199	2.174	2.169	2.153	2.147	2.120	2.114	2.106	2.100
MONITOR	K23	2.135	2.131	2.204	2.199	2.176	2.169	2.156	2.147	2.125	2.113	2.112	2.098
PLL_MON	L20	2.136	2.134	2.207	2.205	2.180	2.178	2.162	2.159	2.134	2.130	2.123	2.118
TOGGLE_MON	L22	2.136	2.133	2.207	2.203	2.180	2.176	2.161	2.156	2.132	2.126	2.120	2.114

Table. 11. LVCMOS 25 VOH – DUT 11677

		2mA		4mA		6mA		8mA		12mA		14mA	
Pin Name	Pin#	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad
TID_BUF_OUT	A33	2.135	2.130	2.204	2.197	2.176	2.167	2.157	2.146	2.124	2.111	2.111	2.095
EPCSRST_N_0	B31	2.136	2.131	2.204	2.197	2.176	2.167	2.157	2.146	2.124	2.110	2.110	2.095
EPCSRST_N_1	B32	2.136	2.131	2.205	2.199	2.177	2.169	2.157	2.147	2.126	2.113	2.113	2.098
EPCSRST_N_2	B34	2.135	2.128	2.203	2.193	2.174	2.160	2.154	2.135	2.121	2.094	2.107	2.077
EPCSRST_N_3	B35	2.136	2.132	2.205	2.201	2.177	2.172	2.157	2.151	2.126	2.119	2.113	2.106
EPCSRST_N_4	B36	2.135	2.131	2.202	2.198	2.172	2.168	2.151	2.145	2.117	2.111	2.102	2.096
EPCSRST_N_5	B37	2.136	2.132	2.204	2.200	2.175	2.171	2.154	2.149	2.122	2.116	2.109	2.102
MONITOR	K23	2.136	2.131	2.205	2.198	2.176	2.167	2.156	2.144	2.125	2.108	2.112	2.093
PLL_MON	L20	2.138	2.135	2.208	2.206	2.182	2.179	2.163	2.160	2.136	2.131	2.124	2.120
TOGGLE_MON	L22	2.138	2.135	2.208	2.205	2.181	2.177	2.162	2.158	2.133	2.128	2.121	2.116

Table. 12. LVCMOS 25 VOH – DUT 11684

		2mA		4mA		6mA		8mA		12mA		14mA	
Pin Name	Pin#	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad
TID_BUF_OUT	A33	2.135	2.130	2.204	2.197	2.176	2.167	2.157	2.146	2.125	2.111	2.112	2.096
EPCSRST_N_0	B31	2.136	2.131	2.204	2.197	2.176	2.167	2.156	2.145	2.124	2.109	2.110	2.093
EPCSRST_N_1	B32	2.136	2.131	2.205	2.199	2.177	2.169	2.156	2.147	2.126	2.113	2.113	2.098
EPCSRST_N_2	B34	2.134	2.127	2.203	2.192	2.175	2.159	2.154	2.134	2.122	2.094	2.109	2.076
EPCSRST_N_3	B35	2.135	2.131	2.204	2.200	2.176	2.172	2.156	2.151	2.125	2.119	2.112	2.106
EPCSRST_N_4	B36	2.134	2.130	2.202	2.198	2.172	2.168	2.151	2.146	2.117	2.112	2.103	2.097
EPCSRST_N_5	B37	2.135	2.131	2.203	2.199	2.174	2.170	2.154	2.148	2.122	2.116	2.107	2.101
MONITOR	K23	2.136	2.131	2.205	2.199	2.176	2.169	2.156	2.147	2.125	2.112	2.112	2.097
PLL_MON	L20	2.138	2.135	2.208	2.206	2.182	2.179	2.164	2.160	2.136	2.132	2.124	2.120
TOGGLE_MON	L22	2.136	2.134	2.207	2.205	2.180	2.178	2.161	2.158	2.132	2.129	2.120	2.117

Table. 13. LVCMOS 25 VOH – DUT 11744

		2mA		4mA		6mA		8mA		12mA		14mA	
Pin Name	Pin#	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad
TID_BUF_OUT	A33	2.133	2.128	2.203	2.196	2.174	2.166	2.155	2.145	2.123	2.109	2.109	2.094
EPCSRST_N_0	B31	2.134	2.130	2.203	2.196	2.174	2.165	2.155	2.144	2.122	2.107	2.108	2.091
EPCSRST_N_1	B32	2.134	2.129	2.204	2.197	2.175	2.167	2.155	2.144	2.124	2.109	2.111	2.094
EPCSRST_N_2	B34	2.132	2.125	2.202	2.191	2.173	2.158	2.152	2.132	2.120	2.091	2.107	2.074
EPCSRST_N_3	B35	2.133	2.130	2.203	2.200	2.175	2.171	2.155	2.150	2.123	2.118	2.110	2.104
EPCSRST_N_4	B36	2.132	2.128	2.200	2.197	2.171	2.167	2.149	2.144	2.115	2.110	2.101	2.095
EPCSRST_N_5	B37	2.133	2.129	2.202	2.198	2.172	2.169	2.152	2.147	2.119	2.113	2.105	2.099
MONITOR	K23	2.134	2.130	2.204	2.198	2.175	2.168	2.155	2.145	2.123	2.110	2.110	2.095
PLL_MON	L20	2.136	2.134	2.207	2.204	2.180	2.178	2.162	2.158	2.134	2.130	2.122	2.118
TOGGLE_MON	L22	2.135	2.133	2.206	2.204	2.179	2.176	2.160	2.157	2.131	2.127	2.119	2.115

Table. 14. LVCMOS 25 VOH – DUT 11772

		2mA		4mA		6mA		8mA		12mA		14mA	
Pin Name	Pin#	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad
TID_BUF_OUT	A33	2.135	2.130	2.204	2.198	2.175	2.168	2.156	2.147	2.124	2.111	2.110	2.096
EPCSRST_N_0	B31	2.137	2.132	2.205	2.198	2.176	2.168	2.157	2.147	2.125	2.110	2.112	2.095
EPCSRST_N_1	B32	2.136	2.131	2.205	2.198	2.177	2.167	2.156	2.144	2.125	2.108	2.112	2.093
EPCSRST_N_2	B34	2.135	2.128	2.203	2.192	2.175	2.159	2.154	2.134	2.121	2.093	2.108	2.075
EPCSRST_N_3	B35	2.136	2.132	2.205	2.201	2.177	2.172	2.157	2.151	2.126	2.119	2.113	2.106
EPCSRST_N_4	B36	2.135	2.131	2.202	2.199	2.173	2.169	2.152	2.147	2.118	2.113	2.104	2.099
EPCSRST_N_5	B37	2.135	2.132	2.203	2.200	2.174	2.171	2.154	2.149	2.122	2.115	2.108	2.101
MONITOR	K23	2.136	2.132	2.205	2.200	2.177	2.170	2.158	2.147	2.127	2.113	2.114	2.098
PLL_MON	L20	2.138	2.136	2.208	2.206	2.182	2.179	2.164	2.160	2.136	2.132	2.124	2.120
TOGGLE_MON	L22	2.137	2.135	2.208	2.205	2.181	2.178	2.162	2.159	2.134	2.130	2.122	2.118

Table. 15. LVCMOS 25 VOH – DUT 11817

		2mA		4mA		6mA		8mA		12mA		14mA	
Pin Name	Pin#	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad
TID_BUF_OUT	A33	2.135	2.129	2.204	2.197	2.175	2.167	2.156	2.146	2.124	2.110	2.111	2.095
EPCSRST_N_0	B31	2.136	2.131	2.205	2.197	2.176	2.167	2.157	2.146	2.124	2.110	2.111	2.094
EPCSRST_N_1	B32	2.137	2.132	2.205	2.199	2.177	2.170	2.157	2.147	2.126	2.113	2.113	2.099
EPCSRST_N_2	B34	2.135	2.127	2.203	2.193	2.174	2.160	2.153	2.135	2.121	2.096	2.107	2.079
EPCSRST_N_3	B35	2.136	2.132	2.205	2.201	2.177	2.173	2.157	2.151	2.126	2.120	2.113	2.106
EPCSRST_N_4	B36	2.134	2.130	2.202	2.198	2.172	2.168	2.150	2.145	2.116	2.110	2.102	2.096
EPCSRST_N_5	B37	2.135	2.131	2.203	2.199	2.175	2.170	2.154	2.148	2.122	2.115	2.108	2.101
MONITOR	K23	2.136	2.131	2.205	2.199	2.177	2.170	2.157	2.147	2.126	2.113	2.112	2.098
PLL_MON	L20	2.138	2.135	2.209	2.206	2.182	2.179	2.164	2.159	2.136	2.131	2.124	2.119
TOGGLE_MON	L22	2.138	2.135	2.208	2.205	2.181	2.178	2.162	2.158	2.134	2.129	2.122	2.117

Table. 16. LVCMOS 25 VOL – DUT 11675

		2mA		4mA		6mA		8mA		12mA		14mA	
Pin Name	Pin#	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad
TID_BUF_OUT	A33	234.4	235.3	166.8	169.9	194.5	199.4	216.7	223.3	247.2	257.3	260.1	272.3
EPCSRST_N_0	B31	233.6	234.6	166.6	169.8	194.5	199.4	216.8	223.2	247.7	257.6	260.7	272.6
EPCSRST_N_1	B32	233.3	233.9	165.9	168.5	193.3	197.6	213.8	218.9	244.5	252.9	257.8	267.7
EPCSRST_N_2	B34	234.8	237.3	167.5	173.8	195.7	205.3	216.4	228.9	248.2	267.5	261.9	284.7
EPCSRST_N_3	B35	233.8	233.8	166.1	167.1	193.4	195.4	213.6	215.8	244.0	247.9	257.1	261.6
EPCSRST_N_4	B36	235.1	234.7	168.6	168.9	197.3	197.8	218.6	219.0	251.2	252.6	265.4	267.1
EPCSRST_N_5	B37	234.8	234.2	167.6	168.0	196.0	196.7	216.8	217.6	248.7	250.3	262.4	264.5
MONITOR	K23	234.0	234.6	166.4	169.0	193.7	198.1	214.0	219.6	244.1	253.2	257.0	267.8
PLL_MON	L20	232.1	231.7	163.0	163.3	189.1	189.5	208.0	208.0	235.2	235.7	246.4	247.4
TOGGLE_MON	L22	232.6	232.3	163.8	164.5	190.0	191.3	209.1	210.3	237.1	239.5	248.7	251.9

Table. 17. LVCMOS 25 VOL – DUT 11677

		2mA		4mA		6mA		8mA		12mA		14mA	
Pin Name	Pin#	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad
TID_BUF_OUT	A33	233.6	234.6	166.2	169.3	193.8	198.7	216.0	222.5	246.6	256.5	259.6	271.6
EPCSRST_N_0	B31	232.2	233.2	165.9	169.2	193.9	198.9	216.4	222.8	247.3	257.3	260.4	272.6
EPCSRST_N_1	B32	231.7	232.5	164.7	167.6	192.1	196.4	212.0	217.6	242.6	251.4	255.7	266.3
EPCSRST_N_2	B34	233.3	236.3	166.8	174.0	194.9	206.0	215.6	230.0	247.5	269.6	261.3	287.1
EPCSRST_N_3	B35	232.8	232.4	165.3	165.7	192.7	193.6	212.6	213.8	243.0	245.0	255.9	258.4
EPCSRST_N_4	B36	234.1	233.6	168.4	168.7	197.3	197.9	218.7	219.3	251.8	253.3	266.3	268.0
EPCSRST_N_5	B37	233.0	232.6	166.5	166.9	194.6	195.2	215.1	215.8	246.5	248.2	260.1	262.3
MONITOR	K23	232.9	234.1	165.9	169.9	193.3	199.7	213.7	222.0	244.1	257.5	257.3	273.0
PLL_MON	L20	230.8	230.4	162.2	162.4	188.0	188.5	206.9	206.9	234.1	234.7	245.5	246.4
TOGGLE_MON	L22	230.7	230.4	162.9	163.2	189.1	189.9	208.3	208.8	236.2	237.6	248.1	249.9

Table. 18. LVCMOS 25 VOL – DUT 11684

		2mA		4mA		6mA		8mA		12mA		14mA	
Pin Name	Pin#	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad
TID_BUF_OUT	A33	236.1	237.0	167.7	170.8	195.6	200.4	217.7	224.2	248.1	258.2	260.9	273.0
EPCSRST_N_0	B31	234.6	235.6	167.6	171.1	195.7	201.2	218.1	225.5	249.3	260.6	262.4	276.1
EPCSRST_N_1	B32	234.6	235.0	166.5	169.1	194.1	198.2	214.4	219.5	244.9	253.4	258.0	268.1
EPCSRST_N_2	B34	236.3	239.3	168.4	175.9	196.4	208.0	216.9	232.2	248.4	271.8	262.1	289.5
EPCSRST_N_3	B35	235.9	235.3	167.4	167.7	195.1	195.7	215.1	215.9	245.8	247.5	258.9	260.8
EPCSRST_N_4	B36	237.4	236.7	170.2	170.3	199.0	199.3	220.5	220.8	253.5	254.6	268.0	269.2
EPCSRST_N_5	B37	236.5	235.8	168.7	168.9	197.1	197.6	217.8	218.3	249.5	251.0	263.3	265.0
MONITOR	K23	235.4	235.6	167.5	170.0	195.2	199.3	215.6	221.1	246.2	255.3	259.0	270.2
PLL_MON	L20	233.1	232.4	163.5	163.9	189.5	190.1	208.5	208.6	235.7	236.6	246.8	248.1
TOGGLE_MON	L22	234.5	233.5	165.0	164.6	191.5	191.0	211.0	210.0	239.6	238.6	251.3	250.5

Table. 19. LVCMOS 25 VOL – DUT 11744

		2mA		4mA		6mA		8mA		12mA		14mA	
Pin Name	Pin#	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad
TID_BUF_OUT	A33	236.1	236.6	168.0	170.8	195.9	200.5	218.1	224.4	249.0	258.6	261.7	273.4
EPCSRST_N_0	B31	235.0	236.0	168.0	171.3	196.3	201.6	218.7	226.1	250.1	261.3	263.2	276.9
EPCSRST_N_1	B32	234.8	235.4	166.7	170.0	194.4	199.4	214.6	221.0	245.2	255.6	258.4	270.7
EPCSRST_N_2	B34	237.0	239.9	168.8	176.3	196.8	208.4	217.4	232.8	249.0	272.7	262.6	290.4
EPCSRST_N_3	B35	236.4	235.5	167.7	167.6	195.6	195.6	215.6	215.8	246.4	247.3	259.5	260.7
EPCSRST_N_4	B36	237.7	236.8	170.5	170.4	199.4	199.6	220.8	220.9	253.9	254.9	268.4	269.7
EPCSRST_N_5	B37	236.8	236.0	169.0	169.1	197.3	197.9	218.1	218.7	250.0	251.5	263.7	265.6
MONITOR	K23	236.1	236.1	167.7	170.3	195.4	199.8	216.0	221.9	246.7	256.5	259.7	271.5
PLL_MON	L20	233.5	233.0	163.9	163.9	190.1	190.3	209.2	209.0	236.5	237.0	247.9	248.8
TOGGLE_MON	L22	234.2	233.1	164.9	164.6	191.3	191.1	210.8	210.3	239.0	239.0	250.8	250.9

Table. 20. LVCMOS 25 VOL – DUT 11772

		2mA		4mA		6mA		8mA		12mA		14mA	
Pin Name	Pin#	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad
TID_BUF_OUT	A33	234.3	234.8	166.8	169.5	194.6	198.9	216.8	222.9	247.6	256.8	260.6	271.7
EPCSRST_N_0	B31	233.0	234.0	166.2	169.6	194.0	199.3	216.1	223.4	246.9	258.1	260.0	273.3
EPCSRST_N_1	B32	232.7	233.5	165.3	169.2	192.9	198.9	213.3	221.0	244.1	256.4	257.3	272.0
EPCSRST_N_2	B34	234.3	237.5	167.4	175.1	195.5	207.3	216.2	231.7	248.0	271.8	261.7	289.8
EPCSRST_N_3	B35	233.5	232.9	165.8	166.4	193.2	194.3	213.2	214.5	243.3	246.0	256.4	259.6
EPCSRST_N_4	B36	234.7	233.9	168.4	168.5	197.0	197.4	218.2	218.4	251.0	252.0	265.1	266.4
EPCSRST_N_5	B37	234.4	233.6	167.4	167.6	195.5	196.1	216.2	216.8	247.8	249.5	261.4	263.6
MONITOR	K23	233.7	234.1	166.0	168.9	193.2	197.9	213.5	219.5	243.3	253.6	256.1	268.2
PLL_MON	L20	231.3	230.7	162.7	162.8	188.4	188.9	207.4	207.5	234.6	235.3	245.9	247.0
TOGGLE_MON	L22	232.0	231.1	163.4	163.2	189.6	189.4	208.8	208.3	236.8	236.7	248.4	248.5

Table. 21. LVCMOS 25 VOL – DUT 11817

		2mA		4mA		6mA		8mA		12mA		14mA	
Pin Name	Pin#	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad
TID_BUF_OUT	A33	235.0	236.2	167.2	170.4	195.0	200.0	217.2	223.7	248.0	257.9	260.8	273.1
EPCSRST_N_0	B31	233.6	235.0	166.7	170.3	194.6	200.1	216.9	224.3	248.2	258.9	261.2	274.3
EPCSRST_N_1	B32	232.8	233.6	165.4	168.2	192.8	197.1	213.0	218.3	243.5	251.9	256.6	266.5
EPCSRST_N_2	B34	235.3	238.2	167.8	174.6	196.0	206.3	216.9	230.3	248.7	269.2	262.5	286.5
EPCSRST_N_3	B35	234.3	234.0	166.1	166.7	193.7	194.4	213.7	214.4	244.1	245.7	257.0	259.0
EPCSRST_N_4	B36	236.0	235.7	169.5	169.9	198.5	199.2	220.0	220.7	253.3	254.8	267.7	269.7
EPCSRST_N_5	B37	234.7	234.4	167.5	168.0	195.6	196.5	216.4	217.4	248.1	250.0	261.8	264.2
MONITOR	K23	234.1	234.7	166.3	169.1	193.9	198.2	214.2	220.1	244.6	254.0	257.5	268.7
PLL_MON	L20	231.7	231.5	162.6	163.1	188.6	189.3	207.7	207.7	235.0	235.7	246.2	247.4
TOGGLE_MON	L22	231.8	231.3	163.1	163.4	189.5	189.8	208.8	208.6	236.8	237.3	248.6	249.3

Table. 22. LVTTL VOH – DUT 11675

		2mA		4mA		8mA		12mA		16mA	
Pin Name	Pin#	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad
TID_BUF_OUT	A33	2.921	2.916	2.912	2.905	2.894	2.883	2.876	2.861	2.858	2.841
EPCSRST_N_0	B31	2.921	2.917	2.912	2.905	2.894	2.883	2.875	2.861	2.858	2.840
EPCSRST_N_1	B32	2.921	2.917	2.912	2.906	2.894	2.885	2.877	2.864	2.859	2.842
EPCSRST_N_2	B34	2.921	2.914	2.911	2.901	2.892	2.876	2.873	2.850	2.854	2.823
EPCSRST_N_3	B35	2.922	2.917	2.913	2.908	2.895	2.889	2.877	2.870	2.860	2.850
EPCSRST_N_4	B36	2.921	2.917	2.910	2.907	2.890	2.886	2.870	2.865	2.850	2.844
EPCSRST_N_5	B37	2.921	2.917	2.911	2.907	2.892	2.887	2.873	2.867	2.854	2.847
MONITOR	K23	2.922	2.918	2.913	2.907	2.896	2.886	2.878	2.865	2.861	2.844
PLL_MON	L20	2.923	2.921	2.916	2.913	2.901	2.898	2.887	2.883	2.873	2.869
TOGGLE_MON	L22	2.923	2.920	2.915	2.912	2.900	2.896	2.885	2.880	2.870	2.863

Table. 23. LVTTL VOH – DUT 11677

		2mA		4mA		8mA		12mA		16mA	
Pin Name	Pin#	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad
TID_BUF_OUT	A33	2.922	2.917	2.913	2.906	2.895	2.884	2.876	2.862	2.859	2.841
EPCSRST_N_0	B31	2.922	2.917	2.913	2.906	2.894	2.884	2.876	2.861	2.858	2.840
EPCSRST_N_1	B32	2.923	2.918	2.914	2.907	2.896	2.887	2.879	2.865	2.861	2.844
EPCSRST_N_2	B34	2.922	2.915	2.912	2.901	2.893	2.874	2.873	2.848	2.855	2.820
EPCSRST_N_3	B35	2.922	2.919	2.914	2.909	2.896	2.891	2.878	2.873	2.861	2.854
EPCSRST_N_4	B36	2.921	2.918	2.911	2.907	2.890	2.886	2.869	2.864	2.849	2.842
EPCSRST_N_5	B37	2.922	2.918	2.912	2.908	2.893	2.889	2.875	2.869	2.856	2.849
MONITOR	K23	2.923	2.918	2.914	2.907	2.896	2.884	2.878	2.861	2.860	2.838
PLL_MON	L20	2.924	2.922	2.917	2.914	2.903	2.900	2.889	2.885	2.874	2.870
TOGGLE_MON	L22	2.924	2.921	2.916	2.913	2.901	2.897	2.886	2.881	2.871	2.865

Table. 24. LVTTL VOH – DUT 11684

		2mA		4mA		8mA		12mA		16mA	
Pin Name	Pin#	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad
TID_BUF_OUT	A33	2.921	2.916	2.912	2.905	2.895	2.884	2.877	2.862	2.860	2.842
EPCSRST_N_0	B31	2.922	2.917	2.913	2.905	2.894	2.882	2.875	2.860	2.857	2.838
EPCSRST_N_1	B32	2.922	2.917	2.913	2.907	2.895	2.886	2.877	2.865	2.860	2.844
EPCSRST_N_2	B34	2.921	2.913	2.911	2.900	2.892	2.873	2.874	2.845	2.856	2.818
EPCSRST_N_3	B35	2.921	2.918	2.912	2.909	2.894	2.890	2.877	2.872	2.860	2.853
EPCSRST_N_4	B36	2.920	2.916	2.909	2.906	2.889	2.885	2.869	2.864	2.849	2.843
EPCSRST_N_5	B37	2.921	2.917	2.911	2.908	2.892	2.888	2.873	2.868	2.855	2.848
MONITOR	K23	2.922	2.918	2.913	2.908	2.896	2.886	2.878	2.865	2.860	2.843
PLL_MON	L20	2.924	2.922	2.917	2.914	2.903	2.900	2.888	2.885	2.875	2.870
TOGGLE_MON	L22	2.923	2.921	2.915	2.913	2.900	2.898	2.885	2.882	2.869	2.867

Table. 25. LVTTL VOH – DUT 11744

		2mA		4mA		8mA		12mA		16mA	
Pin Name	Pin#	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad
TID_BUF_OUT	A33	2.921	2.915	2.911	2.904	2.893	2.883	2.875	2.861	2.857	2.840
EPCSRST_N_0	B31	2.921	2.916	2.911	2.904	2.893	2.881	2.873	2.858	2.856	2.837
EPCSRST_N_1	B32	2.921	2.916	2.912	2.905	2.894	2.884	2.877	2.862	2.859	2.840
EPCSRST_N_2	B34	2.919	2.912	2.910	2.898	2.891	2.871	2.873	2.844	2.854	2.816
EPCSRST_N_3	B35	2.920	2.916	2.911	2.908	2.893	2.889	2.876	2.871	2.858	2.852
EPCSRST_N_4	B36	2.919	2.915	2.908	2.905	2.888	2.884	2.868	2.863	2.848	2.841
EPCSRST_N_5	B37	2.919	2.916	2.910	2.906	2.891	2.886	2.872	2.866	2.853	2.846
MONITOR	K23	2.921	2.917	2.912	2.905	2.894	2.883	2.876	2.861	2.858	2.839
PLL_MON	L20	2.923	2.921	2.916	2.913	2.901	2.898	2.887	2.883	2.872	2.868
TOGGLE_MON	L22	2.922	2.920	2.915	2.912	2.900	2.897	2.884	2.881	2.869	2.865

Table. 26. LVTTL VOH – DUT 11772

		2mA		4mA		8mA		12mA		16mA	
Pin Name	Pin#	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad
TID_BUF_OUT	A33	2.922	2.917	2.913	2.906	2.894	2.885	2.876	2.862	2.858	2.841
EPCSRST_N_0	B31	2.923	2.918	2.913	2.906	2.895	2.884	2.877	2.862	2.859	2.840
EPCSRST_N_1	B32	2.923	2.917	2.913	2.906	2.895	2.884	2.877	2.861	2.860	2.838
EPCSRST_N_2	B34	2.921	2.914	2.911	2.900	2.893	2.873	2.874	2.845	2.855	2.817
EPCSRST_N_3	B35	2.923	2.919	2.914	2.909	2.896	2.891	2.879	2.872	2.862	2.853
EPCSRST_N_4	B36	2.921	2.918	2.911	2.907	2.890	2.887	2.870	2.866	2.851	2.845
EPCSRST_N_5	B37	2.921	2.918	2.912	2.908	2.893	2.888	2.874	2.868	2.855	2.848
MONITOR	K23	2.922	2.916	2.914	2.904	2.897	2.879	2.880	2.854	2.862	2.829
PLL_MON	L20	2.925	2.922	2.917	2.915	2.903	2.900	2.889	2.885	2.874	2.870
TOGGLE_MON	L22	2.924	2.921	2.916	2.914	2.901	2.898	2.886	2.883	2.871	2.867

Table. 27. LVTTL VOH – DUT 11817

		2mA		4mA		8mA		12mA		16mA	
Pin Name	Pin#	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad
TID_BUF_OUT	A33	2.921	2.916	2.913	2.905	2.894	2.884	2.876	2.862	2.859	2.841
EPCSRST_N_0	B31	2.923	2.917	2.913	2.906	2.895	2.884	2.876	2.861	2.858	2.839
EPCSRST_N_1	B32	2.923	2.918	2.914	2.908	2.896	2.887	2.879	2.866	2.861	2.845
EPCSRST_N_2	B34	2.921	2.914	2.912	2.901	2.892	2.875	2.873	2.849	2.854	2.822
EPCSRST_N_3	B35	2.922	2.918	2.913	2.909	2.896	2.891	2.878	2.873	2.861	2.854
EPCSRST_N_4	B36	2.921	2.917	2.910	2.906	2.889	2.885	2.869	2.864	2.849	2.842
EPCSRST_N_5	B37	2.922	2.918	2.912	2.908	2.893	2.888	2.874	2.869	2.856	2.848
MONITOR	K23	2.923	2.918	2.914	2.908	2.896	2.887	2.879	2.866	2.861	2.845
PLL_MON	L20	2.925	2.922	2.918	2.915	2.903	2.900	2.888	2.885	2.874	2.869
TOGGLE_MON	L22	2.924	2.922	2.917	2.914	2.902	2.898	2.887	2.883	2.871	2.867

Table. 28. LVTTL VOL – DUT 11675

		2mA		4mA		8mA		12mA		16mA	
Pin Name	Pin#	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad
TID_BUF_OUT	A33	214.9	215.4	226.4	229.3	241.1	247.1	259.3	268.9	278.3	292.1
EPCSRST_N_0	B31	214.2	214.8	226.7	229.4	241.3	247.5	259.5	269.4	279.2	293.2
EPCSRST_N_1	B32	213.6	214.4	222.6	223.6	239.6	245.2	257.2	266.2	275.6	287.5
EPCSRST_N_2	B34	214.9	217.3	224.1	228.7	242.2	255.2	261.2	280.8	280.6	306.6
EPCSRST_N_3	B35	213.9	213.9	222.7	222.3	239.5	242.2	256.9	261.0	274.7	280.3
EPCSRST_N_4	B36	215.2	214.8	225.0	224.0	244.6	245.5	264.2	265.9	284.4	286.4
EPCSRST_N_5	B37	214.8	214.2	224.4	222.8	242.7	243.6	261.7	263.4	280.7	283.2
MONITOR	K23	214.3	214.7	223.2	225.1	240.0	245.7	257.4	266.7	274.7	287.7
PLL_MON	L20	212.6	212.1	220.5	218.5	233.5	234.0	248.0	248.9	262.9	264.0
TOGGLE_MON	L22	212.8	212.4	221.0	219.8	235.1	236.6	249.9	252.4	265.3	269.2

Table. 29. LVTTL VOL – DUT 11677

		2mA		4mA		8mA		12mA		16mA	
Pin Name	Pin#	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad
TID_BUF_OUT	A33	214.1	214.8	225.8	228.6	240.3	246.4	258.5	268.0	277.8	291.5
EPCSRST_N_0	B31	213.0	213.9	225.4	228.4	240.4	246.9	259.1	269.2	279.0	293.1
EPCSRST_N_1	B32	212.4	213.2	221.1	222.5	237.8	244.0	255.5	264.9	273.5	286.2
EPCSRST_N_2	B34	213.5	216.9	223.2	228.9	241.4	256.1	260.6	282.9	279.8	309.6
EPCSRST_N_3	B35	213.1	212.8	221.6	220.7	238.6	239.7	255.9	258.3	273.6	276.7
EPCSRST_N_4	B36	214.4	214.0	224.8	223.5	244.9	245.7	264.9	266.7	285.6	287.8
EPCSRST_N_5	B37	213.5	213.1	222.9	221.7	240.9	242.0	259.5	261.6	278.5	281.0
MONITOR	K23	213.3	214.5	222.2	225.5	239.5	248.3	257.2	270.7	275.1	293.6
PLL_MON	L20	211.4	210.8	219.3	217.7	232.4	233.1	246.9	247.9	261.7	263.0
TOGGLE_MON	L22	211.2	210.7	219.8	218.6	233.8	234.6	248.9	250.6	264.6	267.1

Table. 30. LVTTL VOL – DUT 11684

		2mA		4mA		8mA		12mA		16mA	
Pin Name	Pin#	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad
TID_BUF_OUT	A33	216.7	217.3	228.6	231.4	242.6	248.7	260.3	270.0	279.3	293.2
EPCSRST_N_0	B31	215.6	216.3	227.9	231.2	243.2	250.3	261.2	272.8	281.3	297.4
EPCSRST_N_1	B32	215.3	215.8	223.8	224.7	240.6	246.2	258.4	267.0	276.1	287.8
EPCSRST_N_2	B34	216.7	220.1	225.9	232.5	243.6	259.8	262.2	286.9	280.7	313.8
EPCSRST_N_3	B35	216.3	215.8	225.1	223.9	241.7	242.8	259.3	261.1	277.1	279.6
EPCSRST_N_4	B36	217.6	217.1	227.8	226.4	247.1	247.7	267.1	268.3	287.5	289.2
EPCSRST_N_5	B37	216.9	216.4	226.4	224.9	244.3	245.3	263.0	264.8	282.1	284.4
MONITOR	K23	216.0	216.1	225.0	226.6	241.9	248.0	259.6	268.9	277.3	290.5
PLL_MON	L20	213.6	213.1	221.7	219.9	234.5	235.1	248.5	249.8	263.3	264.8
TOGGLE_MON	L22	214.9	213.9	223.1	220.8	237.1	236.5	252.8	251.9	268.5	267.7

Table. 31. LVTTL VOL – DUT 11744

		2mA		4mA		8mA		12mA		16mA	
Pin Name	Pin#	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad
TID_BUF_OUT	A33	216.2	216.6	228.2	230.9	242.7	248.4	260.5	270.0	280.0	293.4
EPCSRST_N_0	B31	215.4	215.9	228.3	231.5	243.3	250.2	262.0	272.9	281.8	297.6
EPCSRST_N_1	B32	215.0	215.8	223.8	225.4	240.5	247.7	258.2	268.9	276.3	290.6
EPCSRST_N_2	B34	216.7	220.0	225.9	232.2	243.6	259.7	262.0	286.8	281.0	314.0
EPCSRST_N_3	B35	216.4	215.4	224.8	223.3	241.6	242.1	259.2	260.6	277.3	279.0
EPCSRST_N_4	B36	217.5	216.9	227.7	226.3	247.0	247.7	267.1	268.3	287.5	289.2
EPCSRST_N_5	B37	216.7	215.9	226.1	224.7	244.5	245.4	263.1	264.9	282.3	284.6
MONITOR	K23	216.0	216.6	224.8	227.5	241.8	249.2	259.8	271.4	277.5	293.8
PLL_MON	L20	213.8	213.1	221.6	220.2	235.2	235.2	249.2	250.1	264.0	265.3
TOGGLE_MON	L22	214.2	213.4	222.4	220.9	236.7	236.2	251.7	252.0	267.4	268.0

Table. 32. LVTTL VOL – DUT 11772

		2mA		4mA		8mA		12mA		16mA	
Pin Name	Pin#	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad
TID_BUF_OUT	A33	215.1	215.4	227.0	229.5	241.9	247.1	259.9	268.8	279.4	292.1
EPCSRST_N_0	B31	213.9	214.8	226.2	229.2	240.9	247.8	259.0	270.2	278.7	294.2
EPCSRST_N_1	B32	213.5	214.7	222.1	224.6	239.5	247.5	257.1	269.8	275.7	292.6
EPCSRST_N_2	B34	214.9	218.2	224.4	231.0	242.7	258.9	261.5	286.3	280.6	313.8
EPCSRST_N_3	B35	214.1	213.7	222.5	221.6	239.4	241.1	257.0	259.7	274.4	278.3
EPCSRST_N_4	B36	215.4	214.8	225.3	224.1	244.8	245.2	264.5	265.7	284.5	286.5
EPCSRST_N_5	B37	215.0	214.3	224.5	223.3	242.8	243.5	261.3	263.1	280.3	283.0
MONITOR	K23	214.5	216.7	223.3	229.1	239.7	253.7	256.9	278.6	274.2	304.0
PLL_MON	L20	212.2	211.6	220.1	219.0	233.4	233.7	247.6	248.8	262.5	264.0
TOGGLE_MON	L22	212.9	211.8	220.8	219.0	235.1	234.5	249.8	250.2	265.4	265.8

Table. 33. LVTTL VOL – DUT 11817

		2mA		4mA		8mA		12mA		16mA	
Pin Name	Pin#	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad	Pre-rad	Post-rad
TID_BUF_OUT	A33	215.5	216.2	227.1	229.8	241.7	248.1	259.8	269.4	279.0	292.8
EPCSRST_N_0	B31	214.2	215.2	226.2	229.5	241.3	248.2	260.0	270.5	279.8	294.8
EPCSRST_N_1	B32	213.1	214.0	221.8	223.1	238.7	244.5	256.4	265.1	274.3	285.8
EPCSRST_N_2	B34	215.5	218.4	224.7	230.1	242.8	256.7	261.7	282.7	281.0	308.9
EPCSRST_N_3	B35	214.6	213.9	223.0	222.1	239.7	240.7	257.0	259.0	274.7	277.2
EPCSRST_N_4	B36	216.2	215.9	226.3	225.3	246.0	247.2	266.4	268.0	287.1	289.5
EPCSRST_N_5	B37	214.9	214.6	224.4	223.3	242.3	243.7	261.0	263.4	280.2	283.0
MONITOR	K23	214.6	215.4	223.0	225.1	240.1	246.1	257.6	267.2	275.3	288.6
PLL_MON	L20	212.3	211.9	220.1	218.2	233.1	233.9	247.6	249.0	262.6	264.0
TOGGLE_MON	L22	212.1	211.7	220.4	218.8	234.4	234.8	249.5	250.2	265.3	266.4

E. Propagation Delay

Table 34 lists the pre-irradiation and post-irradiation propagation delay measurements. It shows that the change due to radiation on each DUT is not significant and every DUT passes the 10% degradation criterion.

Table. 34. Pre-irradiation and Post-irradiation Propagation Delay Change

DUT	Total Dose	Pre-irradiation (µs)	Post-irradiation (µs)	Change Degradation (%)
11675	125 krad	0.453	0.457	0.88
11677	125 krad	0.45	0.452	0.44
11684	125 krad	0.462	0.466	0.87
11744	125 krad	0.467	0.469	0.43
11772	125 krad	0.455	0.456	0.22
11817	125 krad	0.462	0.467	1.08

F. Transition Time

The figures below show the pre-irradiation and post-irradiation transitions edges. In each case the radiation induced transition degradation is not observable.

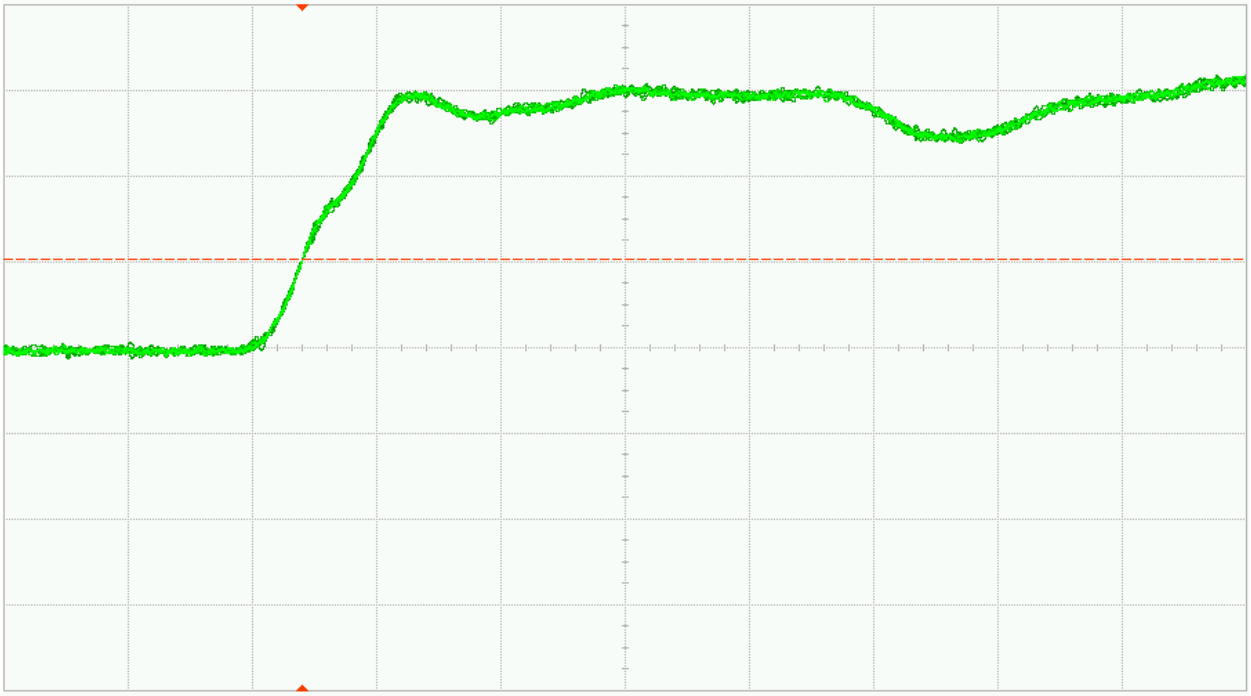

Fig. 26 (a). DUT 11675 pre-irradiation rising edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

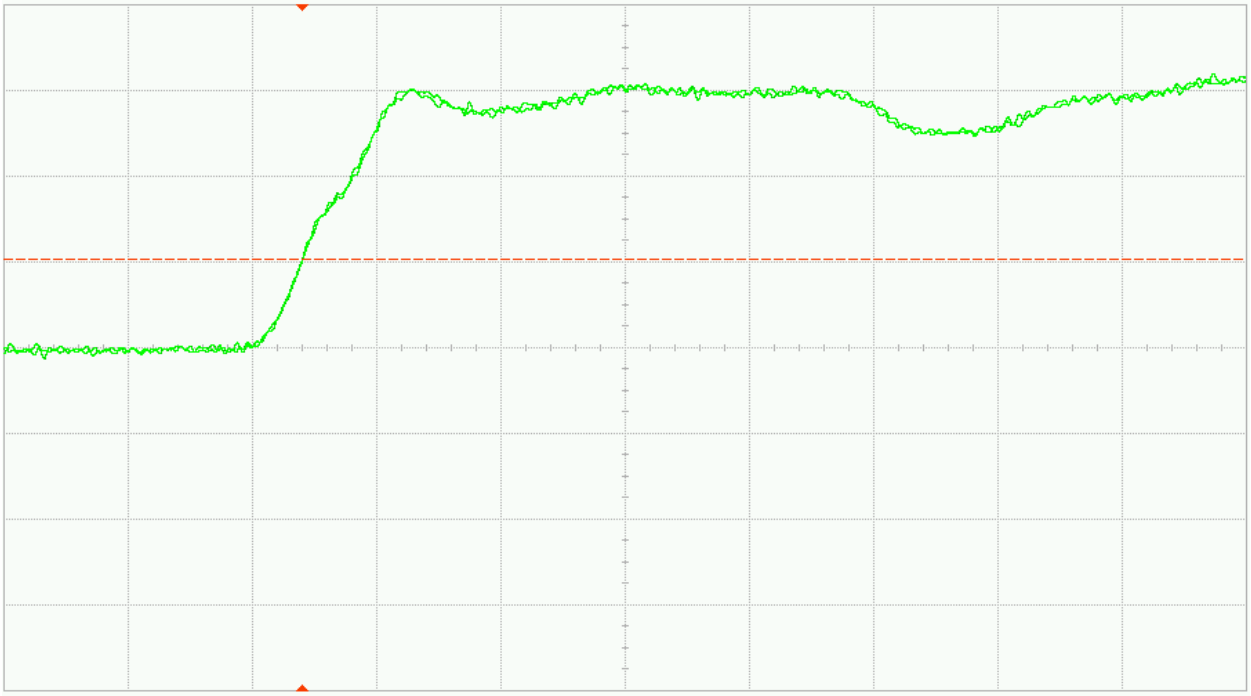

Fig. 26 (b). DUT 11675 post-annealing rising edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

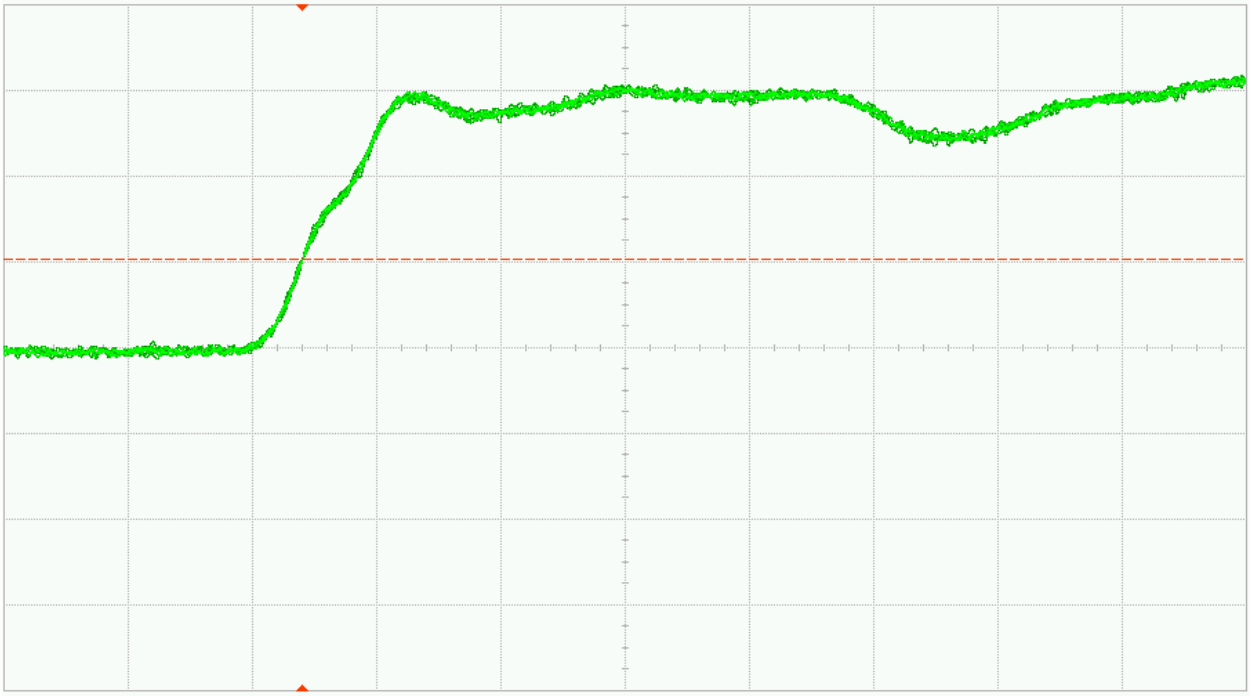

Fig. 27 (a). DUT 11677 pre-irradiation rising edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

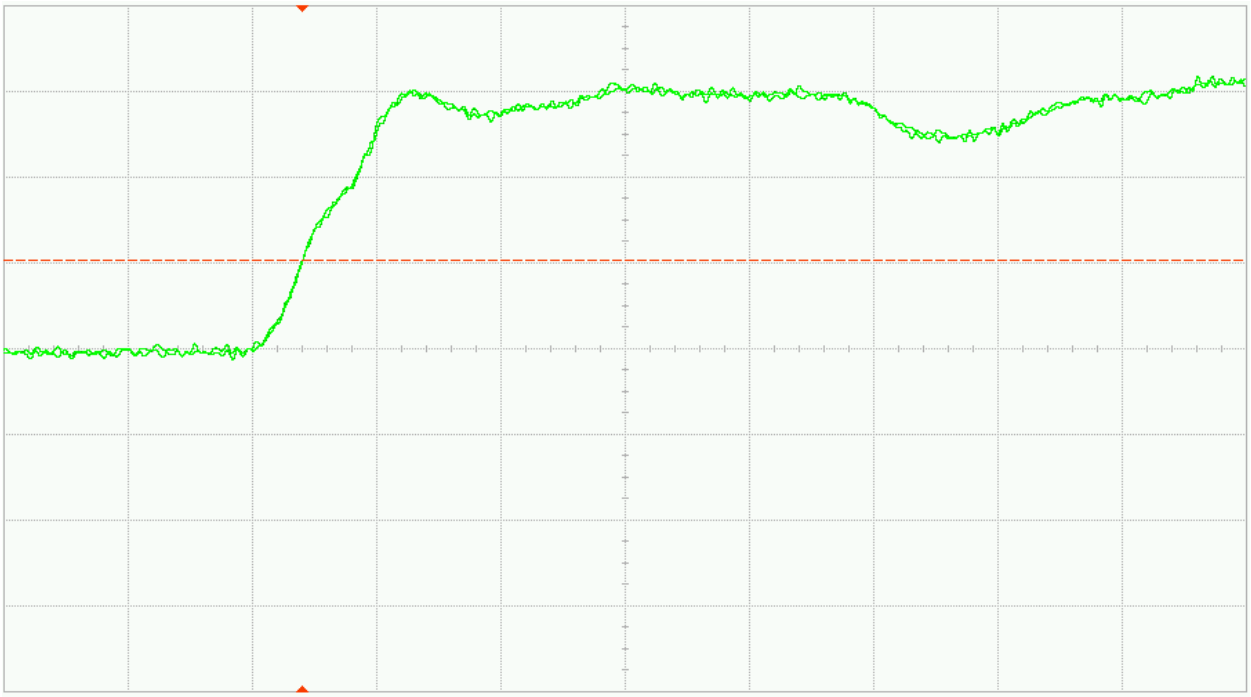

Fig. 27 (b). DUT 11677 post-annealing rising edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

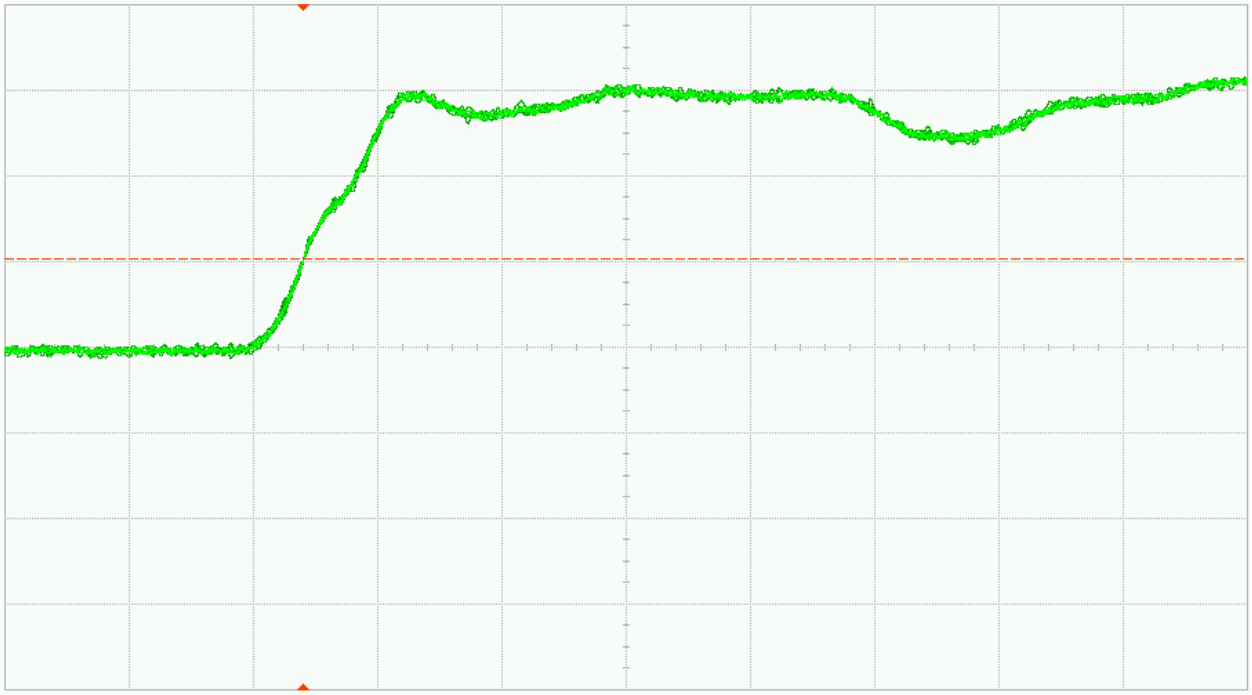

Fig. 28 (a). DUT 11684 pre-irradiation rising edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

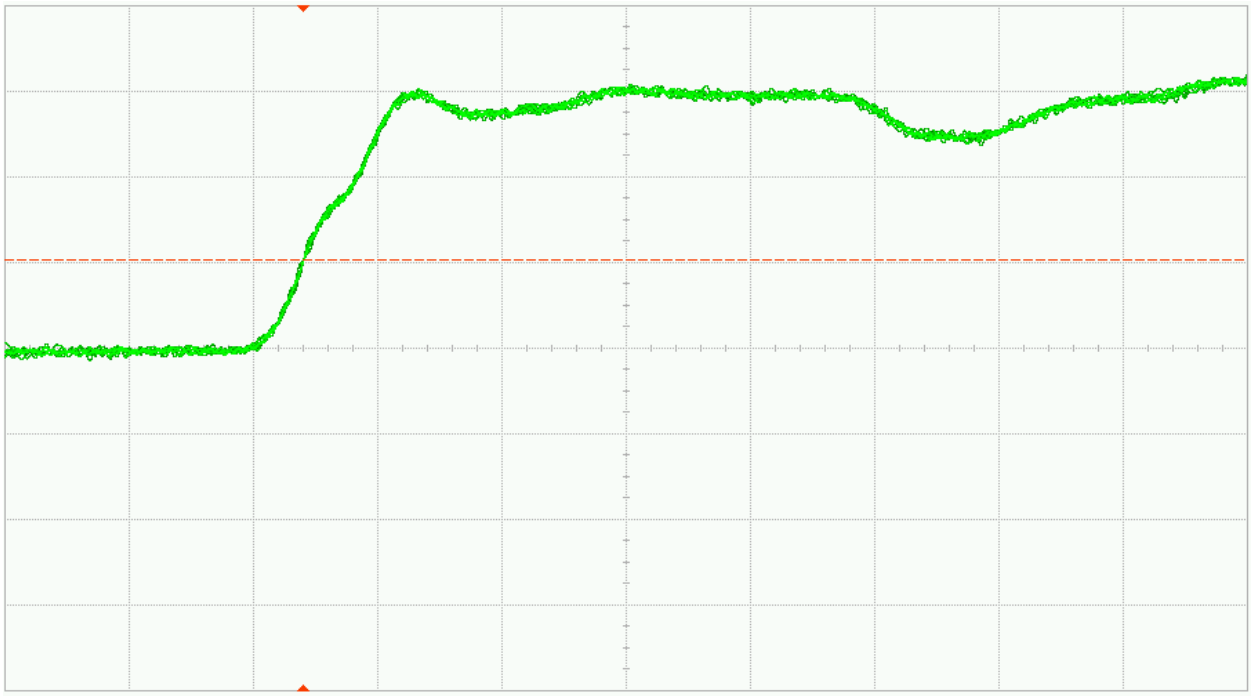

Fig. 28 (b). DUT 11684 post-annealing rising edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

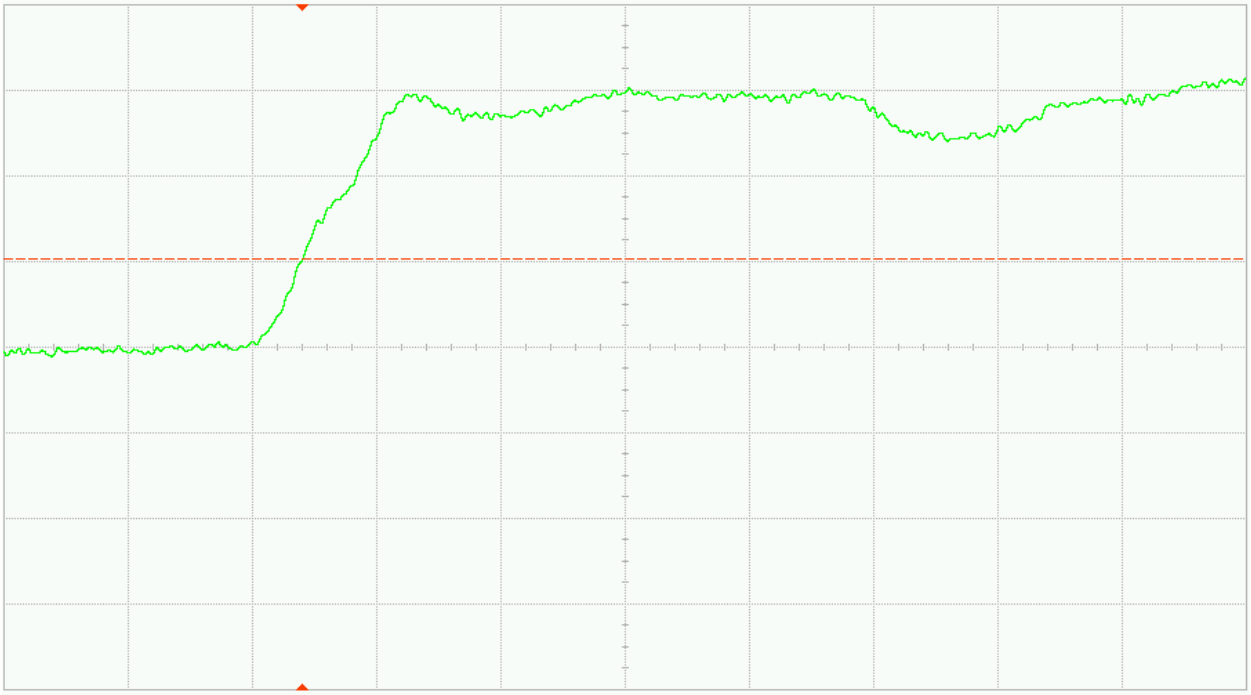

Fig. 29 (a). DUT 11744 pre-irradiation rising edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

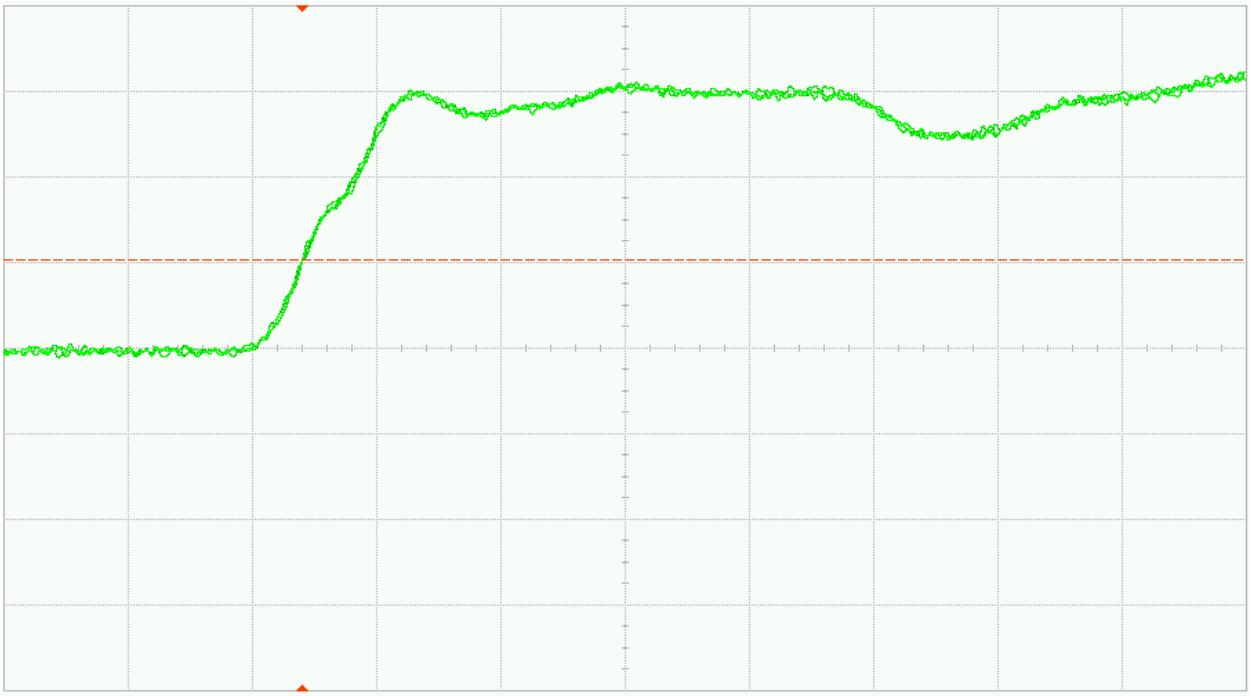

Fig. 29 (b). DUT 11744 post-annealing rising edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

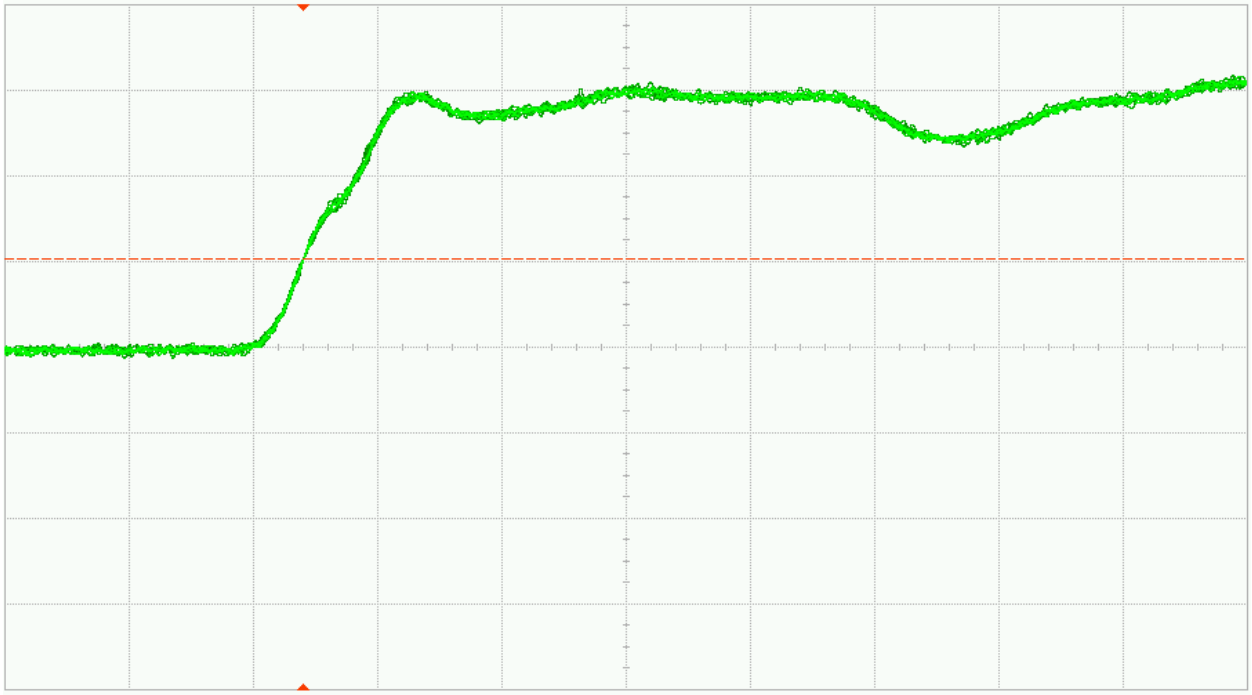

Fig. 30 (a). DUT 11772 pre-irradiation rising edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

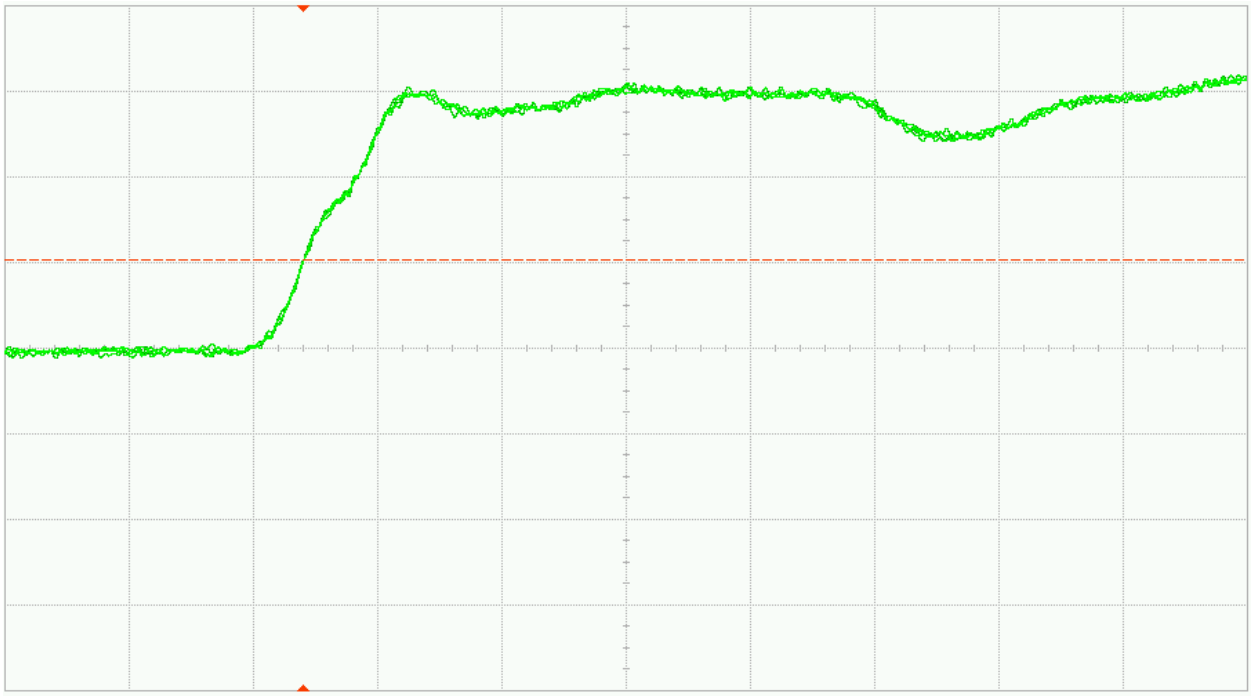

Fig. 30 (b). DUT 11772 post-annealing rising edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

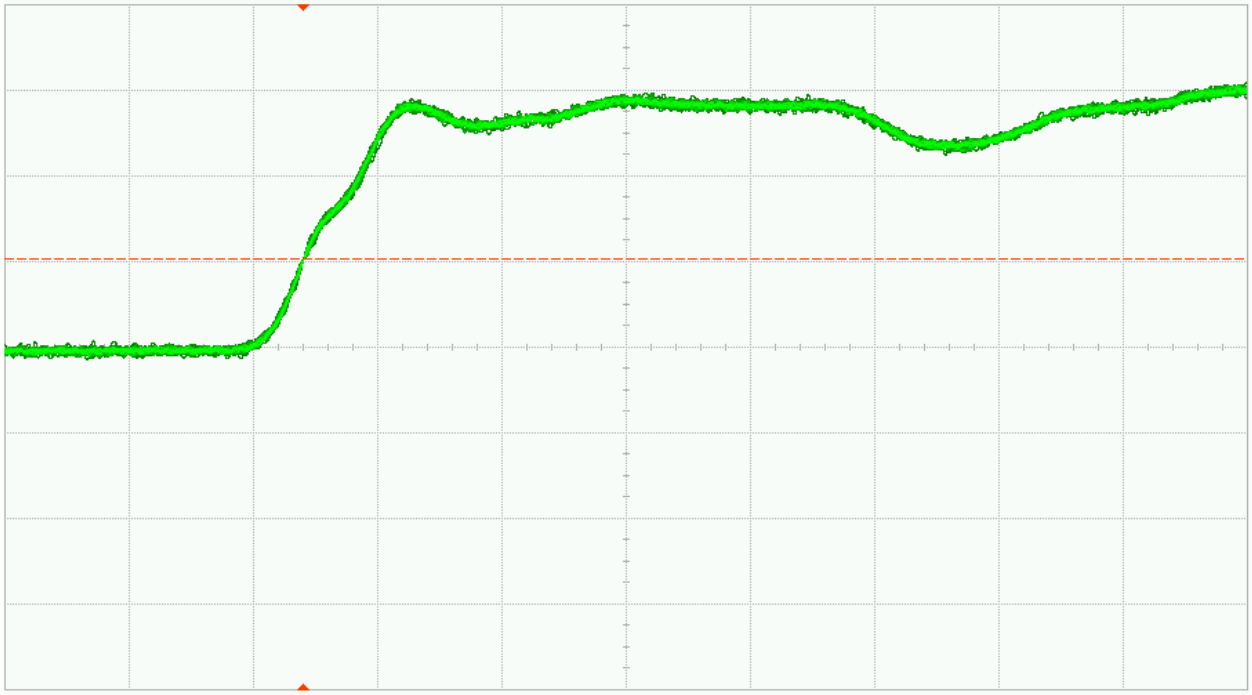

Fig. 31 (a). DUT 11817 pre-irradiation rising edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

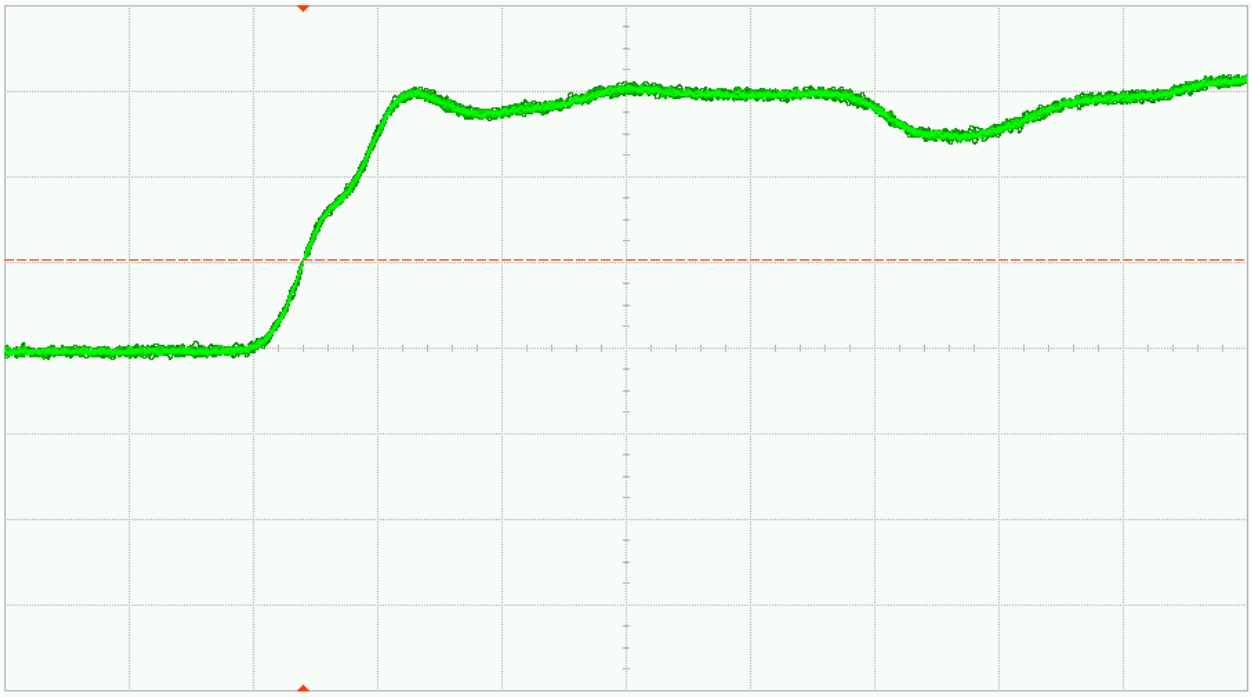

Fig. 31 (b). DUT 11817 post-annealing rising edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

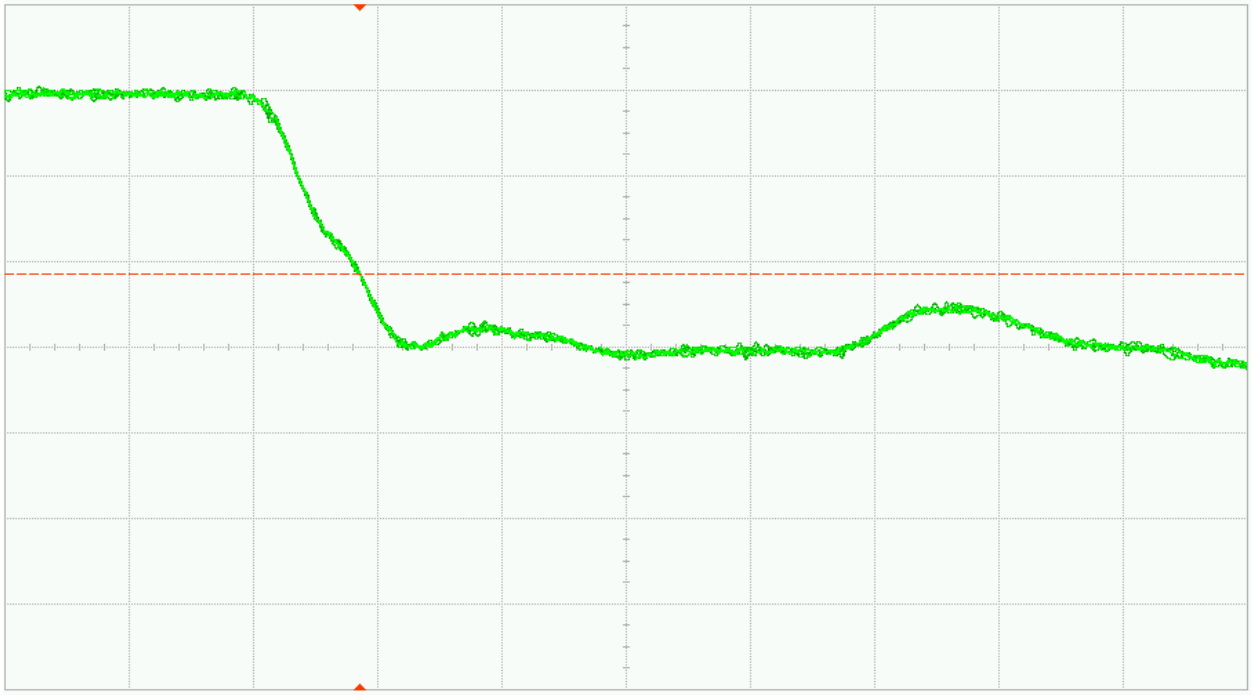

Fig. 32 (a). DUT 11675 pre-irradiation falling edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

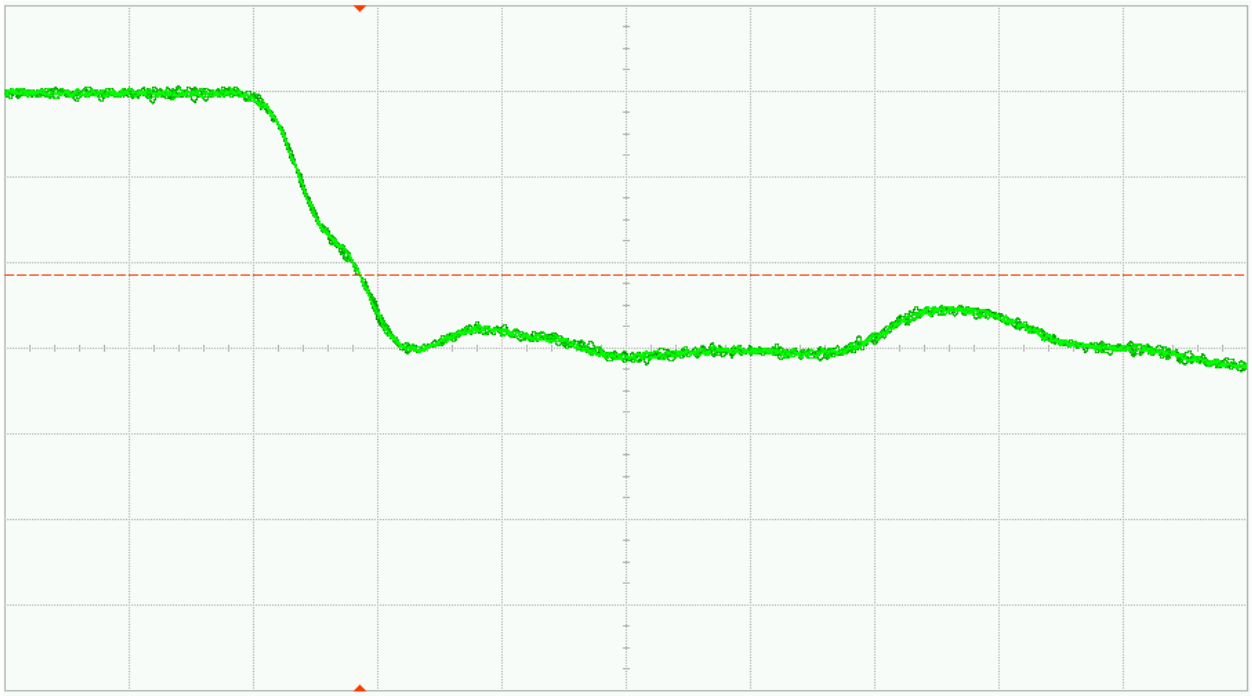

Fig. 32 (b). DUT 11675 post-annealing falling edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

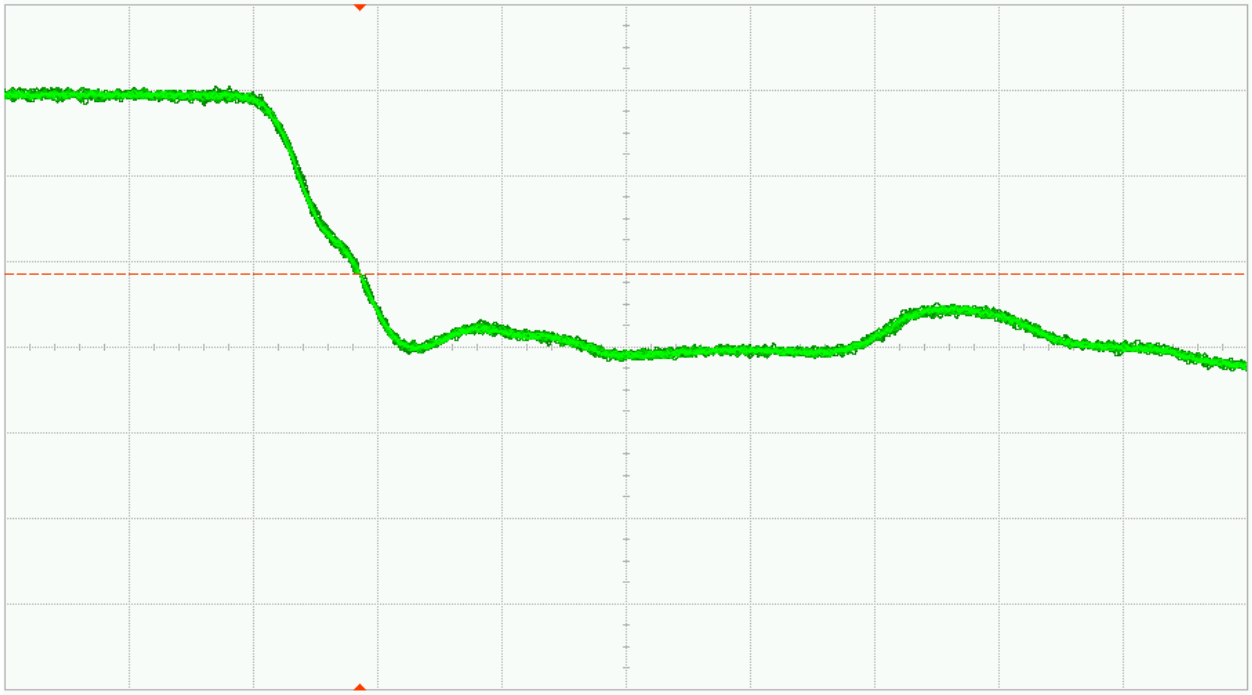

Fig. 33 (a). DUT 11677 pre-irradiation falling edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

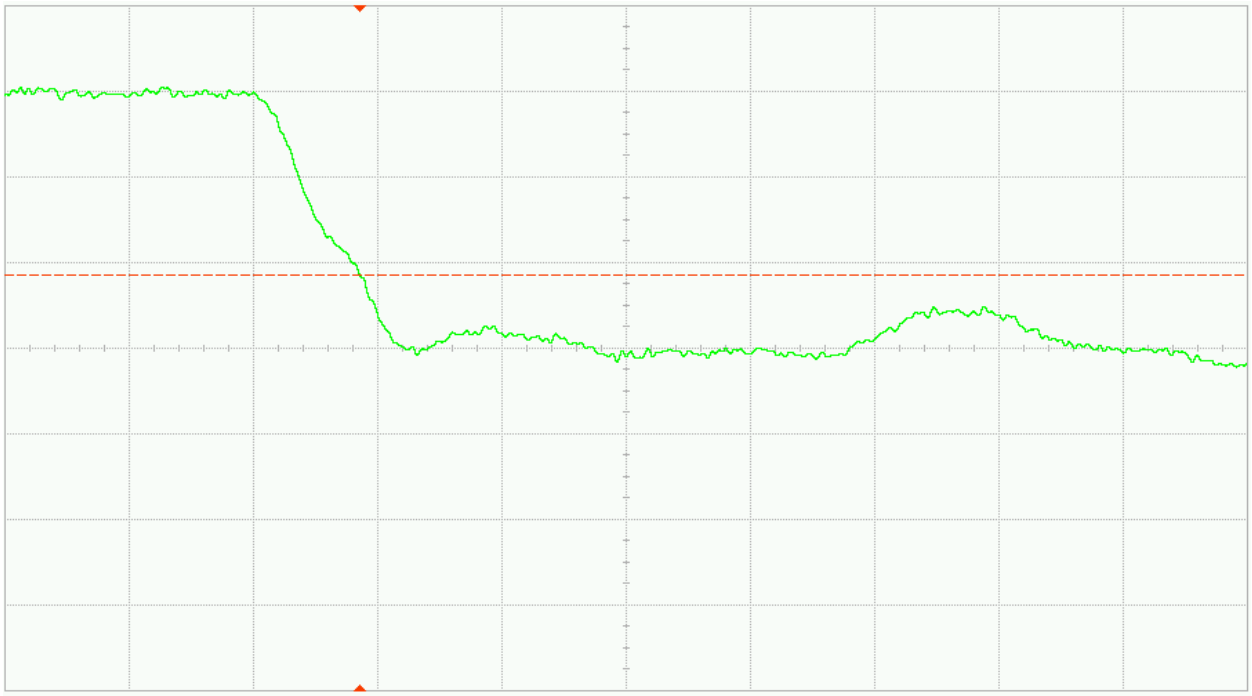

Fig. 33 (b). DUT 11677 post-annealing falling edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

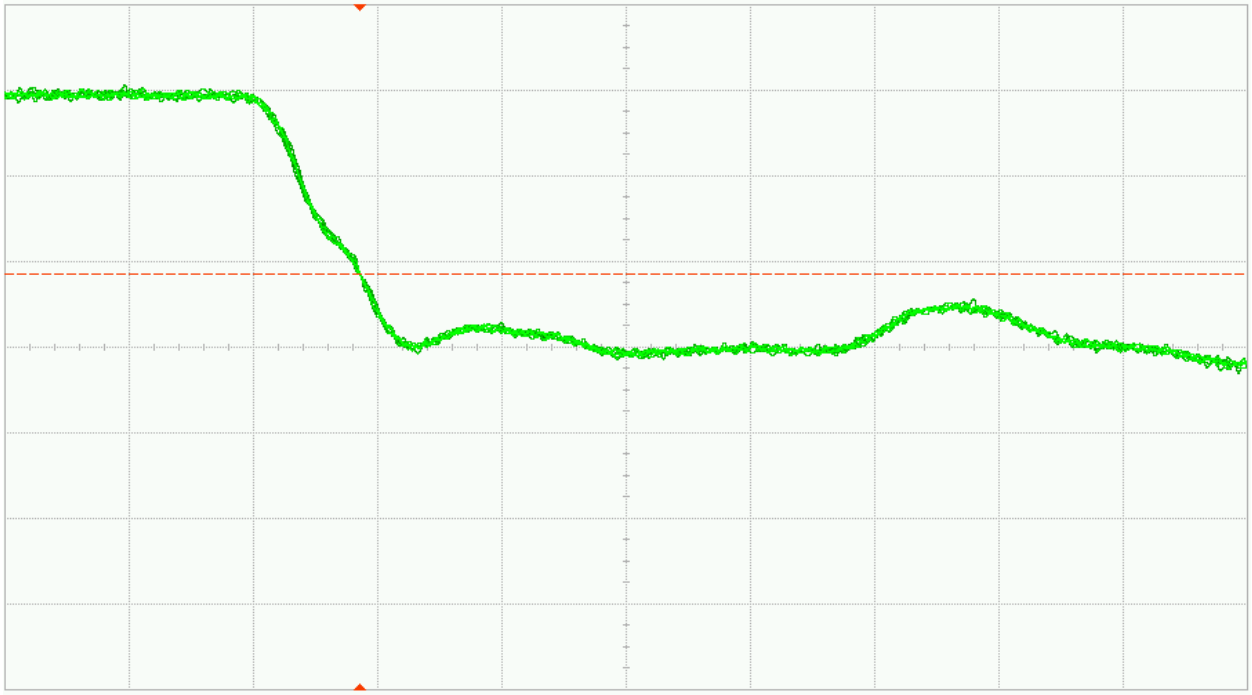

Fig. 34 (a). DUT 11684 pre-irradiation falling edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

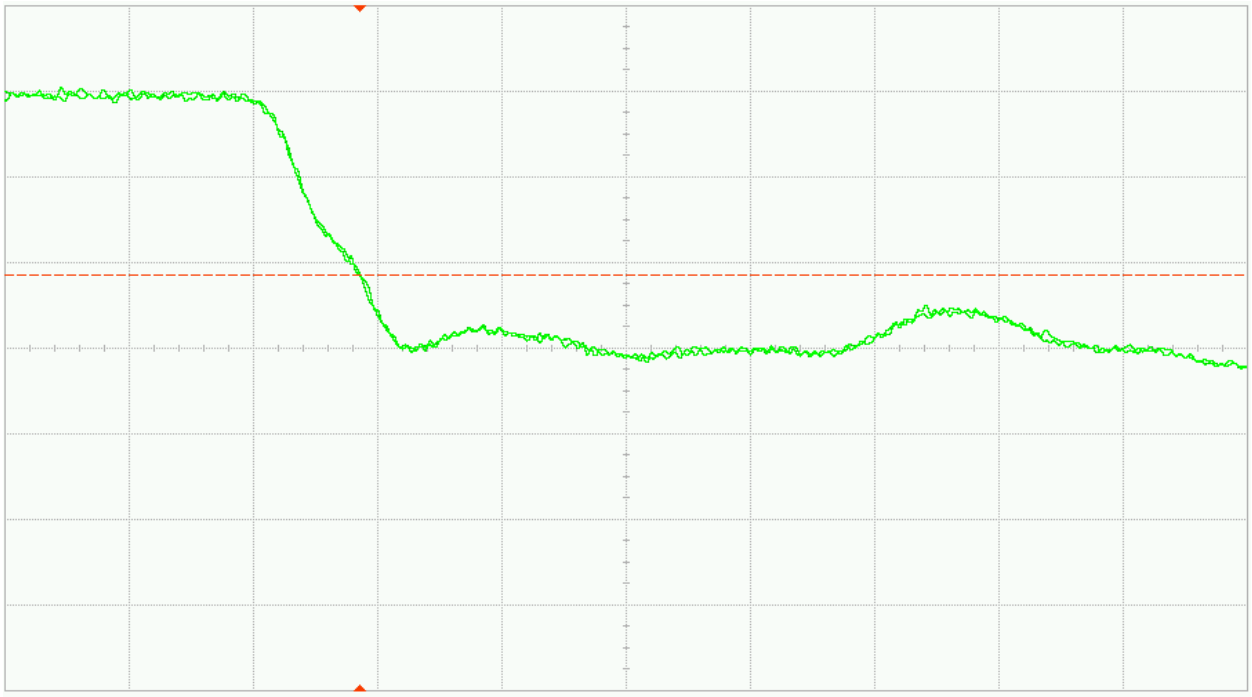

Fig. 34 (b). DUT 11684 post-annealing falling edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

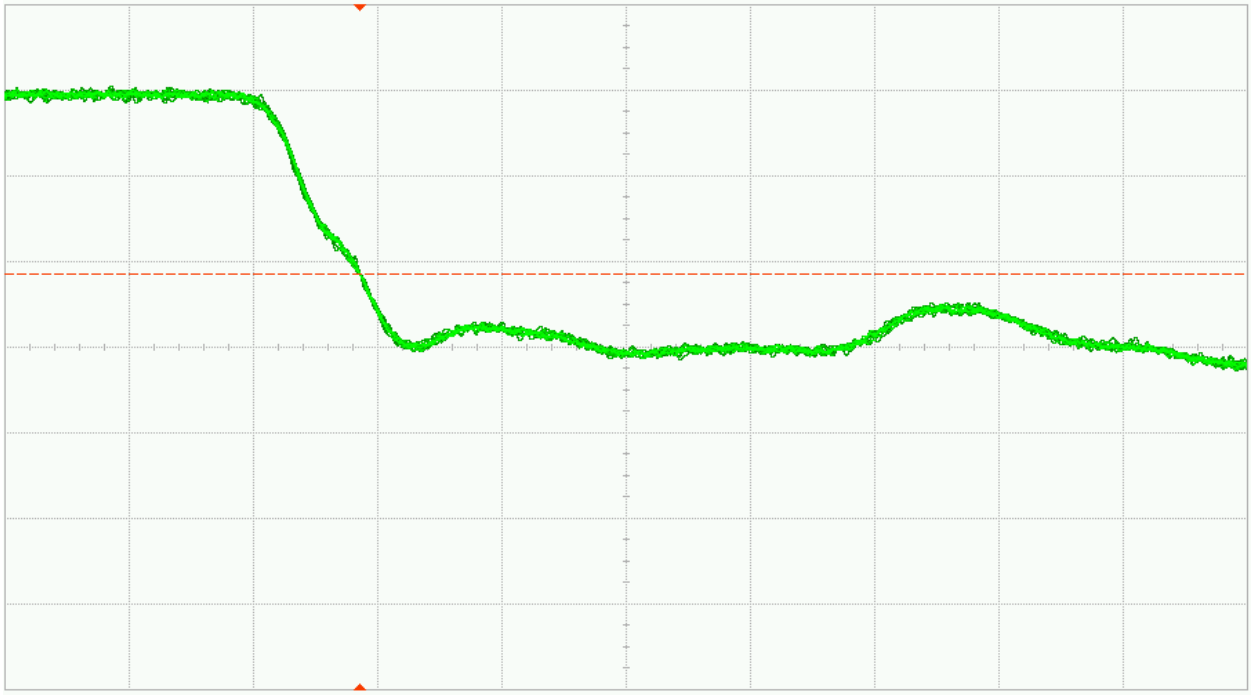

Fig. 35 (a). DUT 11744 pre-irradiation falling edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

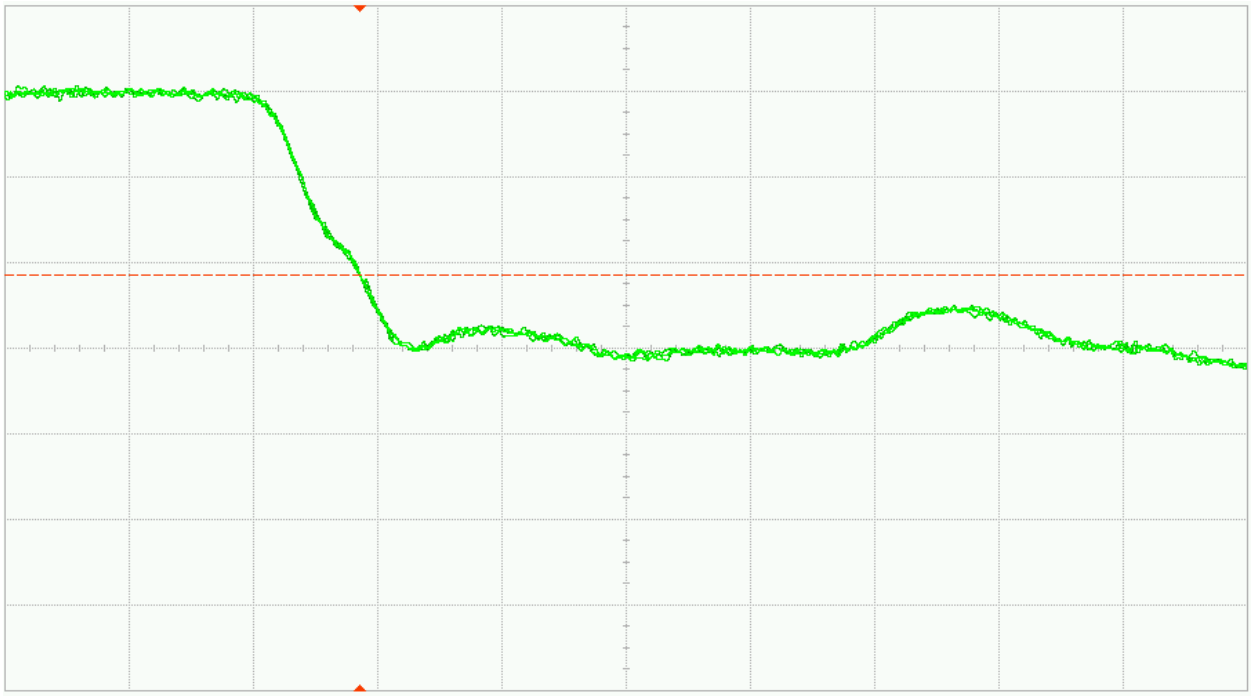

Fig. 35 (b). DUT 11744 post-annealing falling edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

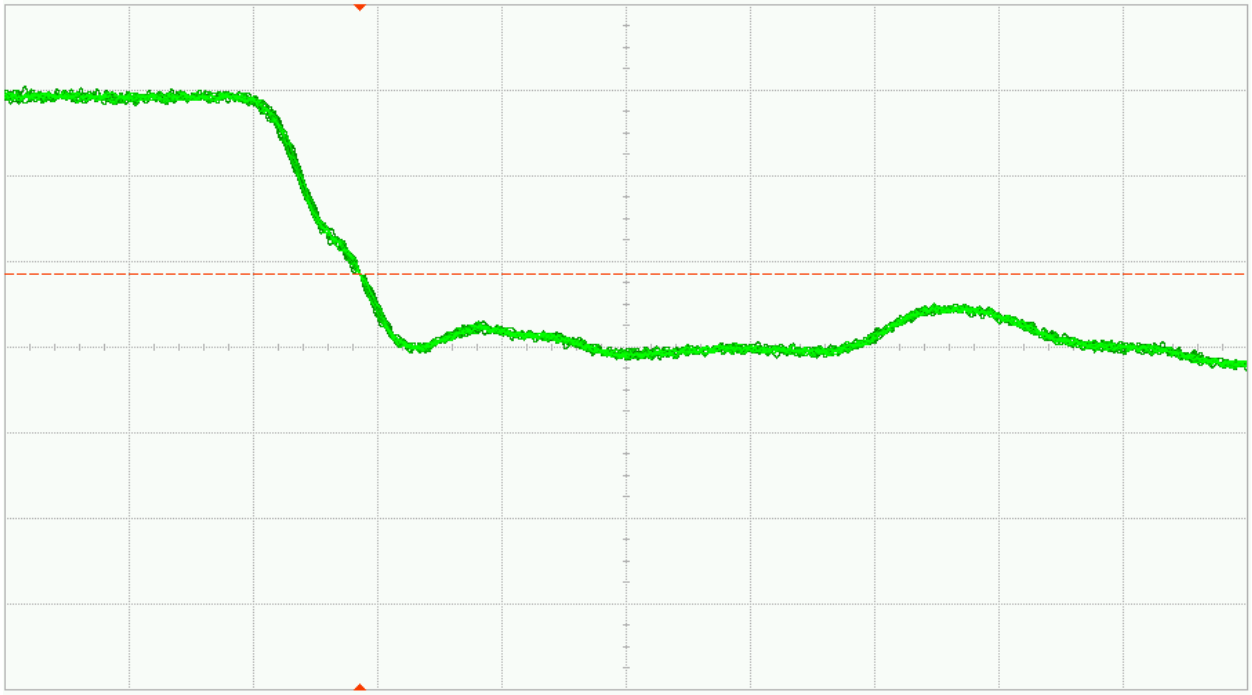

Fig. 36 (a). DUT 11772 pre-irradiation falling edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

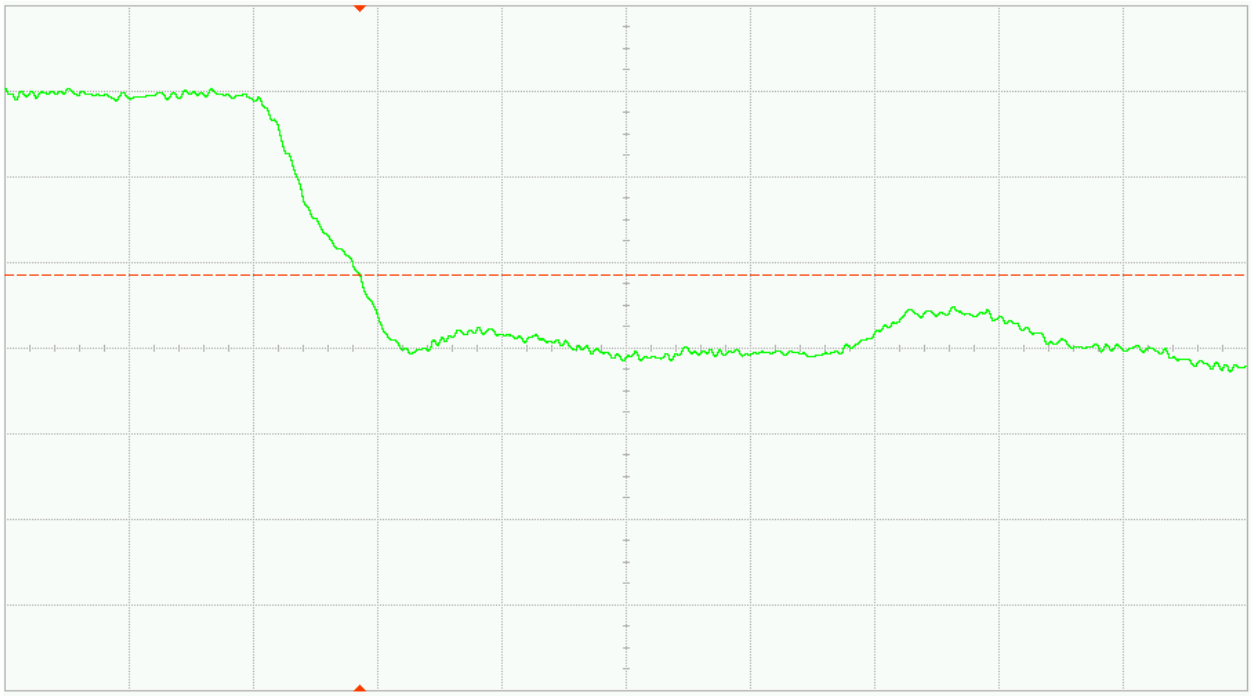

Fig. 36 (b). DUT 11772 post-annealing falling edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

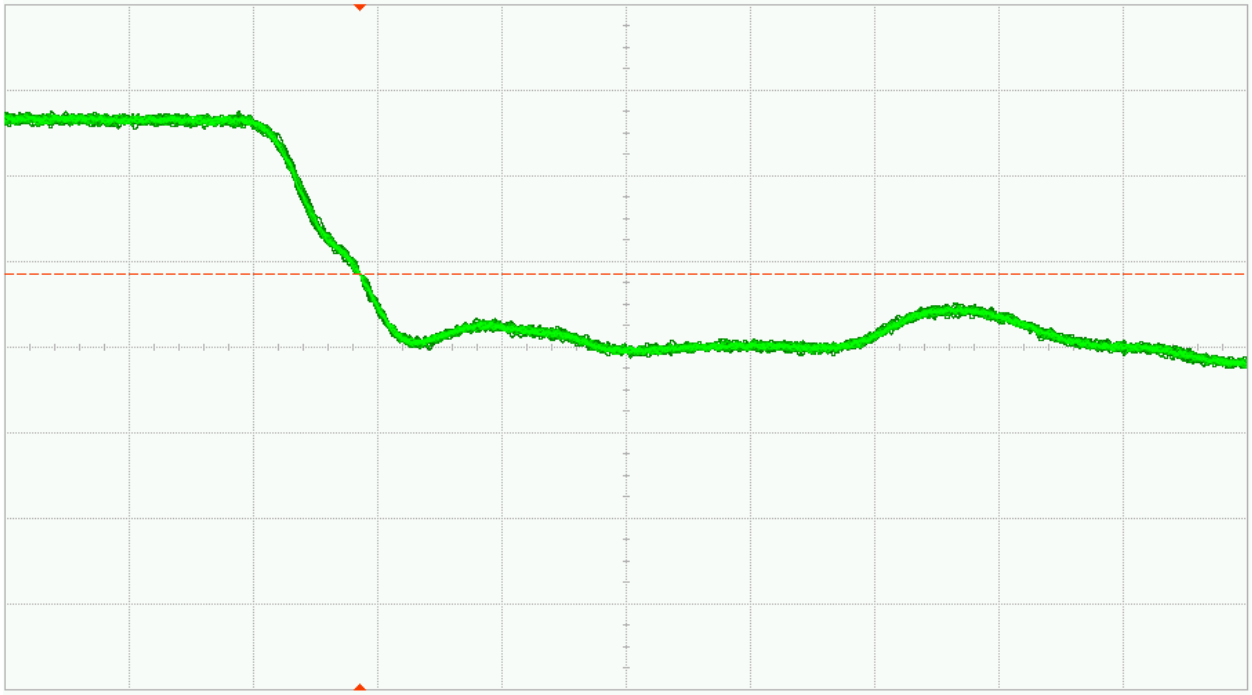

Fig. 37 (a). DUT 11817 pre-irradiation falling edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

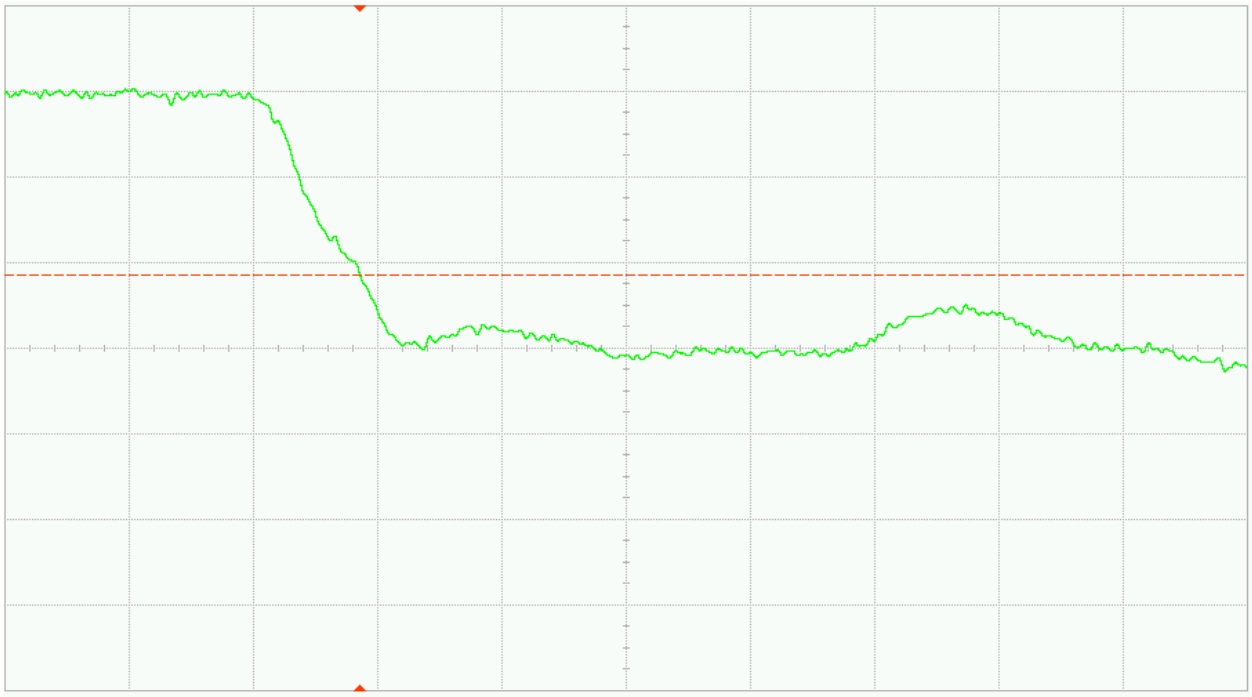

Fig. 37 (b). DUT 11817 post-annealing falling edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

Appendix A

Table. 35. High level block diagrams of blocks used to perform fabric functional coverage pre and post-irradiation

Block	Coverage
Combo Block	combinatorial macros available in the RTG4 library
Register Block	sequential macros available in the RTG4 library
UPROM	
Embedded SRAM Blocks	full toggle coverage on 209 fabric LSRAM & 210 µRAM blocks using dual port/ two port configurations (x18 width)
Shift Register Block	core utilization
IO Block	IO utilization
Math Block	full toggle coverage on 462 fabric math blocks with maximum width configuration

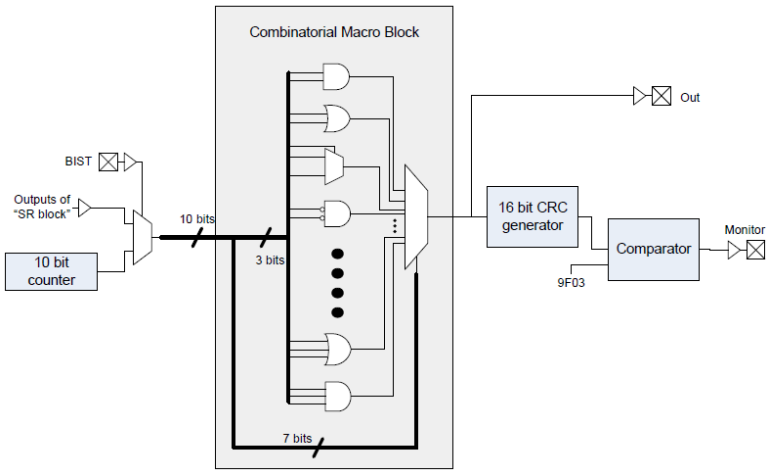

Fig. 38. Combo Block

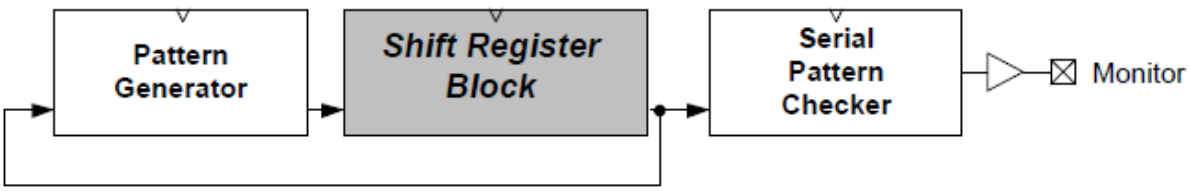

Fig. 39. Shift Register Block

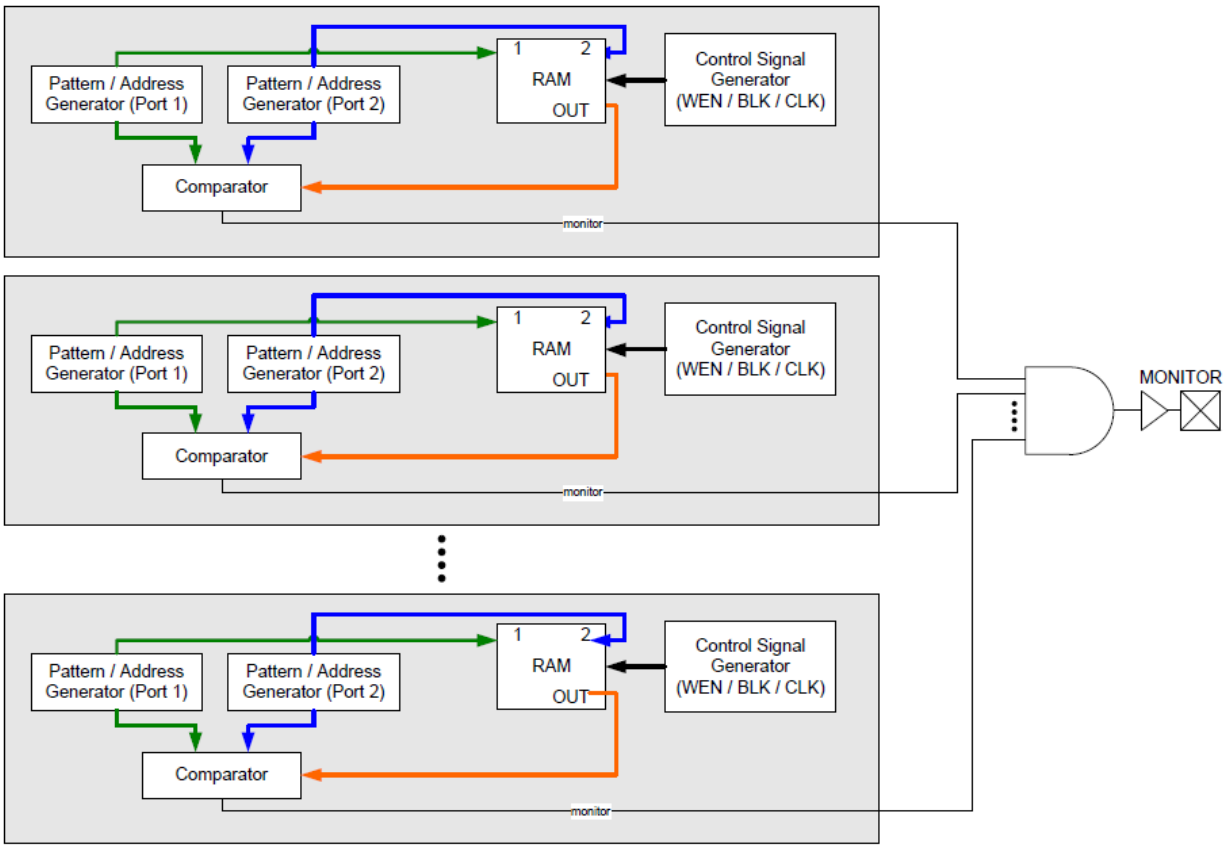

Fig. 40. Embedded Ram Blocks

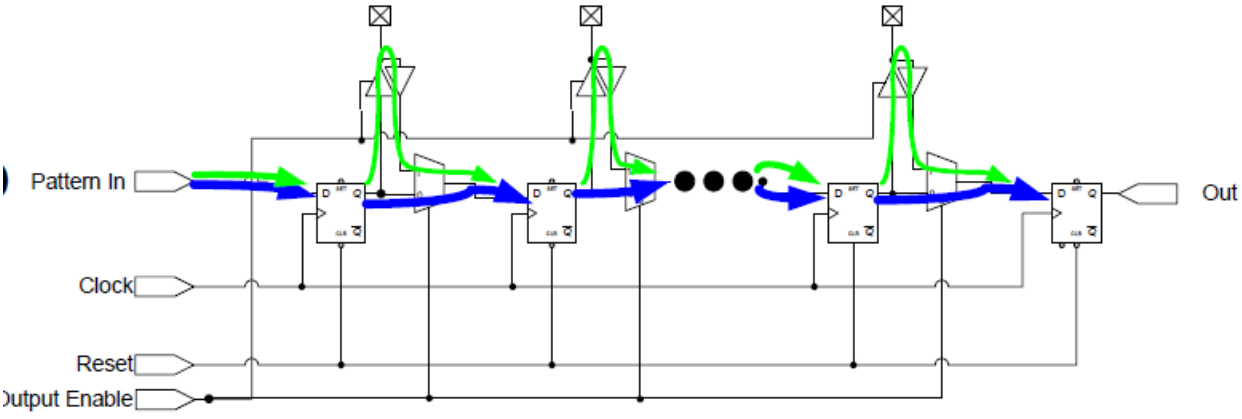

Fig. 41. IO Block

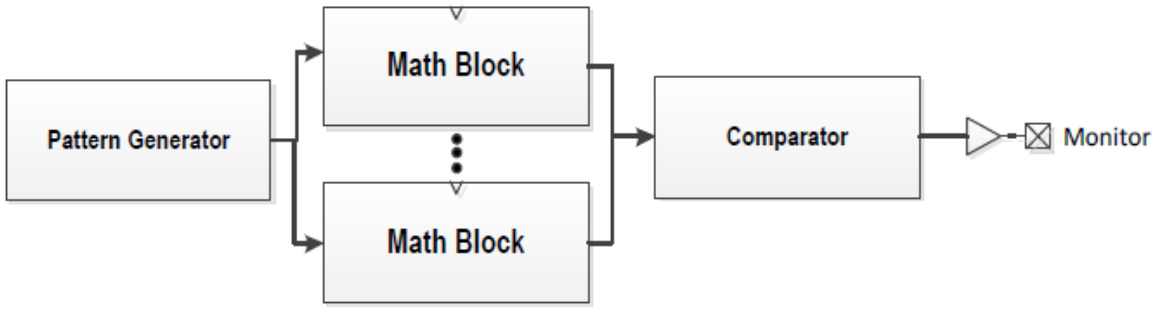

Fig. 42. Math Block

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