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Total Ionizing Dose Test Report

No. 20T-RT4G150-LG1657- K2MAC

February 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	K2MAC
Quantity Tested	6
Serial Number (Dose)	09297 (125 krad), 09318 (125 krad), 09344 (125 krad), 09360 (125 krad), 09363 (125 krad), 09371 (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

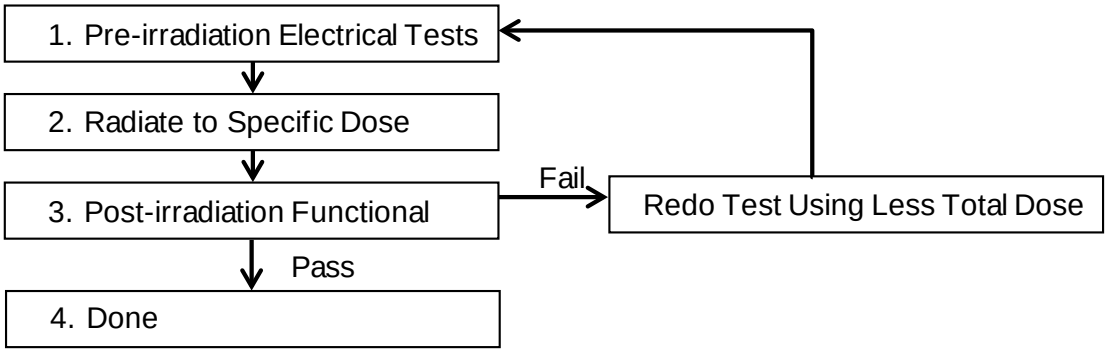

Fig. 1. Parametric test flow chart

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 (%)
09297	125 krad	0.3585	0.3684	2.76
09318	125 krad	0.3261	0.3366	3.22
09344	125 krad	0.3976	0.4115	3.50
09360	125 krad	0.3981	0.4093	2.81
09363	125 krad	0.3206	0.3338	4.12
09371	125 krad	0.3086	0.3275	6.12

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

DUT	Total Dose	Pre-irradiation (A)	Post-irradiation (A)	Increase (%)
09297	125 krad	0.0080	0.0102	27.50
09318	125 krad	0.0082	0.0103	25.61
09344	125 krad	0.0088	0.0111	26.14
09360	125 krad	0.0091	0.0114	25.27
09363	125 krad	0.0119	0.0143	20.17
09371	125 krad	0.0095	0.0118	24.21

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

DUT	Total Dose	Pre-irradiation (A)	Post-irradiation (A)	Increase (%)
09297	125 krad	0.0340	0.0367	7.94
09318	125 krad	0.0338	0.0366	8.28
09344	125 krad	0.0342	0.0370	8.19
09360	125 krad	0.0340	0.0367	7.94
09363	125 krad	0.0345	0.0376	8.99
09371	125 krad	0.0350	0.0377	7.71

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

DUT	Total Dose	Pre-irradiation (A)	Post-irradiation (A)	Increase (%)
09297	125 krad	0.0156	0.0160	2.56
09318	125 krad	0.0155	0.0162	4.52
09344	125 krad	0.0155	0.0173	11.61
09360	125 krad	0.0154	0.0167	8.44
09363	125 krad	0.0158	0.0169	6.96
09371	125 krad	0.0157	0.0159	1.27

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

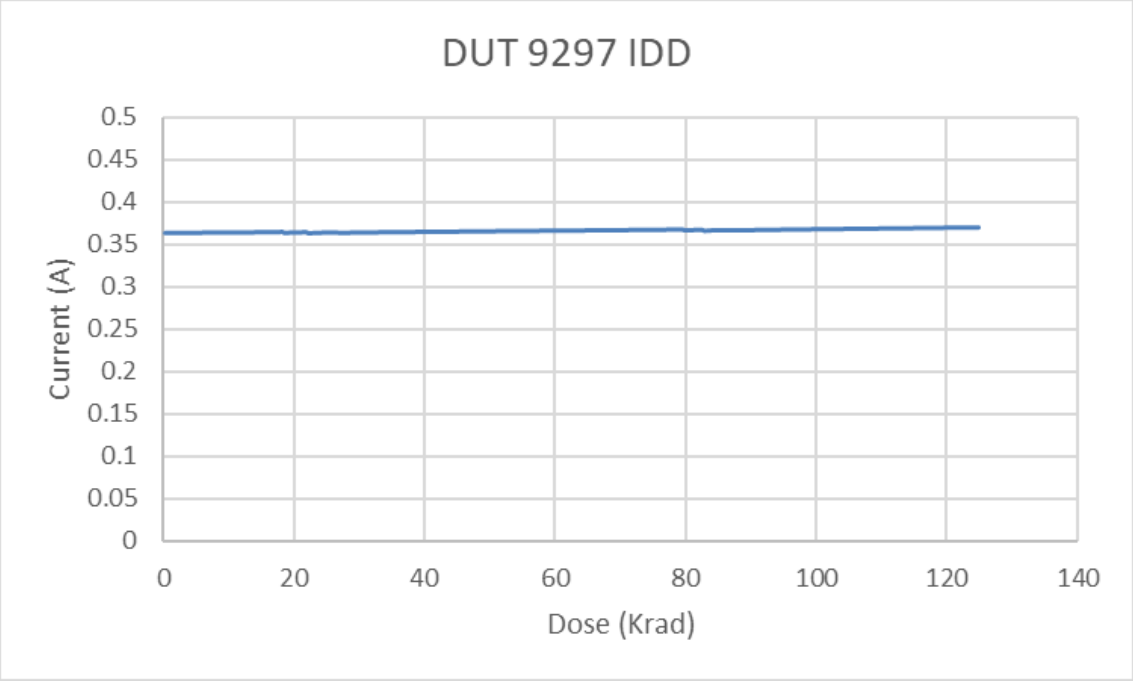

Fig. 2. DUT 09297 core power supply current (I_{DD}) versus TID

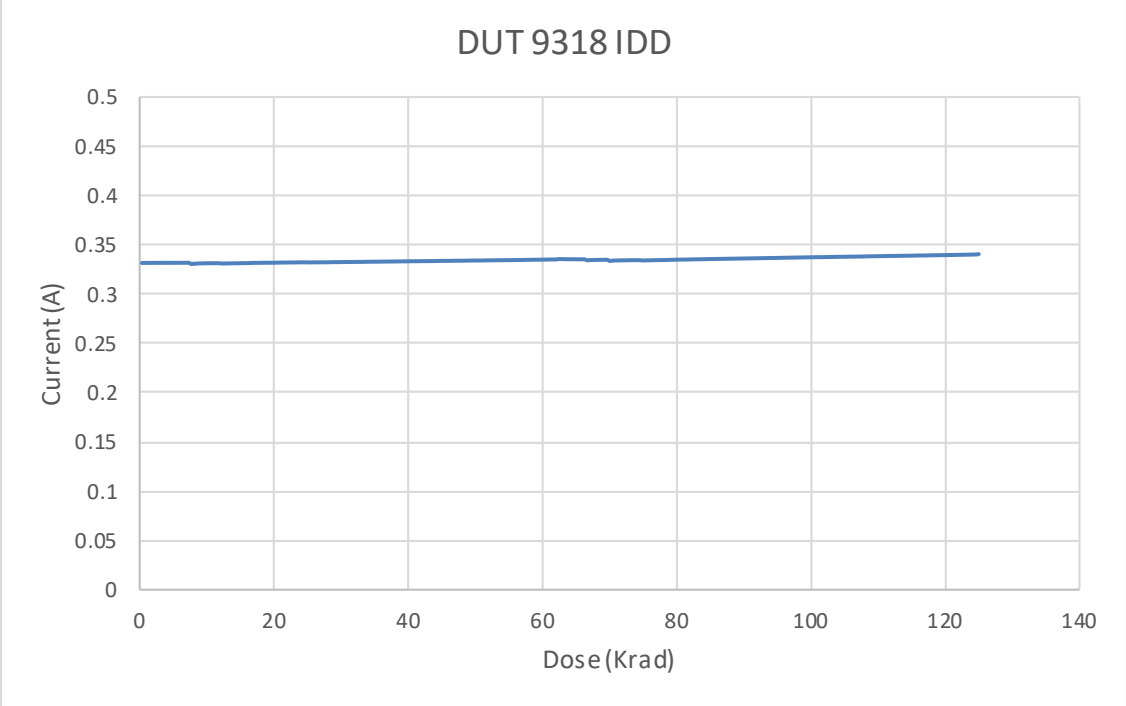

Fig. 3. DUT 09318 core power supply current (I_{DD}) versus TID

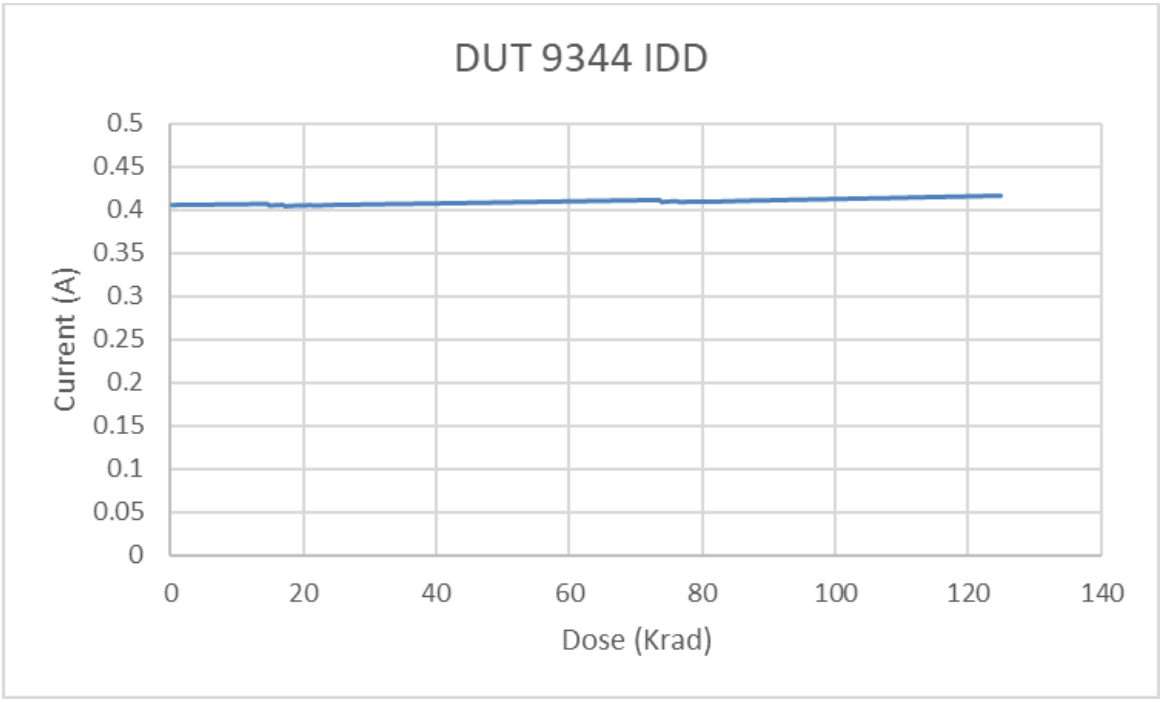

Fig. 4. DUT 09344 core power supply current (I_{DD}) versus TID

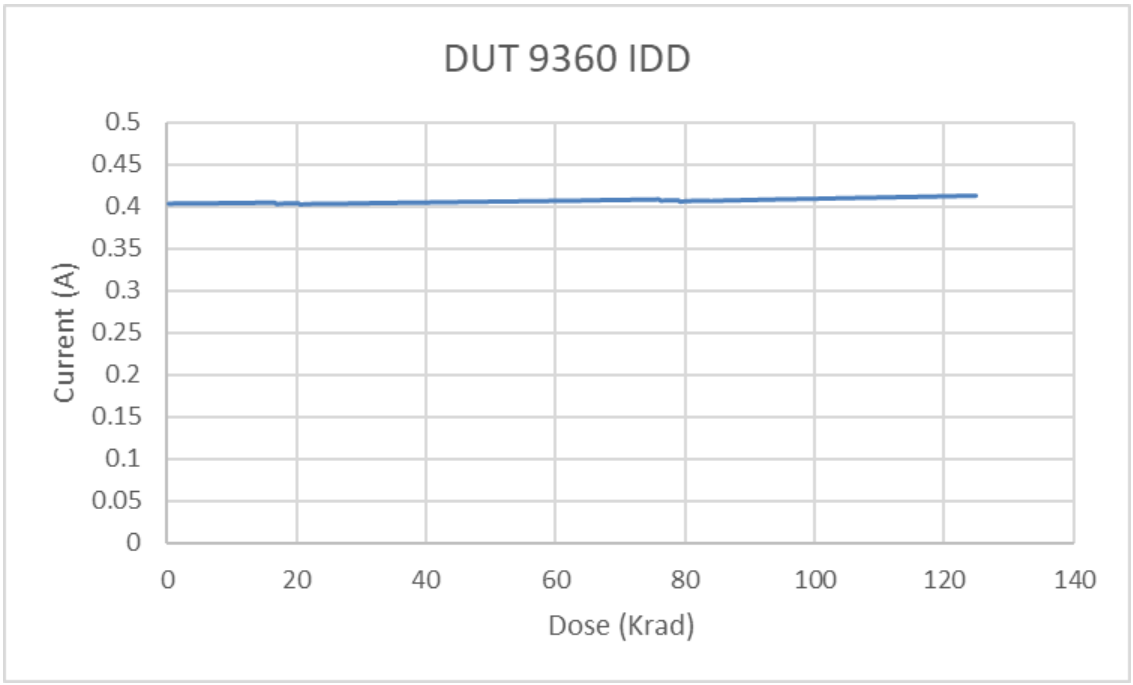

Fig. 5. DUT 09360 core power supply current (I_{DD}) versus TID

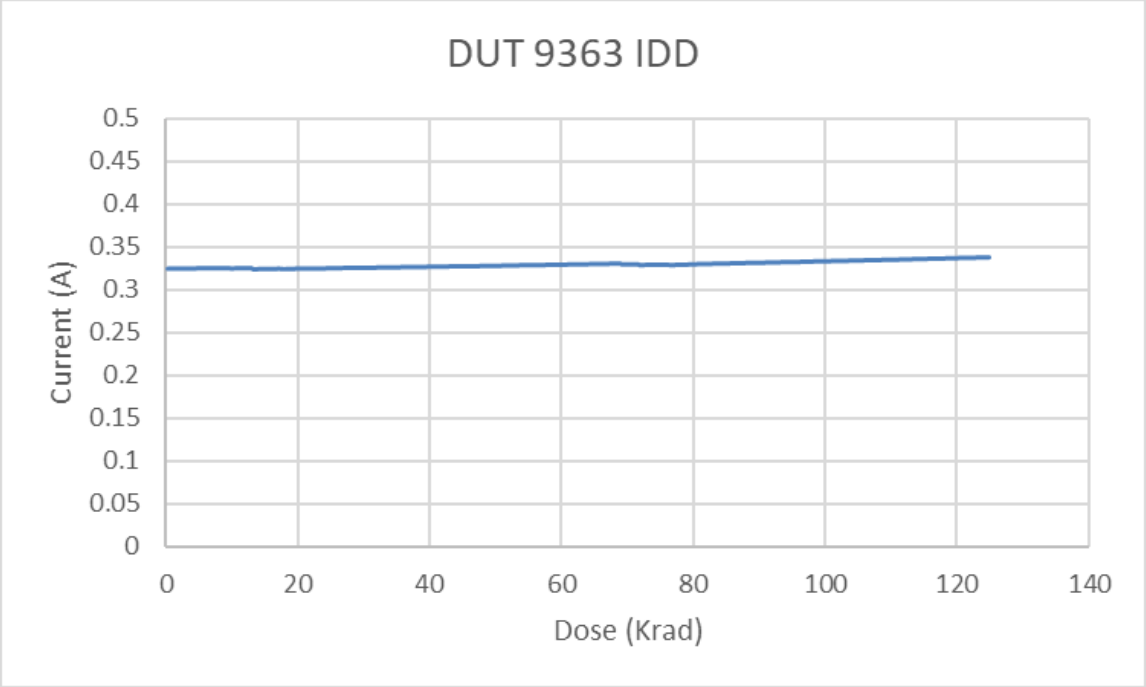

Fig. 6. DUT 09363 core power supply current (I_{DD}) versus TID

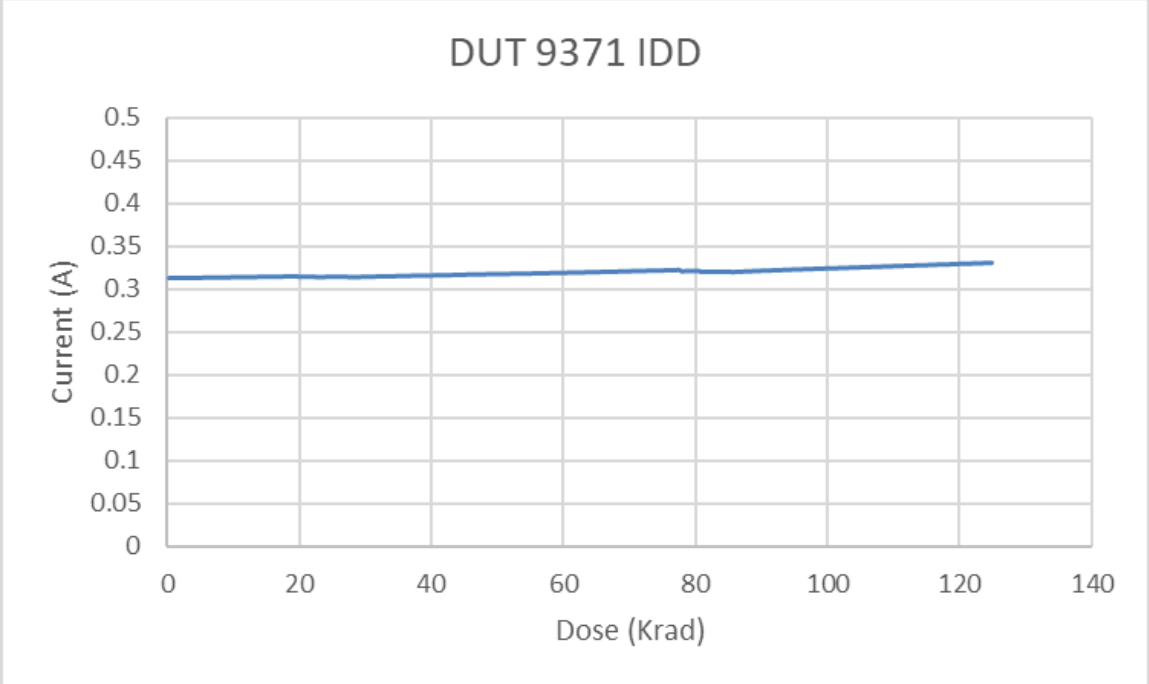

Fig. 7. DUT 09371 core power supply current (I_{DD}) versus TID

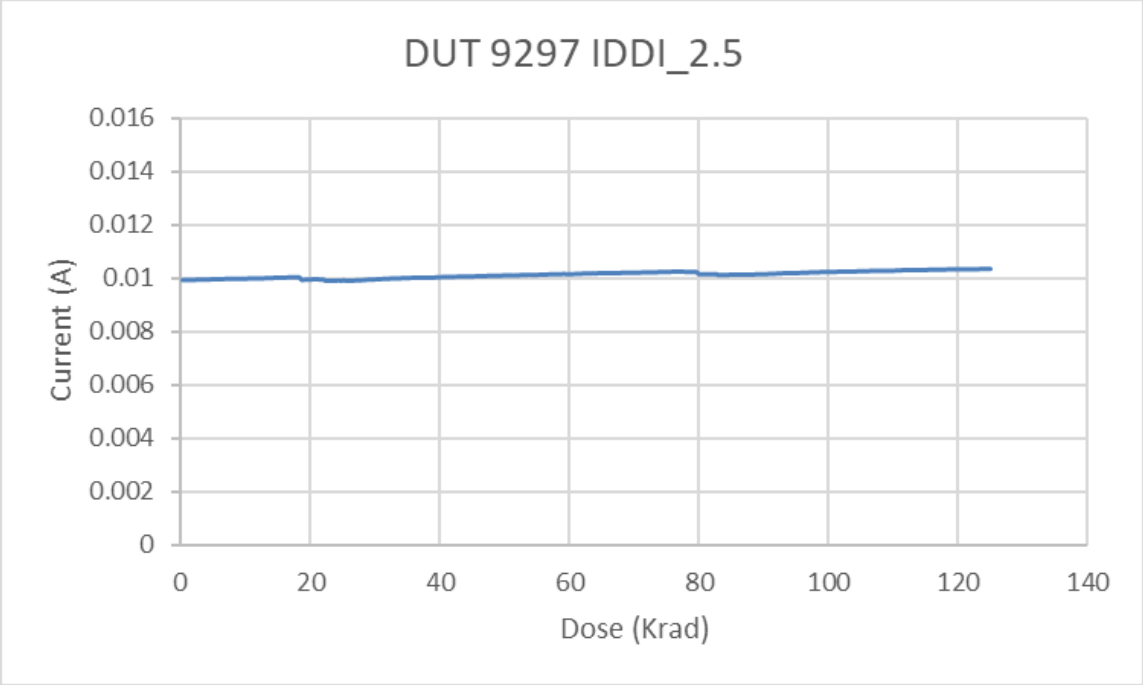

Fig. 8. DUT 09297 I/O bank 2.5V power supply current ($I_{DDI\_2.5}$) versus TID

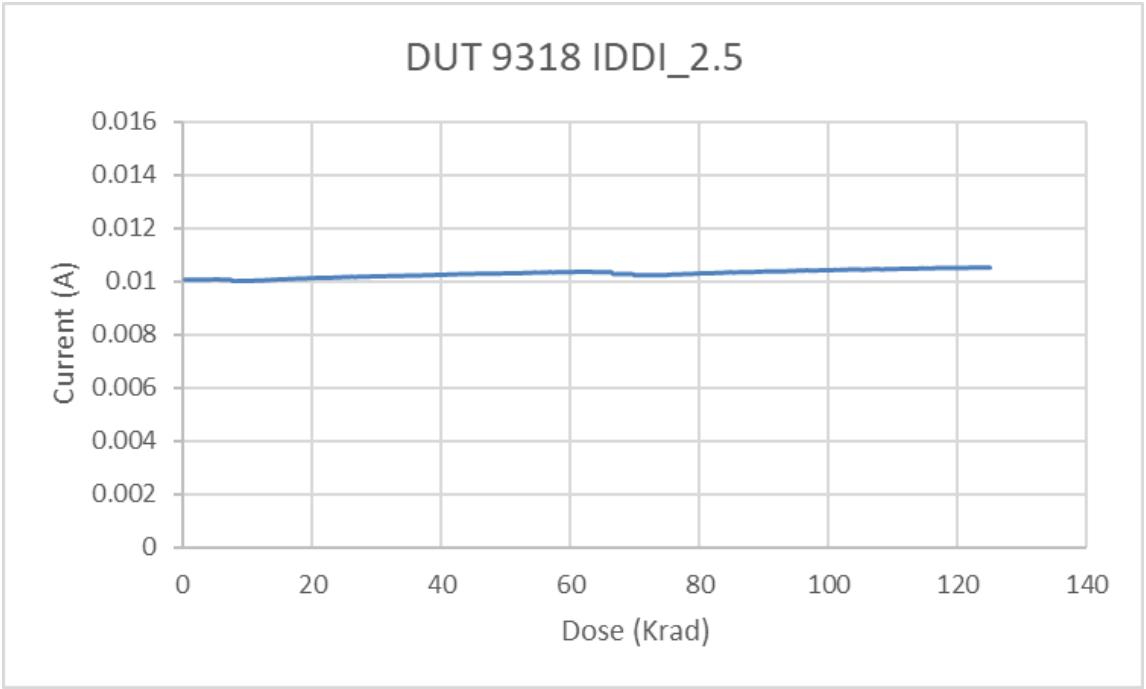

Fig. 9. DUT 09318 I/O bank 2.5V power supply current ($I_{DDI\_2.5}$) versus TID

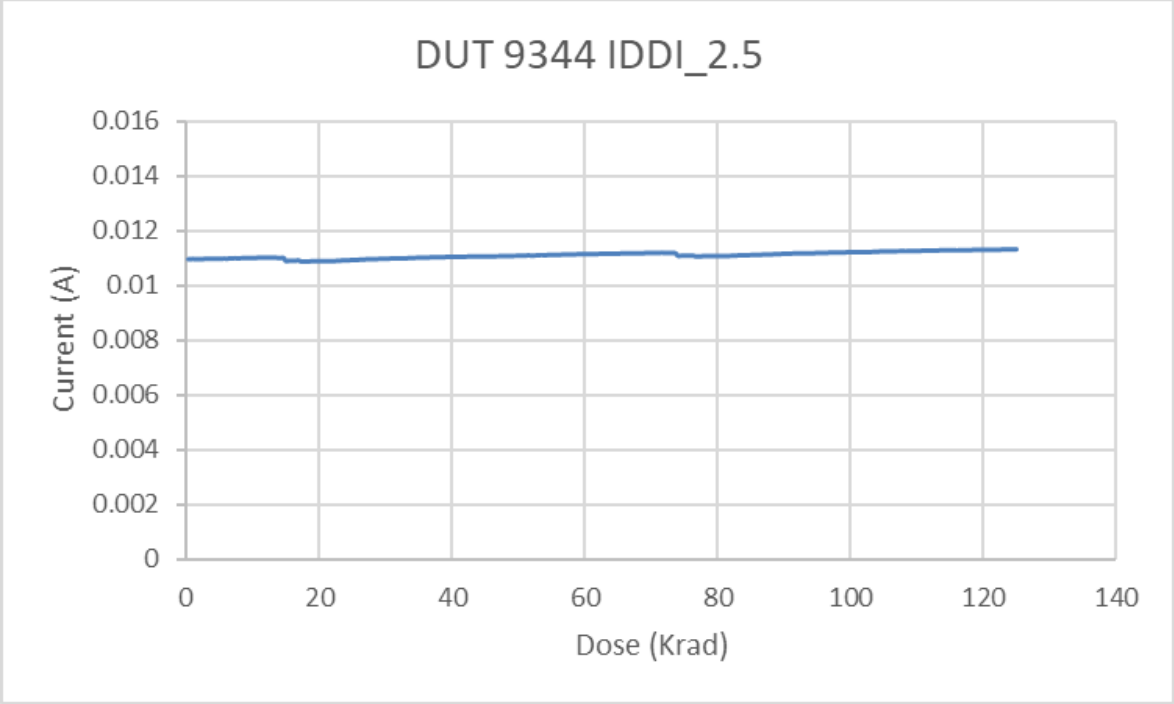

Fig. 10. DUT 09344 I/O bank 2.5V power supply current ($I_{DDI\_2.5}$) versus TID

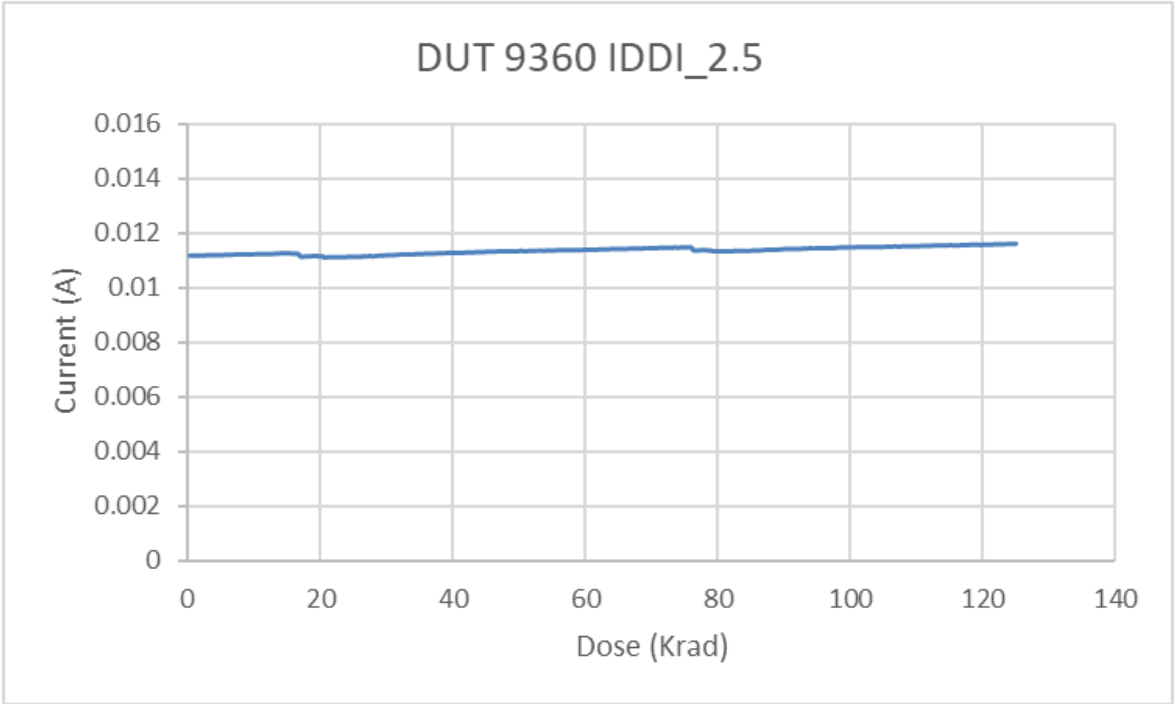

Fig. 11. DUT 09360 I/O bank 2.5V power supply current ($I_{DDI\_2.5}$) versus TID

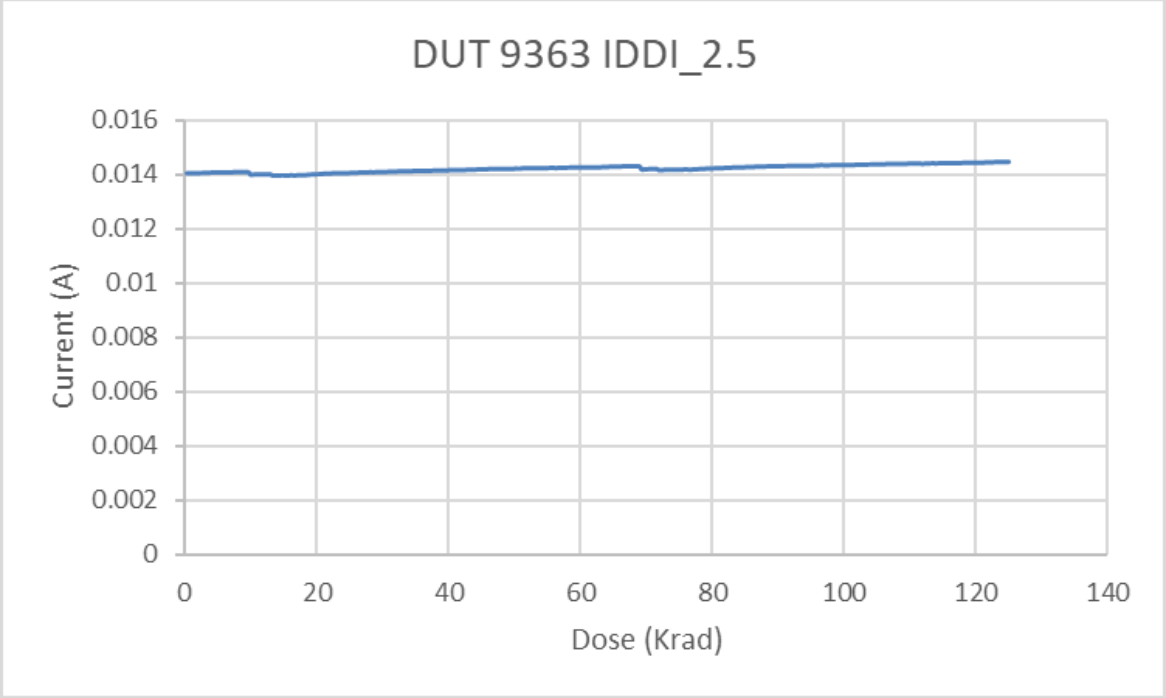

Fig. 12. DUT 09363 I/O bank 2.5V power supply current ($I_{DDI\_2.5}$) versus TID

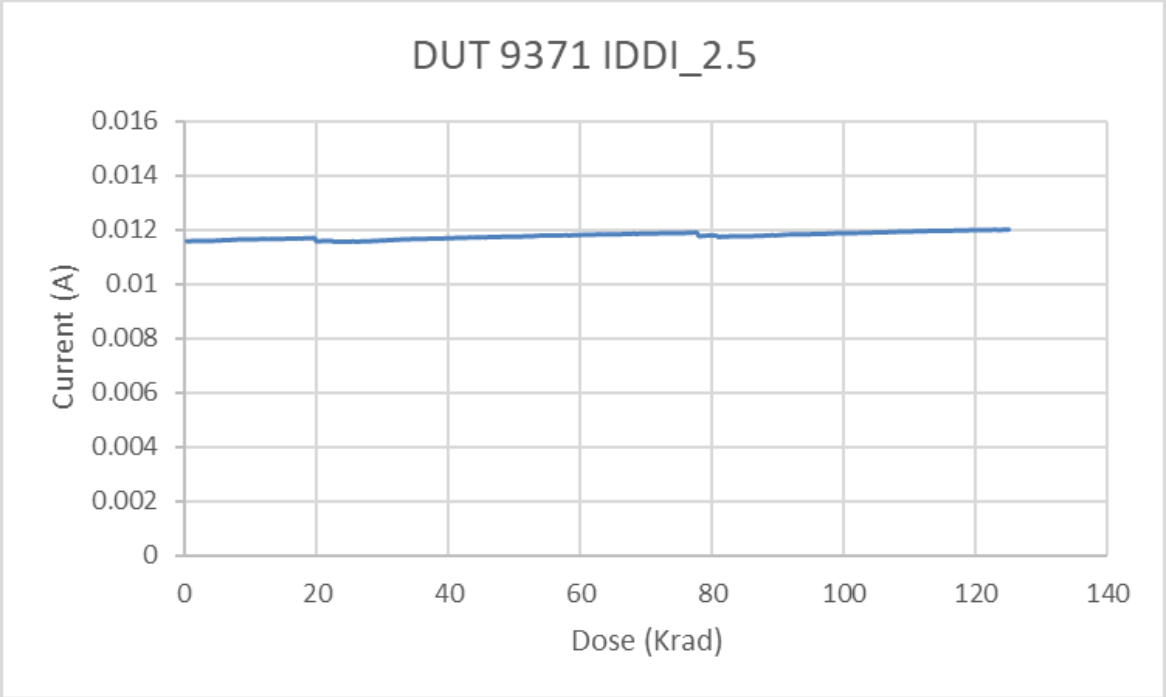

Fig. 13. DUT 09371 I/O bank 2.5V power supply current ($I_{DDI\_2.5}$) versus TID

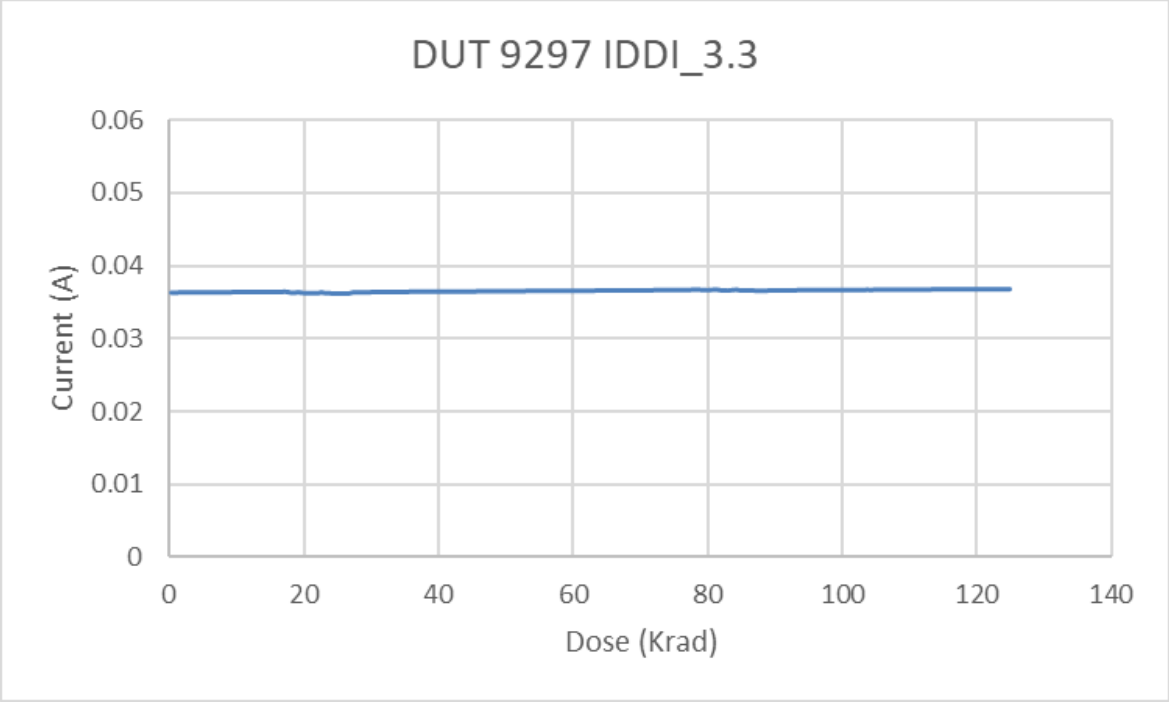

Fig. 14. DUT 09297 I/O bank 3.3V power supply current ($I_{DDI\_3.3}$) versus TID

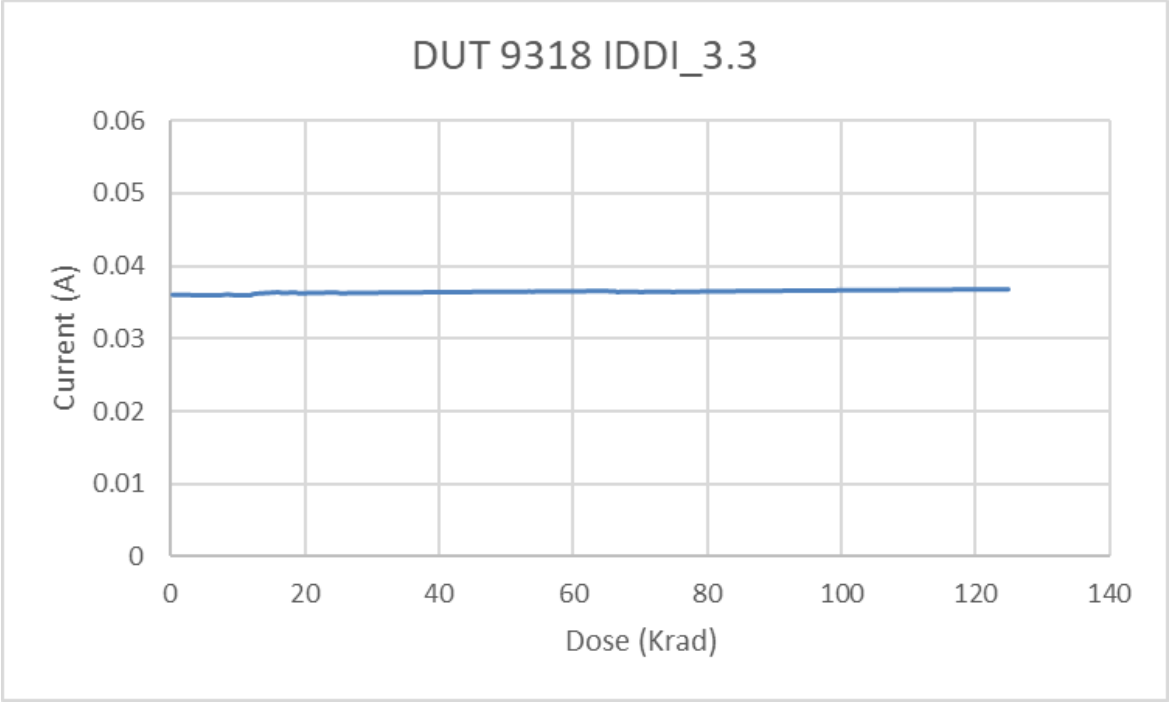

Fig. 15. DUT 09318 I/O bank 3.3V power supply current ($I_{DDI\_3.3}$) versus TID

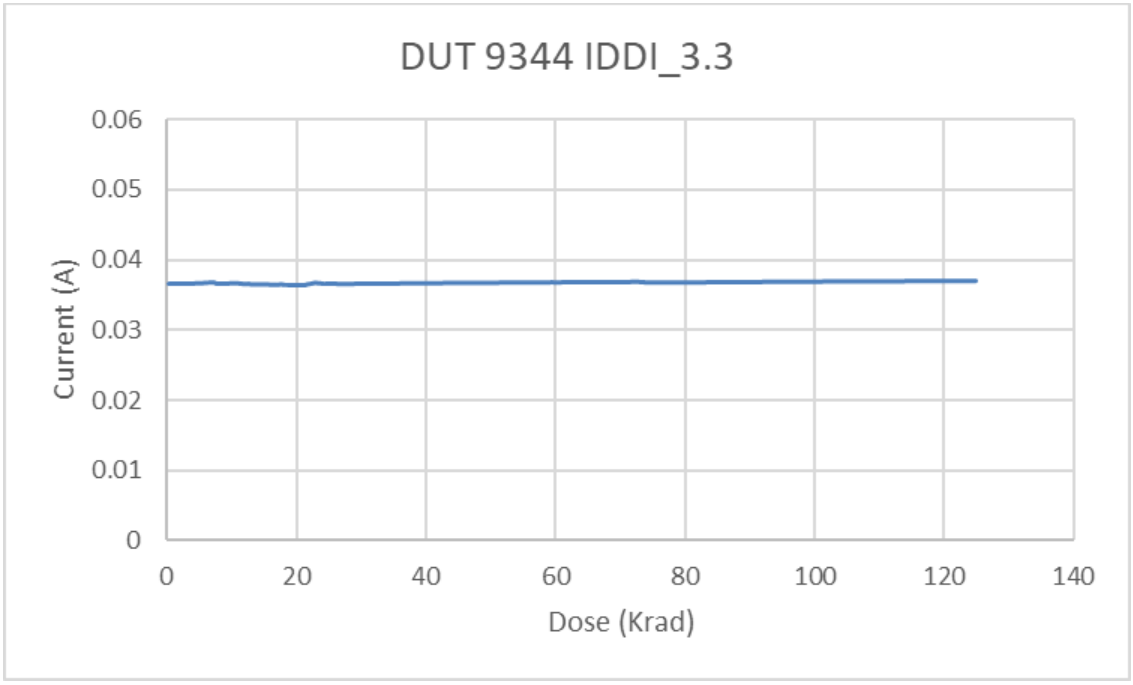

Fig. 16. DUT 09344 I/O bank 3.3V power supply current ($I_{DDI\_3.3}$) versus TID

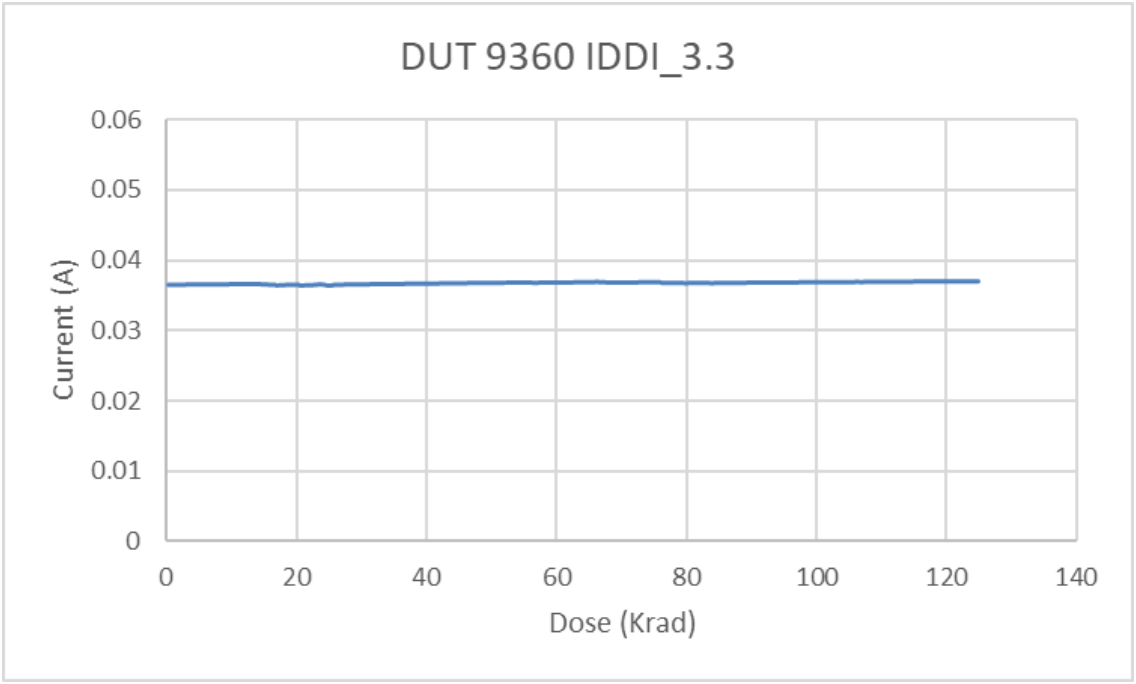

Fig. 17. DUT 09360 I/O bank 3.3V power supply current ($I_{DDI\_3.3}$) versus TID

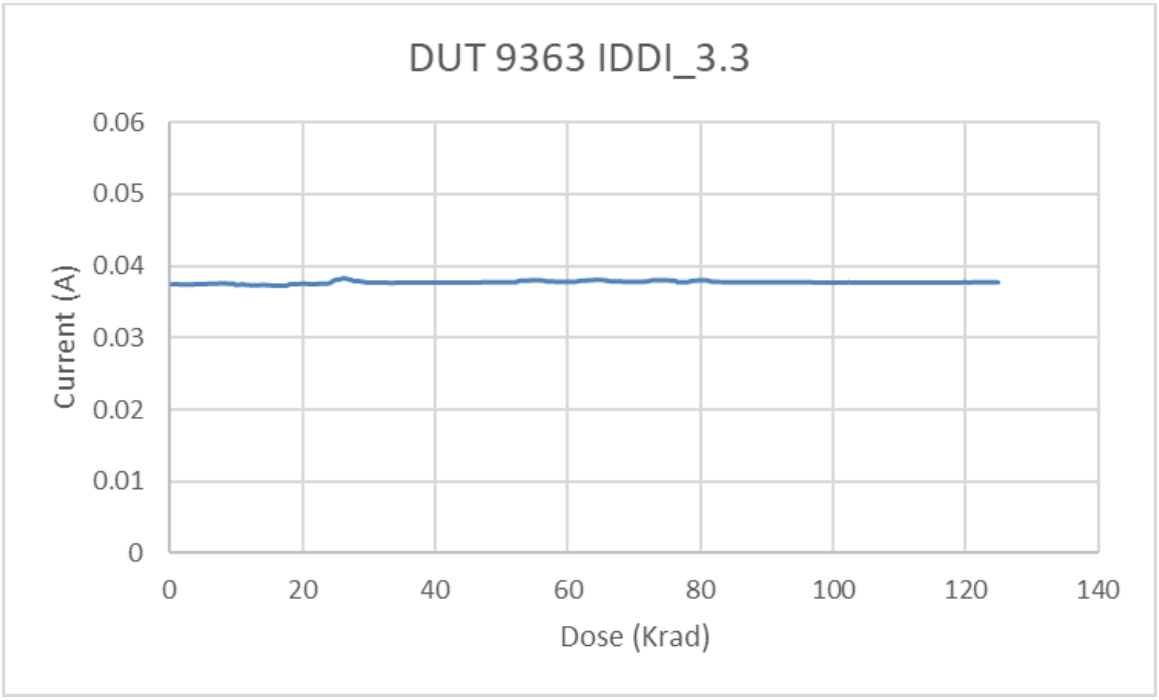

Fig. 18. DUT 09363 I/O bank 3.3V power supply current ($I_{DDI\_3.3}$) versus TID

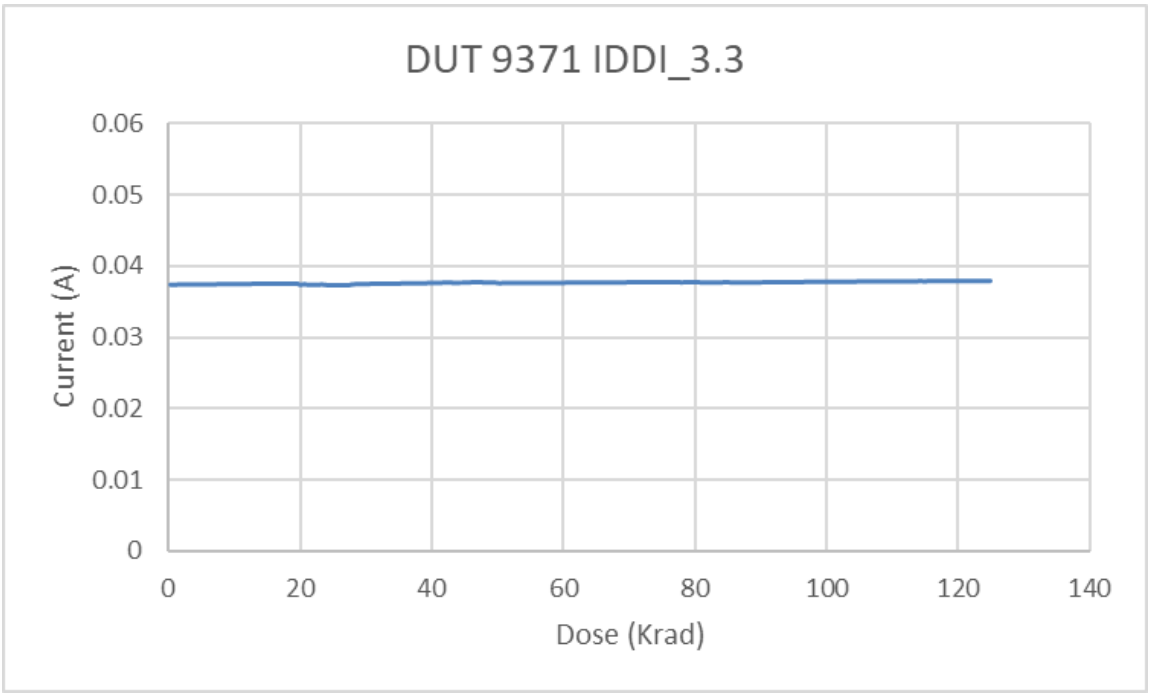

Fig. 19. DUT 09371 I/O bank 3.3V power supply current ($I_{DDI\_3.3}$) versus TID

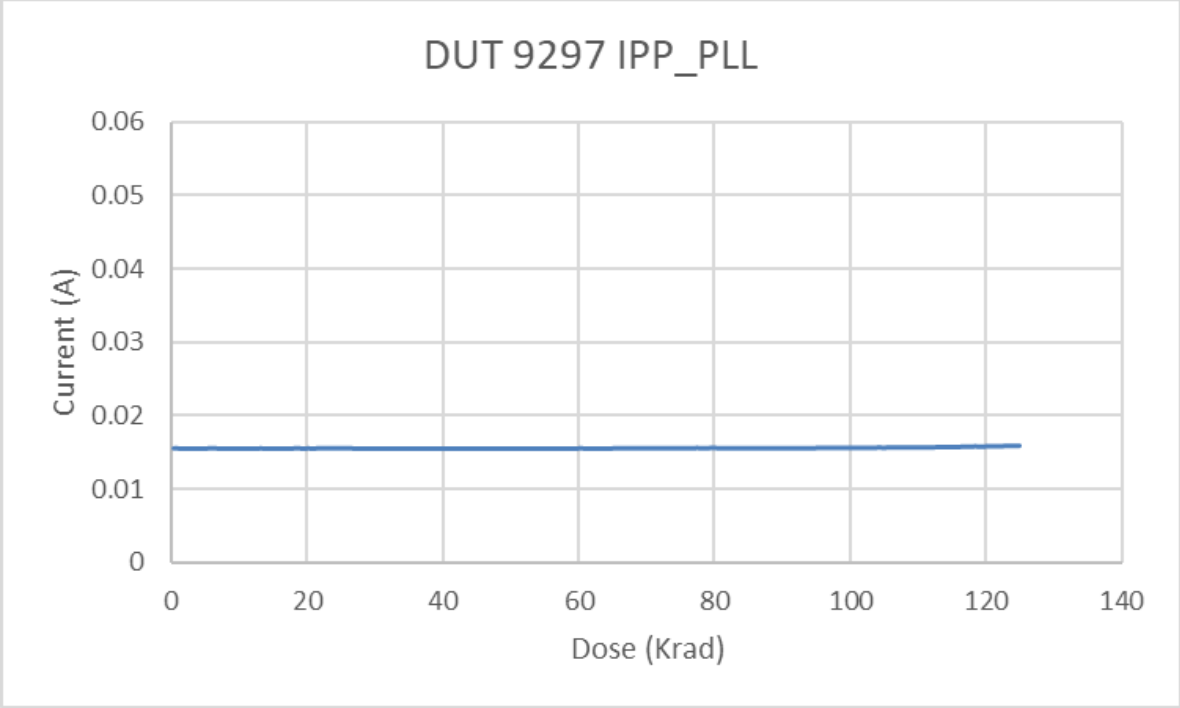

Fig. 20. DUT 09297 charge pump and PLL power supply current (I_{PP_PLL}) versus TID

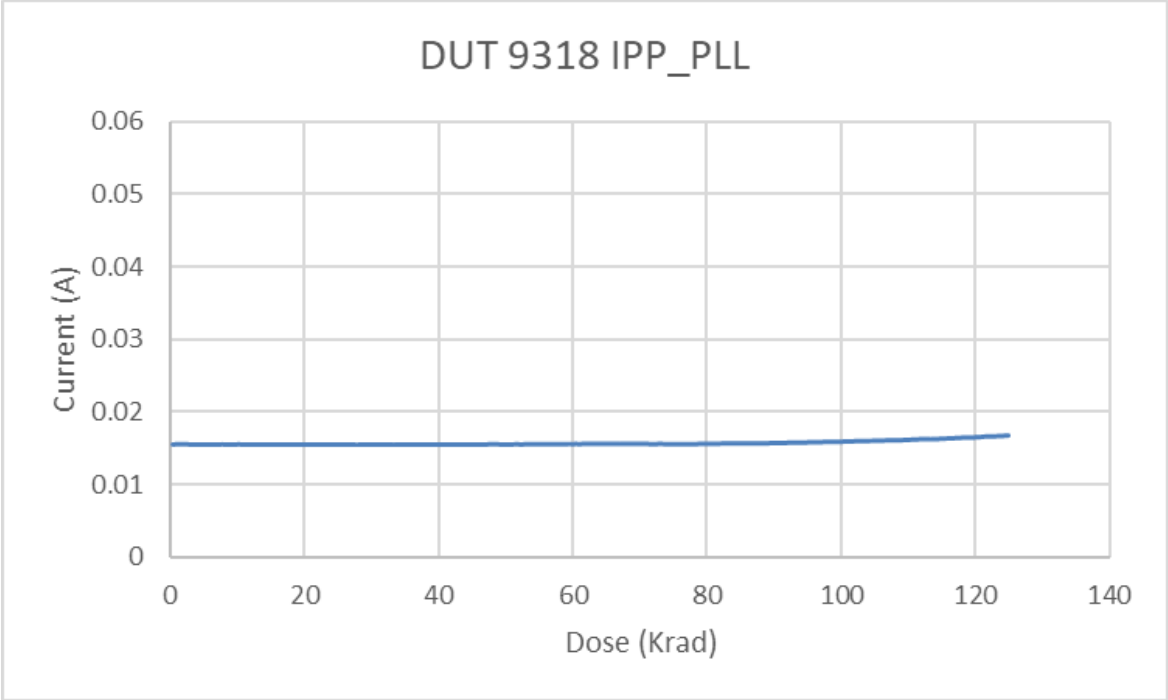

Fig. 21. DUT 09318 charge pump and PLL power supply current (I_{PP_PLL}) versus TID

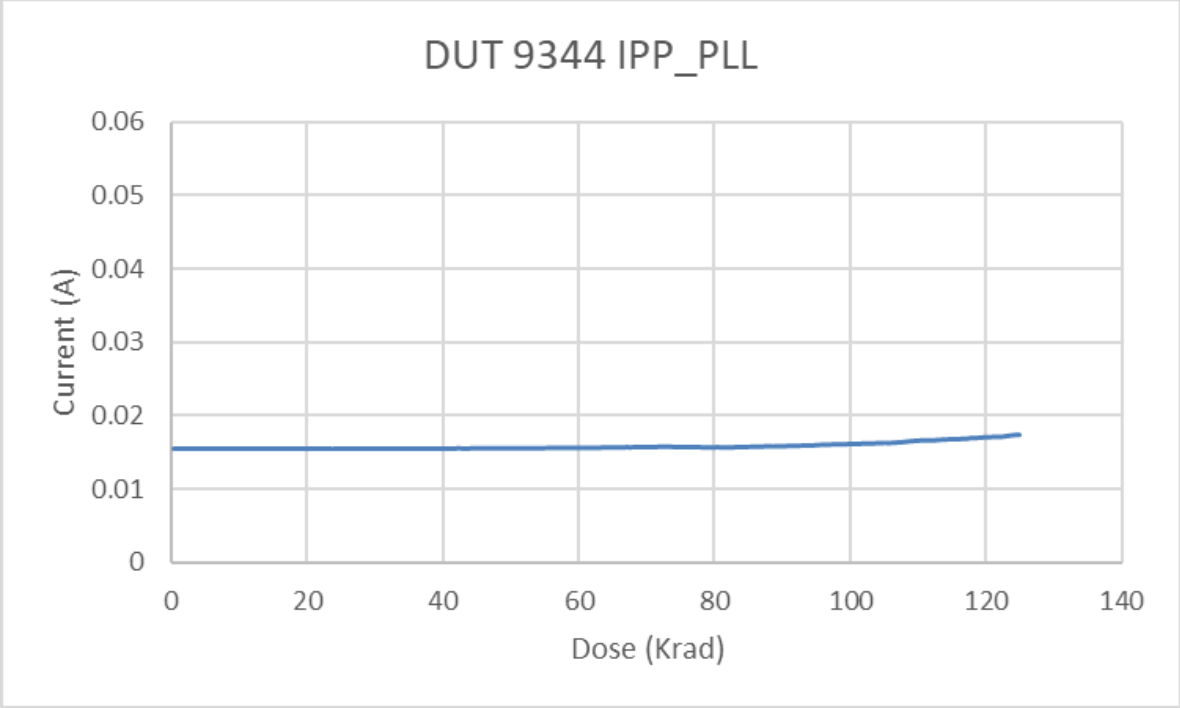

Fig. 22. DUT 09344 charge pump and PLL power supply current (I_{PP_PLL}) versus TID

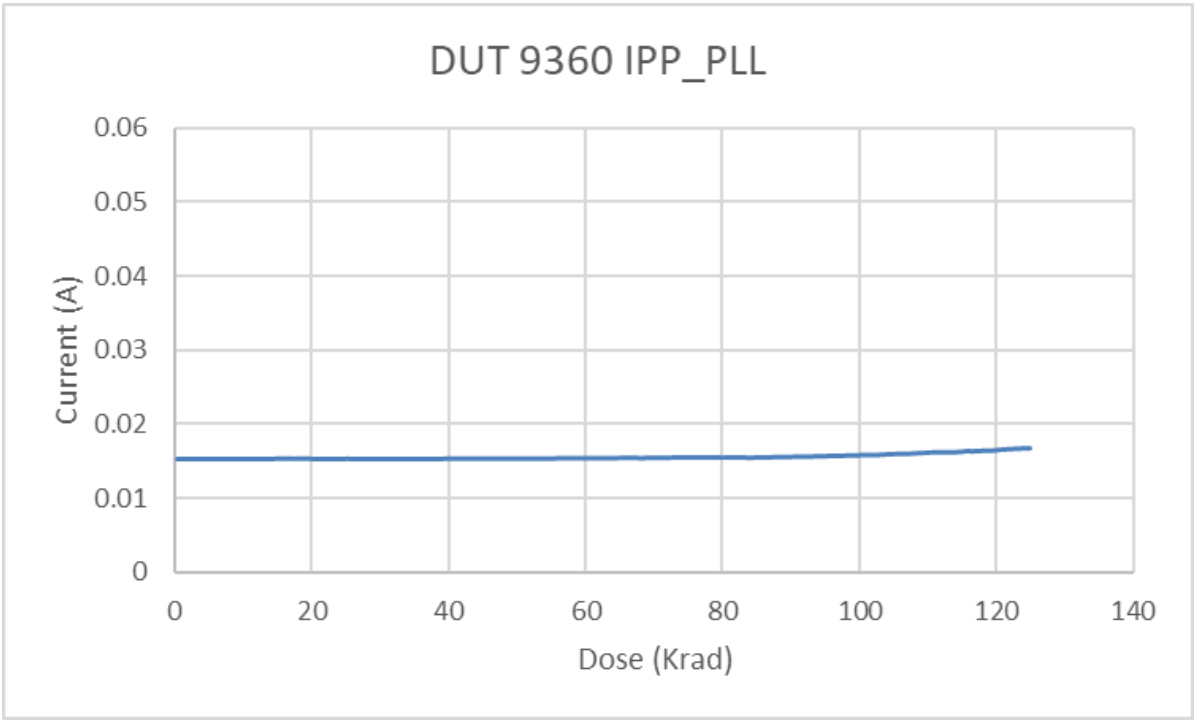

Fig. 23. DUT 09360 charge pump and PLL power supply current (I_{PP_PLL}) versus TID

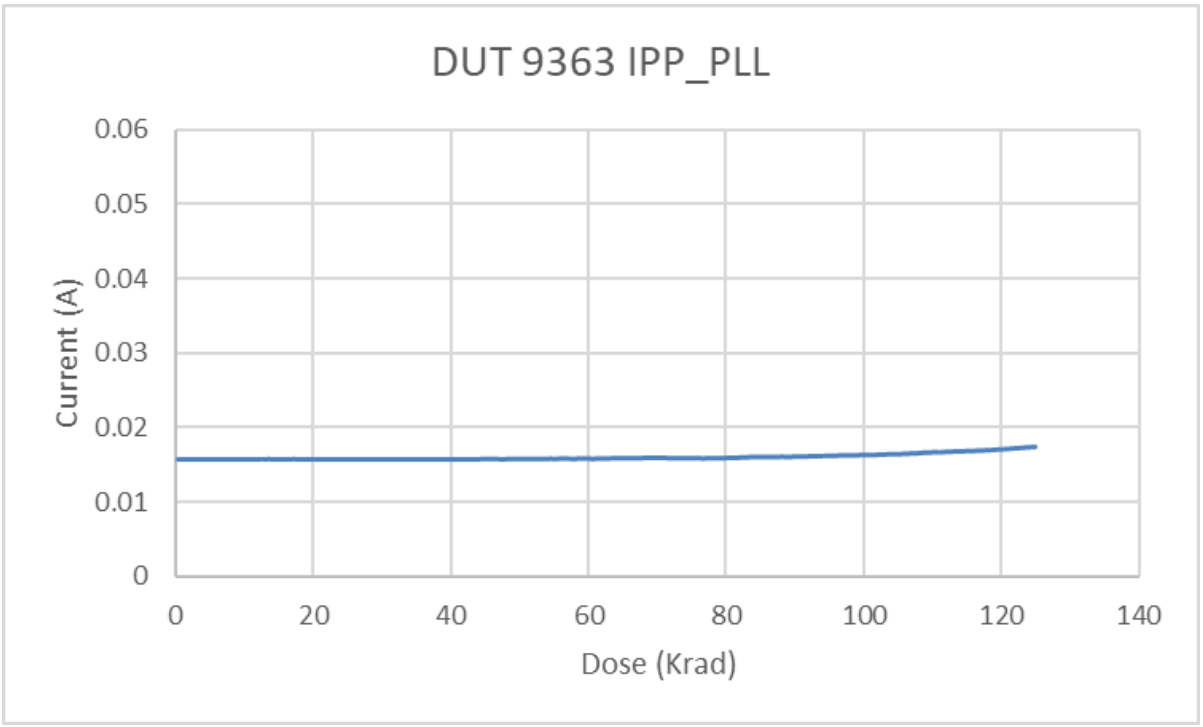

Fig. 24. DUT 09363 charge pump and PLL power supply current (I_{PP_PLL}) versus TID

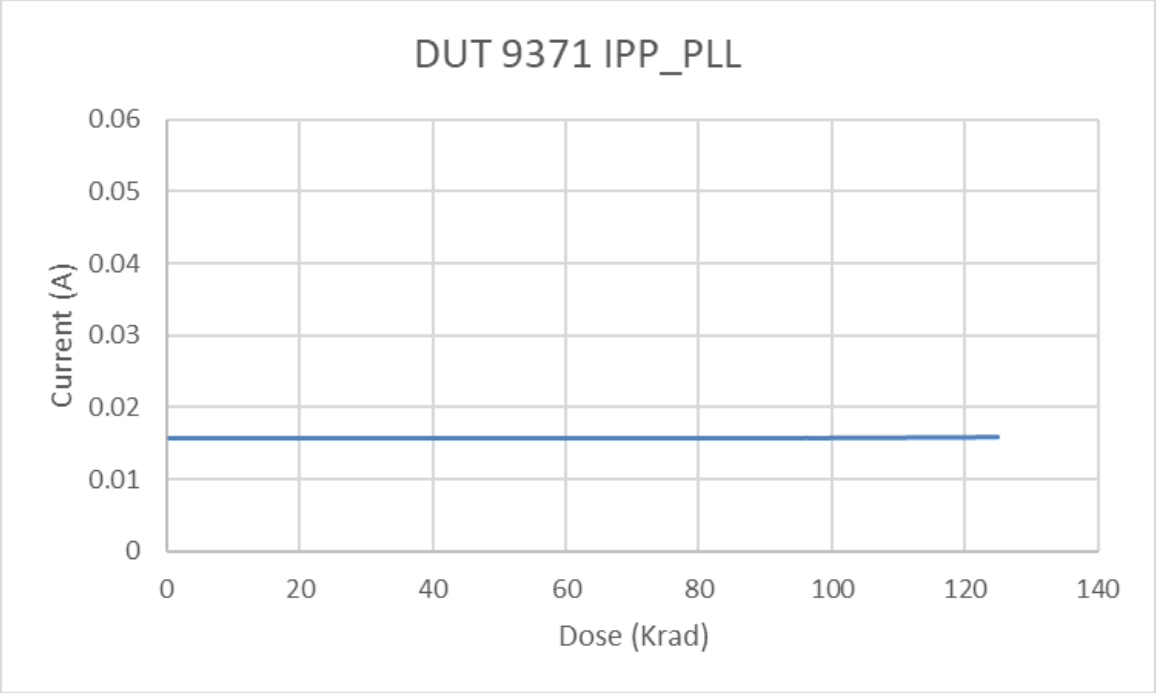

Fig. 25. DUT 09371 charge pump and PLL power supply current (I_{PP_PLL}) versus TID

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
09297	Passed	Passed
09318	Passed	Passed
09344	Passed	Passed
09360	Passed	Passed
09363	Passed	Passed
09371	Passed	Passed

Table. 9. VIL Summary

DUT	Pre-irradiation	Post-irradiation
09297	Passed	Passed
09318	Passed	Passed
09344	Passed	Passed
09360	Passed	Passed
09363	Passed	Passed
09371	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 09297

		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	2.137	2.136	2.204	2.204	2.176	2.176	2.155	2.155	2.123	2.123	2.109	2.108
EPCSRST_N_0	B31	2.138	2.137	2.204	2.204	2.176	2.176	2.155	2.155	2.122	2.122	2.108	2.108
EPCSRST_N_1	B32	2.139	2.138	2.207	2.207	2.179	2.179	2.159	2.159	2.128	2.128	2.115	2.115
EPCSRST_N_2	B34	2.137	2.136	2.205	2.205	2.177	2.176	2.157	2.156	2.125	2.125	2.112	2.111
EPCSRST_N_3	B35	2.139	2.136	2.207	2.202	2.179	2.172	2.160	2.150	2.130	2.115	2.117	2.101
EPCSRST_N_4	B36	2.137	2.133	2.204	2.197	2.174	2.165	2.154	2.141	2.120	2.102	2.106	2.085
EPCSRST_N_5	B37	2.138	2.137	2.205	2.205	2.178	2.177	2.157	2.157	2.126	2.125	2.113	2.112
MONITOR	K23	2.137	2.136	2.205	2.205	2.177	2.177	2.158	2.157	2.126	2.127	2.114	2.114
PLL_MON	L20	2.139	2.139	2.208	2.208	2.182	2.181	2.164	2.164	2.137	2.136	2.125	2.124
TOGGLE_MON	L22	2.139	2.138	2.208	2.207	2.181	2.181	2.163	2.162	2.135	2.134	2.123	2.122

Table. 11. LVCMOS 25 VOH – DUT 09318

		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	2.135	2.203	2.203	2.173	2.174	2.152	2.153	2.120	2.120	2.106	2.107
EPCSRST_N_0	B31	2.135	2.135	2.203	2.203	2.174	2.175	2.153	2.154	2.121	2.121	2.107	2.107
EPCSRST_N_1	B32	2.137	2.137	2.205	2.205	2.177	2.177	2.157	2.157	2.126	2.127	2.113	2.114
EPCSRST_N_2	B34	2.135	2.135	2.203	2.203	2.175	2.175	2.154	2.154	2.122	2.122	2.108	2.108
EPCSRST_N_3	B35	2.136	2.135	2.206	2.202	2.178	2.172	2.159	2.151	2.129	2.118	2.116	2.103
EPCSRST_N_4	B36	2.135	2.132	2.203	2.197	2.174	2.166	2.154	2.143	2.121	2.105	2.107	2.089
EPCSRST_N_5	B37	2.135	2.135	2.204	2.204	2.175	2.175	2.155	2.155	2.124	2.124	2.110	2.110
MONITOR	K23	2.135	2.135	2.204	2.204	2.176	2.176	2.156	2.156	2.125	2.125	2.111	2.112
PLL_MON	L20	2.137	2.136	2.207	2.207	2.180	2.180	2.163	2.162	2.135	2.134	2.123	2.123

TOGGLE_MON	L22	2.137	2.136	2.207	2.206	2.180	2.180	2.161	2.161	2.133	2.133	2.122	2.121

Table. 12. LVCMOS 25 VOH – DUT 09344

		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	2.137	2.136	2.204	2.204	2.175	2.175	2.154	2.154	2.122	2.122	2.108	2.109
EPCSRST_N_0	B31	2.136	2.136	2.204	2.204	2.175	2.175	2.154	2.153	2.121	2.120	2.108	2.107
EPCSRST_N_1	B32	2.138	2.137	2.206	2.205	2.178	2.177	2.157	2.156	2.126	2.125	2.113	2.112
EPCSRST_N_2	B34	2.136	2.136	2.204	2.204	2.176	2.176	2.155	2.155	2.123	2.123	2.110	2.110
EPCSRST_N_3	B35	2.138	2.135	2.206	2.201	2.179	2.171	2.159	2.150	2.129	2.115	2.117	2.100
EPCSRST_N_4	B36	2.136	2.132	2.203	2.197	2.174	2.164	2.153	2.140	2.119	2.101	2.106	2.083
EPCSRST_N_5	B37	2.136	2.136	2.205	2.205	2.177	2.176	2.156	2.156	2.125	2.125	2.111	2.111
MONITOR	K23	2.136	2.135	2.204	2.202	2.177	2.173	2.157	2.152	2.126	2.119	2.113	2.105
PLL_MON	L20	2.138	2.137	2.208	2.207	2.181	2.180	2.163	2.162	2.135	2.134	2.124	2.122
TOGGLE_MON	L22	2.137	2.136	2.207	2.206	2.180	2.179	2.162	2.160	2.133	2.131	2.122	2.119

Table. 13. LVCMOS 25 VOH – DUT 09360

		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	2.134	2.200	2.203	2.169	2.174	2.147	2.153	2.111	2.121	2.095	2.107
EPCSRST_N_0	B31	2.135	2.136	2.203	2.203	2.174	2.175	2.153	2.154	2.121	2.121	2.107	2.107
EPCSRST_N_1	B32	2.137	2.137	2.205	2.206	2.178	2.178	2.158	2.158	2.127	2.127	2.114	2.115
EPCSRST_N_2	B34	2.135	2.135	2.204	2.204	2.175	2.175	2.155	2.155	2.123	2.123	2.110	2.110
EPCSRST_N_3	B35	2.137	2.134	2.205	2.202	2.178	2.172	2.158	2.150	2.128	2.116	2.115	2.102
EPCSRST_N_4	B36	2.135	2.132	2.202	2.196	2.173	2.165	2.152	2.141	2.118	2.102	2.104	2.085
EPCSRST_N_5	B37	2.137	2.136	2.204	2.204	2.176	2.176	2.155	2.155	2.124	2.124	2.111	2.110
MONITOR	K23	2.136	2.136	2.204	2.204	2.176	2.176	2.156	2.157	2.125	2.126	2.112	2.113
PLL_MON	L20	2.138	2.137	2.207	2.207	2.181	2.181	2.163	2.163	2.135	2.134	2.124	2.123
TOGGLE_MON	L22	2.137	2.137	2.207	2.207	2.180	2.180	2.162	2.161	2.133	2.132	2.122	2.121

Table. 14. LVCMOS 25 VOH – DUT 09363

		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	2.133	2.202	2.202	2.173	2.173	2.152	2.152	2.120	2.119	2.106	2.106
EPCSRST_N_0	B31	2.134	2.134	2.202	2.202	2.174	2.172	2.152	2.151	2.120	2.118	2.106	2.104
EPCSRST_N_1	B32	2.135	2.135	2.204	2.204	2.176	2.177	2.156	2.157	2.125	2.126	2.112	2.113
EPCSRST_N_2	B34	2.135	2.135	2.202	2.203	2.173	2.174	2.153	2.153	2.120	2.122	2.107	2.108
EPCSRST_N_3	B35	2.136	2.133	2.205	2.200	2.177	2.170	2.158	2.147	2.128	2.112	2.115	2.097
EPCSRST_N_4	B36	2.134	2.131	2.202	2.196	2.173	2.164	2.152	2.139	2.119	2.100	2.105	2.083
EPCSRST_N_5	B37	2.135	2.135	2.203	2.203	2.175	2.175	2.154	2.155	2.123	2.123	2.110	2.110
MONITOR	K23	2.134	2.134	2.203	2.203	2.175	2.175	2.155	2.156	2.124	2.125	2.111	2.112
PLL_MON	L20	2.136	2.136	2.206	2.206	2.180	2.179	2.162	2.162	2.134	2.134	2.122	2.122
TOGGLE_MON	L22	2.136	2.136	2.206	2.206	2.180	2.179	2.161	2.160	2.133	2.132	2.121	2.120

Table. 15. LVCMOS 25 VOH – DUT 09371

		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	2.133	2.202	2.202	2.173	2.173	2.152	2.152	2.119	2.120	2.106	2.106
EPCSRST_N_0	B31	2.133	2.134	2.202	2.201	2.172	2.172	2.151	2.151	2.118	2.118	2.104	2.103
EPCSRST_N_1	B32	2.135	2.135	2.204	2.204	2.175	2.176	2.155	2.156	2.124	2.125	2.110	2.111
EPCSRST_N_2	B34	2.134	2.135	2.203	2.203	2.174	2.175	2.153	2.154	2.121	2.122	2.108	2.109
EPCSRST_N_3	B35	2.135	2.133	2.204	2.199	2.176	2.168	2.156	2.145	2.125	2.109	2.112	2.094
EPCSRST_N_4	B36	2.134	2.131	2.202	2.195	2.173	2.162	2.152	2.138	2.119	2.097	2.105	2.080
EPCSRST_N_5	B37	2.135	2.135	2.203	2.203	2.175	2.175	2.154	2.155	2.123	2.123	2.109	2.110
MONITOR	K23	2.133	2.134	2.202	2.203	2.174	2.175	2.154	2.155	2.123	2.124	2.109	2.111
PLL_MON	L20	2.135	2.135	2.205	2.205	2.179	2.179	2.161	2.161	2.132	2.133	2.121	2.121
TOGGLE_MON	L22	2.135	2.135	2.205	2.205	2.178	2.178	2.159	2.159	2.131	2.131	2.119	2.119

Table. 16. LVCMOS 25 VOL – DUT 09297

		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	231.1	230.5	165.0	164.6	192.7	192.3	213.5	213.2	244.8	244.4	258.3	257.9
EPCSRST_N_0	B31	230.3	229.7	164.8	164.6	192.9	192.5	213.9	213.4	245.5	245.0	259.4	258.7
EPCSRST_N_1	B32	229.7	228.9	163.3	162.7	190.3	189.7	210.1	209.1	240.5	239.1	253.2	252.0
EPCSRST_N_2	B34	231.0	230.5	164.8	164.4	192.4	191.9	212.7	211.9	243.4	242.6	256.6	255.9
EPCSRST_N_3	B35	230.4	232.0	163.4	167.3	190.2	196.3	209.8	218.0	239.4	252.0	251.8	266.8
EPCSRST_N_4	B36	232.1	234.5	166.7	172.3	195.0	203.5	216.2	227.4	248.5	265.7	262.5	282.7
EPCSRST_N_5	B37	231.2	230.6	164.7	164.3	192.1	191.7	212.4	211.7	243.0	242.5	256.1	255.4
MONITOR	K23	230.6	229.8	164.2	163.6	191.2	190.6	211.4	210.2	241.5	240.0	254.1	252.8
PLL_MON	L20	228.2	228.0	160.6	160.6	186.2	186.2	205.6	205.6	232.6	232.7	243.6	243.8
TOGGLE_MON	L22	228.6	228.2	161.0	161.0	186.9	186.9	205.7	205.4	233.4	233.3	244.8	244.7

Table. 17. LVCMOS 25 VOL – DUT 09318

		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	233.5	232.4	167.0	166.1	195.2	194.1	216.4	215.0	248.3	246.7	261.9	260.3
EPCSRST_N_0	B31	232.6	231.8	166.3	165.7	194.4	193.7	215.4	214.6	247.1	246.4	260.9	260.0
EPCSRST_N_1	B32	231.7	230.8	164.7	164.0	192.2	191.1	212.3	211.2	242.9	241.3	255.9	254.1
EPCSRST_N_2	B34	233.4	232.4	166.8	166.1	194.7	194.0	215.4	214.7	247.1	246.0	260.6	259.6
EPCSRST_N_3	B35	233.2	234.0	164.8	168.0	191.8	196.6	211.4	217.8	240.6	250.7	253.1	264.9
EPCSRST_N_4	B36	234.1	235.9	167.4	172.1	195.4	202.7	216.4	226.2	248.0	263.1	261.5	279.5
EPCSRST_N_5	B37	233.8	232.7	166.5	165.8	194.2	193.3	214.6	213.7	245.9	244.7	259.0	257.8
MONITOR	K23	232.5	231.5	165.5	164.8	192.8	191.9	213.1	211.9	243.4	241.9	256.2	254.6
PLL_MON	L20	231.1	230.3	162.2	161.9	188.0	187.6	207.5	207.1	234.6	234.3	245.7	245.5
TOGGLE_MON	L22	230.7	230.0	162.3	161.9	188.4	187.8	207.3	206.7	234.9	234.4	246.3	245.8

Table. 18. LVCMOS 25 VOL – DUT 09344

		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	231.6	230.6	165.9	164.9	193.8	192.7	214.8	213.5	246.2	244.5	259.8	257.9
EPCSRST_N_0	B31	231.5	231.1	165.6	165.4	193.6	193.6	214.5	214.6	246.2	246.5	260.0	260.3
EPCSRST_N_1	B32	230.5	230.3	164.2	164.3	191.5	191.7	211.6	212.1	242.2	242.9	255.2	256.0
EPCSRST_N_2	B34	232.5	231.9	165.8	165.2	193.6	193.0	214.0	213.4	245.4	244.4	258.7	257.8
EPCSRST_N_3	B35	231.5	233.2	163.9	168.3	190.7	197.5	210.5	219.6	239.8	253.8	252.2	268.6
EPCSRST_N_4	B36	233.1	235.7	167.3	173.2	195.6	204.5	216.9	228.9	249.2	267.6	263.2	284.6
EPCSRST_N_5	B37	232.5	231.8	165.6	165.1	193.0	192.6	213.5	212.9	244.3	243.7	257.7	256.9
MONITOR	K23	231.5	232.0	164.7	166.4	192.1	194.9	212.2	216.2	242.5	248.4	255.0	262.0
PLL_MON	L20	229.2	228.9	161.3	161.4	187.1	187.3	206.6	206.9	233.5	234.2	244.8	245.6
TOGGLE_MON	L22	230.2	229.9	162.1	162.2	187.9	188.3	206.9	207.5	234.8	235.7	246.1	247.4

Table. 19. LVCMOS 25 VOL – DUT 09360

		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	232.2	169.8	165.6	199.4	193.5	222.0	214.3	256.9	245.6	272.2	259.3
EPCSRST_N_0	B31	232.2	231.4	165.9	165.5	194.0	193.5	215.0	214.4	246.9	246.0	260.7	259.9
EPCSRST_N_1	B32	230.7	229.8	164.1	163.5	191.4	190.3	211.4	210.2	241.7	240.1	254.5	252.9
EPCSRST_N_2	B34	232.9	232.3	166.3	165.6	193.9	193.1	214.5	213.4	245.6	244.2	258.7	257.6
EPCSRST_N_3	B35	232.5	233.5	164.7	168.0	191.8	196.9	211.6	218.5	241.1	252.0	253.7	266.3
EPCSRST_N_4	B36	233.9	235.8	168.0	173.0	196.5	204.1	218.0	228.2	250.6	266.3	264.8	283.2
EPCSRST_N_5	B37	232.5	231.8	165.8	165.4	193.6	193.0	214.1	213.5	244.9	244.3	258.0	257.5
MONITOR	K23	232.1	230.9	165.0	164.1	192.3	191.2	212.8	211.3	242.9	241.0	255.7	253.6
PLL_MON	L20	229.9	229.1	161.7	161.3	187.5	187.1	206.8	206.6	234.0	233.8	245.2	245.0
TOGGLE_MON	L22	230.0	229.1	162.0	161.5	188.1	187.8	206.9	206.6	234.8	234.6	246.2	246.1

Table. 20. LVCMOS 25 VOL – DUT 09363

		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	234.9	234.2	167.7	167.1	195.7	195.4	216.8	216.2	248.5	247.7	262.1	261.4
EPCSRST_N_0	B31	234.1	233.6	167.3	167.4	195.5	195.8	216.6	217.1	248.6	249.6	262.3	263.7
EPCSRST_N_1	B32	233.3	232.6	166.0	165.2	193.4	192.4	213.6	212.3	244.1	242.4	257.1	255.5
EPCSRST_N_2	B34	234.9	234.0	168.0	167.1	196.1	194.9	217.1	215.6	248.7	246.8	262.4	260.2
EPCSRST_N_3	B35	233.8	235.7	165.5	170.4	192.7	200.0	212.4	222.4	241.8	256.9	254.2	271.9
EPCSRST_N_4	B36	235.6	238.2	168.6	174.3	197.0	206.0	218.2	230.2	250.2	268.7	264.1	285.8
EPCSRST_N_5	B37	234.7	234.0	167.3	166.6	195.1	194.3	215.6	214.9	246.5	245.6	259.7	258.6
MONITOR	K23	234.1	233.4	166.5	165.6	193.9	192.9	214.4	213.1	244.7	243.0	257.5	255.5
PLL_MON	L20	231.7	231.0	162.8	162.3	188.7	188.3	208.4	208.0	235.5	235.4	246.8	246.7
TOGGLE_MON	L22	231.7	231.3	163.2	163.0	189.3	189.1	208.2	208.2	235.8	236.0	247.3	247.5

Table. 21. LVCMOS 25 VOL – DUT 09371

		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	236.2	234.5	168.4	167.2	196.4	195.2	217.6	216.1	249.2	247.8	262.9	261.2
EPCSRST_N_0	B31	235.6	234.4	168.4	167.9	196.8	196.5	218.3	217.9	250.5	250.5	264.5	264.8
EPCSRST_N_1	B32	234.7	233.3	167.0	165.8	194.5	193.2	215.2	213.4	246.0	244.0	259.1	257.1
EPCSRST_N_2	B34	235.6	234.2	168.2	167.1	196.3	194.8	216.9	215.4	248.4	246.5	261.8	259.6
EPCSRST_N_3	B35	235.5	236.8	166.9	171.6	194.5	201.6	214.7	224.5	244.8	260.2	257.7	275.9
EPCSRST_N_4	B36	236.5	238.7	169.1	175.5	197.7	207.5	218.8	232.2	250.9	271.6	264.7	289.0
EPCSRST_N_5	B37	236.0	234.4	168.0	166.8	195.7	194.5	216.4	214.9	247.2	246.0	260.5	259.0
MONITOR	K23	235.9	234.4	167.6	166.5	195.3	193.8	215.9	214.2	246.2	244.1	259.0	256.7
PLL_MON	L20	234.2	232.7	164.3	163.7	190.6	189.7	210.2	209.4	237.6	236.7	248.8	248.0
TOGGLE_MON	L22	233.8	232.5	164.4	163.8	190.8	190.1	210.1	209.4	238.1	237.4	249.7	249.1

Table. 22. LVTTL VOH – DUT 09297

		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	2.924	2.924	2.915	2.914	2.896	2.896	2.877	2.877	2.858	2.857
EPCSRST_N_0	B31	2.924	2.924	2.915	2.915	2.896	2.896	2.876	2.876	2.857	2.857
EPCSRST_N_1	B32	2.926	2.925	2.917	2.917	2.899	2.899	2.882	2.882	2.864	2.865
EPCSRST_N_2	B34	2.924	2.924	2.915	2.914	2.897	2.897	2.878	2.878	2.860	2.860
EPCSRST_N_3	B35	2.925	2.922	2.917	2.912	2.900	2.891	2.883	2.869	2.867	2.848
EPCSRST_N_4	B36	2.924	2.920	2.914	2.907	2.894	2.881	2.874	2.855	2.854	2.829
EPCSRST_N_5	B37	2.924	2.924	2.916	2.915	2.897	2.897	2.879	2.879	2.861	2.861
MONITOR	K23	2.924	2.923	2.914	2.914	2.897	2.897	2.880	2.880	2.862	2.863
PLL_MON	L20	2.925	2.925	2.918	2.918	2.904	2.903	2.889	2.888	2.875	2.874
TOGGLE_MON	L22	2.925	2.925	2.918	2.917	2.903	2.902	2.888	2.887	2.873	2.872

Table. 23. LVTTL VOH – DUT 09318

		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	2.922	2.913	2.913	2.893	2.894	2.874	2.875	2.854	2.856
EPCSRST_N_0	B31	2.923	2.923	2.913	2.913	2.894	2.894	2.875	2.875	2.856	2.856
EPCSRST_N_1	B32	2.924	2.924	2.915	2.916	2.897	2.898	2.880	2.880	2.862	2.863
EPCSRST_N_2	B34	2.923	2.923	2.913	2.913	2.894	2.894	2.875	2.875	2.857	2.857
EPCSRST_N_3	B35	2.924	2.922	2.915	2.912	2.899	2.891	2.882	2.871	2.866	2.851
EPCSRST_N_4	B36	2.922	2.920	2.913	2.907	2.894	2.883	2.875	2.858	2.856	2.834
EPCSRST_N_5	B37	2.923	2.923	2.914	2.913	2.896	2.895	2.877	2.877	2.859	2.859
MONITOR	K23	2.922	2.922	2.913	2.913	2.895	2.896	2.878	2.878	2.860	2.861
PLL_MON	L20	2.923	2.923	2.916	2.916	2.902	2.901	2.887	2.887	2.873	2.873
TOGGLE_MON	L22	2.924	2.923	2.916	2.916	2.901	2.901	2.886	2.886	2.872	2.871

Table. 24. LVTTL VOH – DUT 09344

		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	2.924	2.924	2.914	2.914	2.895	2.895	2.876	2.877	2.856	2.858
EPCSRST_N_0	B31	2.923	2.923	2.914	2.913	2.894	2.894	2.875	2.875	2.856	2.855
EPCSRST_N_1	B32	2.924	2.924	2.916	2.915	2.897	2.897	2.880	2.878	2.862	2.860
EPCSRST_N_2	B34	2.923	2.923	2.914	2.914	2.895	2.895	2.877	2.877	2.858	2.858
EPCSRST_N_3	B35	2.925	2.922	2.917	2.911	2.900	2.889	2.883	2.868	2.866	2.847
EPCSRST_N_4	B36	2.923	2.919	2.913	2.906	2.893	2.880	2.873	2.854	2.853	2.828
EPCSRST_N_5	B37	2.923	2.923	2.915	2.914	2.896	2.896	2.878	2.878	2.860	2.860
MONITOR	K23	2.922	2.921	2.914	2.911	2.896	2.891	2.878	2.871	2.861	2.851
PLL_MON	L20	2.924	2.924	2.917	2.917	2.902	2.901	2.888	2.886	2.874	2.872
TOGGLE_MON	L22	2.924	2.923	2.916	2.915	2.901	2.900	2.886	2.884	2.871	2.869

Table. 25. LVTTL VOH – DUT 09360

		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	2.920	2.922	2.909	2.913	2.887	2.894	2.865	2.875	2.842	2.856
EPCSRST_N_0	B31	2.922	2.922	2.913	2.913	2.894	2.894	2.875	2.875	2.855	2.856
EPCSRST_N_1	B32	2.924	2.924	2.915	2.916	2.898	2.898	2.880	2.881	2.863	2.864
EPCSRST_N_2	B34	2.922	2.923	2.913	2.914	2.895	2.895	2.877	2.877	2.858	2.859
EPCSRST_N_3	B35	2.923	2.921	2.915	2.911	2.898	2.890	2.881	2.870	2.865	2.849
EPCSRST_N_4	B36	2.922	2.919	2.912	2.906	2.892	2.881	2.872	2.855	2.852	2.829
EPCSRST_N_5	B37	2.923	2.923	2.914	2.914	2.896	2.895	2.877	2.877	2.859	2.859
MONITOR	K23	2.922	2.922	2.913	2.913	2.896	2.896	2.878	2.879	2.861	2.862
PLL_MON	L20	2.924	2.924	2.917	2.916	2.902	2.901	2.888	2.887	2.874	2.873
TOGGLE_MON	L22	2.924	2.924	2.916	2.916	2.901	2.901	2.886	2.885	2.871	2.870

Table. 26. LVTTL VOH – DUT 09363

		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	2.921	2.912	2.912	2.893	2.893	2.873	2.874	2.854	2.854
EPCSRST_N_0	B31	2.921	2.921	2.912	2.911	2.893	2.892	2.873	2.872	2.854	2.852
EPCSRST_N_1	B32	2.922	2.922	2.914	2.914	2.896	2.896	2.878	2.879	2.861	2.862
EPCSRST_N_2	B34	2.921	2.922	2.912	2.912	2.893	2.893	2.874	2.875	2.855	2.856
EPCSRST_N_3	B35	2.923	2.920	2.914	2.909	2.898	2.887	2.881	2.865	2.865	2.843
EPCSRST_N_4	B36	2.921	2.918	2.911	2.904	2.892	2.878	2.872	2.852	2.853	2.826
EPCSRST_N_5	B37	2.922	2.922	2.913	2.913	2.894	2.894	2.876	2.876	2.858	2.858
MONITOR	K23	2.921	2.921	2.912	2.912	2.895	2.895	2.877	2.878	2.859	2.861
PLL_MON	L20	2.923	2.923	2.916	2.915	2.901	2.900	2.886	2.885	2.873	2.872
TOGGLE_MON	L22	2.923	2.923	2.915	2.915	2.900	2.900	2.885	2.885	2.871	2.870

Table. 27. LVTTL VOH – DUT 09371

		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	2.920	2.921	2.911	2.912	2.892	2.893	2.873	2.874	2.854	2.855
EPCSRST_N_0	B31	2.920	2.921	2.911	2.911	2.892	2.891	2.872	2.871	2.852	2.851
EPCSRST_N_1	B32	2.922	2.922	2.913	2.913	2.895	2.896	2.877	2.878	2.859	2.860
EPCSRST_N_2	B34	2.921	2.922	2.912	2.913	2.893	2.894	2.874	2.875	2.856	2.857
EPCSRST_N_3	B35	2.922	2.920	2.913	2.908	2.896	2.885	2.879	2.862	2.861	2.839
EPCSRST_N_4	B36	2.921	2.917	2.911	2.903	2.892	2.874	2.872	2.846	2.853	2.818
EPCSRST_N_5	B37	2.922	2.922	2.913	2.913	2.894	2.895	2.876	2.877	2.858	2.859
MONITOR	K23	2.920	2.920	2.911	2.911	2.893	2.894	2.876	2.877	2.858	2.859
PLL_MON	L20	2.921	2.921	2.914	2.914	2.899	2.899	2.885	2.885	2.871	2.871
TOGGLE_MON	L22	2.921	2.922	2.914	2.914	2.899	2.899	2.884	2.883	2.868	2.868

Table. 28. LVTTL VOL – DUT 09297

		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	211.5	211.2	220.9	220.3	239.1	238.6	257.6	257.2	277.0	276.8
EPCSRST_N_0	B31	211.1	210.6	220.4	220.0	239.3	238.8	258.6	258.1	278.4	277.8
EPCSRST_N_1	B32	210.7	210.1	219.0	218.2	236.2	235.2	253.4	252.4	271.4	269.9
EPCSRST_N_2	B34	212.0	211.8	221.2	219.9	238.6	238.1	256.7	256.1	275.5	274.5
EPCSRST_N_3	B35	211.1	213.1	219.8	223.1	235.7	244.3	252.4	265.7	269.7	287.2
EPCSRST_N_4	B36	213.0	215.4	223.1	228.3	242.3	253.9	261.8	279.6	282.1	305.7
EPCSRST_N_5	B37	212.2	211.4	220.8	220.0	238.4	237.8	256.2	255.7	274.6	273.9
MONITOR	K23	211.3	210.6	220.1	218.8	237.1	236.0	254.5	253.3	272.4	270.8
PLL_MON	L20	209.5	209.4	218.3	217.9	230.9	230.7	245.2	245.3	260.4	260.6
TOGGLE_MON	L22	209.9	209.4	217.2	216.7	231.5	231.5	246.6	246.7	261.5	261.8

Table. 29. LVTTL VOL – DUT 09318

		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	213.6	212.8	223.6	222.1	241.8	240.7	260.9	259.6	280.9	279.1
EPCSRST_N_0	B31	213.0	212.3	222.3	221.5	241.1	240.2	260.0	259.2	279.9	278.9
EPCSRST_N_1	B32	212.4	211.6	221.0	220.2	237.9	237.1	255.8	254.5	274.1	272.3
EPCSRST_N_2	B34	214.1	213.3	223.3	222.2	241.6	240.8	260.4	259.3	279.6	278.3
EPCSRST_N_3	B35	213.7	214.6	221.7	224.4	237.4	244.0	253.8	264.2	270.6	284.4
EPCSRST_N_4	B36	214.7	216.7	224.1	228.6	242.4	252.5	261.3	276.5	280.6	301.2
EPCSRST_N_5	B37	214.2	213.5	223.3	222.2	240.8	239.8	258.9	257.8	277.5	276.3
MONITOR	K23	213.0	212.0	221.8	220.7	238.9	237.7	256.5	254.9	274.4	272.6
PLL_MON	L20	212.0	211.2	220.1	219.5	232.9	232.5	247.4	246.9	262.5	262.2
TOGGLE_MON	L22	211.6	211.2	218.9	218.2	233.2	232.8	247.8	247.6	263.1	262.7

Table. 30. LVTTL VOL – DUT 09344

		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	212.1	211.2	222.0	220.9	240.3	239.1	259.4	257.8	278.8	276.8
EPCSRST_N_0	B31	212.3	212.0	221.7	221.2	240.3	240.4	259.5	259.6	279.2	279.7
EPCSRST_N_1	B32	211.8	211.5	220.4	220.5	237.8	238.0	255.4	256.0	273.9	274.8
EPCSRST_N_2	B34	213.4	212.7	222.4	222.1	240.1	239.3	258.7	257.8	277.6	276.7
EPCSRST_N_3	B35	212.3	214.0	220.3	224.8	236.3	245.7	253.1	267.2	270.2	289.2
EPCSRST_N_4	B36	214.0	216.9	223.6	229.8	243.0	255.3	262.7	281.0	282.7	307.6
EPCSRST_N_5	B37	213.5	213.0	222.1	221.7	239.7	239.1	257.7	257.0	276.3	275.6
MONITOR	K23	212.5	213.3	221.2	223.1	238.1	242.8	255.4	262.4	273.5	282.7
PLL_MON	L20	210.5	210.2	219.1	219.3	232.0	232.5	246.3	247.0	261.6	262.6
TOGGLE_MON	L22	211.4	211.3	218.9	219.2	233.2	233.8	248.2	249.2	263.3	264.8

Table. 31. LVTTL VOL – DUT 09360

		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	213.0	226.3	221.8	247.9	240.3	270.1	258.9	293.0	278.4
EPCSRST_N_0	B31	212.9	212.5	222.2	221.5	240.9	240.2	260.1	259.3	280.0	279.3
EPCSRST_N_1	B32	211.9	211.3	220.7	219.8	237.7	236.5	254.8	253.6	273.0	271.4
EPCSRST_N_2	B34	214.0	213.5	223.0	221.9	240.6	239.8	259.1	257.8	277.7	276.5
EPCSRST_N_3	B35	213.4	214.9	221.7	224.7	237.8	244.9	254.6	265.6	271.7	286.5
EPCSRST_N_4	B36	214.8	217.0	225.0	229.5	244.3	254.6	264.5	280.0	284.6	306.1
EPCSRST_N_5	B37	213.7	212.8	222.9	221.9	240.3	239.8	258.4	258.0	277.1	276.3
MONITOR	K23	212.9	212.1	221.5	220.1	238.6	237.3	256.2	254.3	274.2	271.9
PLL_MON	L20	211.1	210.5	219.6	219.2	232.6	232.1	246.8	246.5	262.0	262.2
TOGGLE_MON	L22	211.0	210.5	218.6	218.3	233.1	233.1	248.3	248.1	263.3	263.5

Table. 32. LVTTL VOL – DUT 09363

		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	215.2	214.4	224.6	223.5	242.9	242.2	261.7	261.0	281.4	280.6
EPCSRST_N_0	B31	214.6	214.2	224.1	223.9	242.7	243.2	261.7	263.1	281.5	283.5
EPCSRST_N_1	B32	214.4	213.5	222.8	221.9	240.1	238.7	257.6	255.9	275.7	273.6
EPCSRST_N_2	B34	215.7	214.8	225.1	224.0	243.4	242.0	262.4	260.4	281.8	279.3
EPCSRST_N_3	B35	214.3	216.5	223.1	227.6	239.0	248.9	255.5	270.6	272.4	292.9
EPCSRST_N_4	B36	216.5	219.2	226.1	231.9	244.6	257.4	263.8	283.6	283.5	310.1
EPCSRST_N_5	B37	215.5	214.7	224.5	223.9	242.1	241.3	259.9	258.9	278.6	277.5
MONITOR	K23	214.9	214.2	223.2	222.3	240.5	239.0	258.0	256.0	276.1	273.8
PLL_MON	L20	212.7	212.2	221.4	221.0	234.2	233.4	248.5	248.1	263.8	263.7
TOGGLE_MON	L22	212.8	212.4	220.3	220.2	234.5	234.6	249.3	249.3	264.3	264.7

Table. 33. LVTTL VOL – DUT 09371

		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	216.3	215.0	225.3	223.7	243.5	241.9	262.1	260.7	281.8	280.1
EPCSRST_N_0	B31	215.9	214.7	225.3	224.4	244.2	243.8	263.5	263.5	283.8	283.9
EPCSRST_N_1	B32	215.2	214.2	224.2	222.8	241.3	239.6	259.2	257.2	277.8	275.5
EPCSRST_N_2	B34	216.5	214.9	225.5	224.2	243.5	241.9	261.9	259.7	280.6	278.7
EPCSRST_N_3	B35	215.9	217.2	224.1	228.5	241.1	250.8	258.1	273.8	275.9	297.2
EPCSRST_N_4	B36	217.1	220.1	226.5	234.3	245.0	261.6	264.2	289.4	284.1	317.9
EPCSRST_N_5	B37	216.5	215.1	225.1	223.9	242.6	241.2	260.5	259.3	279.2	277.8
MONITOR	K23	216.2	214.9	224.7	223.4	242.2	240.3	259.4	257.3	277.5	275.2
PLL_MON	L20	214.7	213.3	223.3	222.4	236.0	234.9	250.6	249.2	265.7	264.9
TOGGLE_MON	L22	214.3	213.4	221.8	221.1	236.3	235.8	251.6	250.8	266.8	266.3

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 (%)
09297	125 krad	0.448	0.447	-0.22
09318	125 krad	0.459	0.457	-0.44
09344	125 krad	0.45	0.45	0.00
09360	125 krad	0.451	0.45	-0.22
09363	125 krad	0.457	0.459	0.44
09371	125 krad	0.466	0.469	0.64

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.

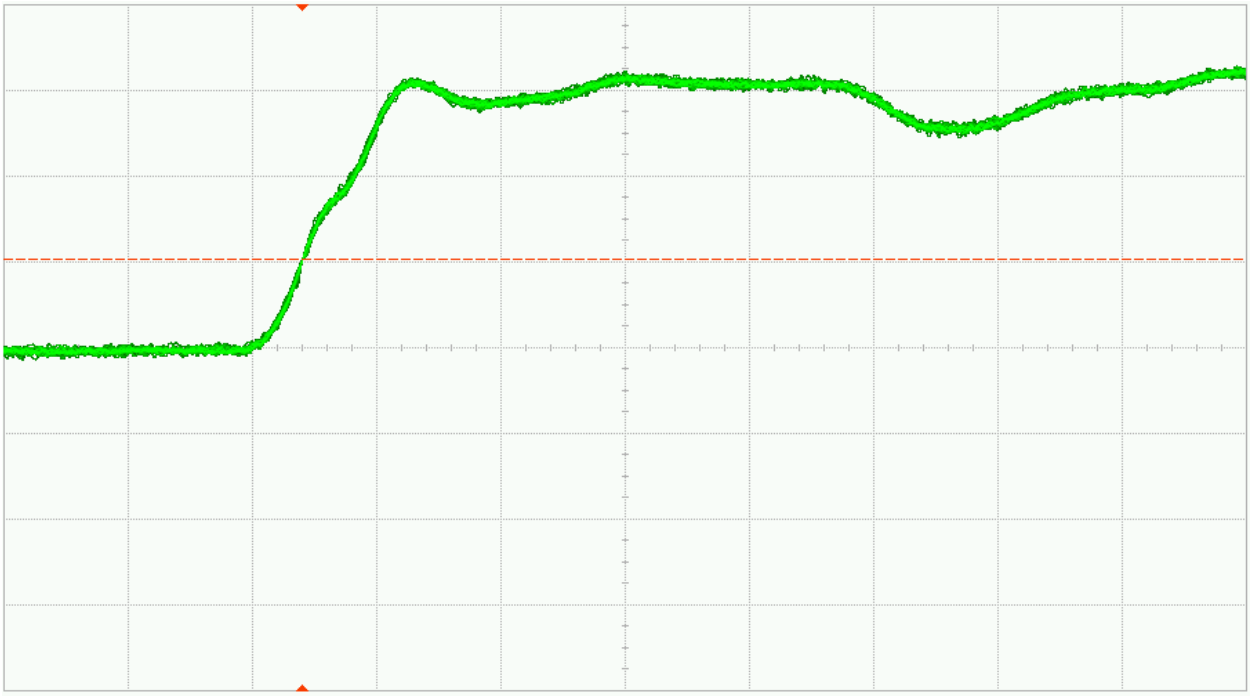

Fig. 26 (a). DUT 09297 pre-irradiation rising edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

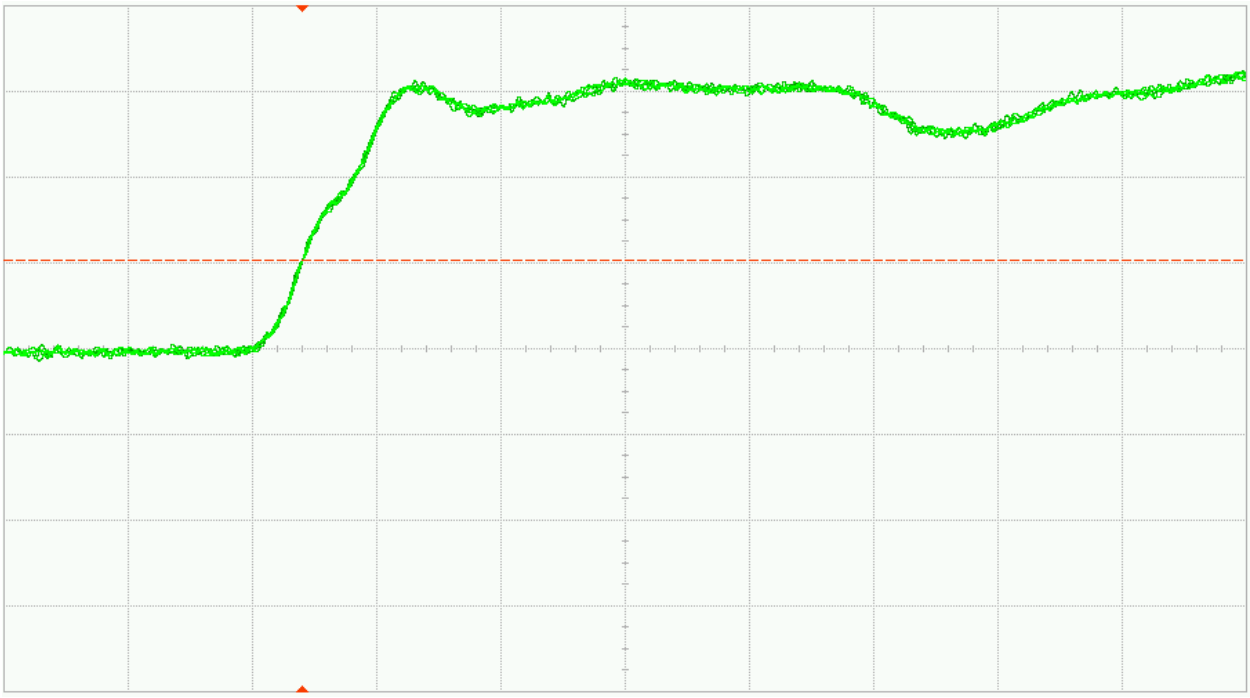

Fig. 26 (b). DUT 09297 post-annealing rising edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

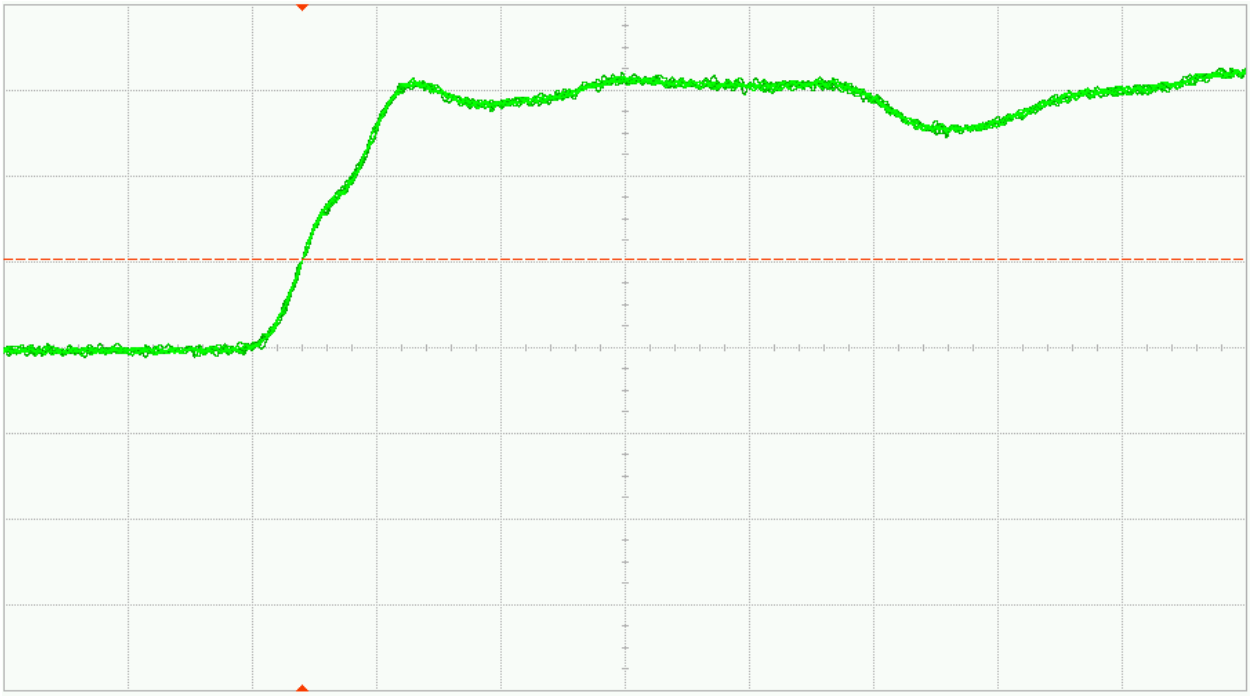

Fig. 27 (a). DUT 09318 pre-irradiation rising edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

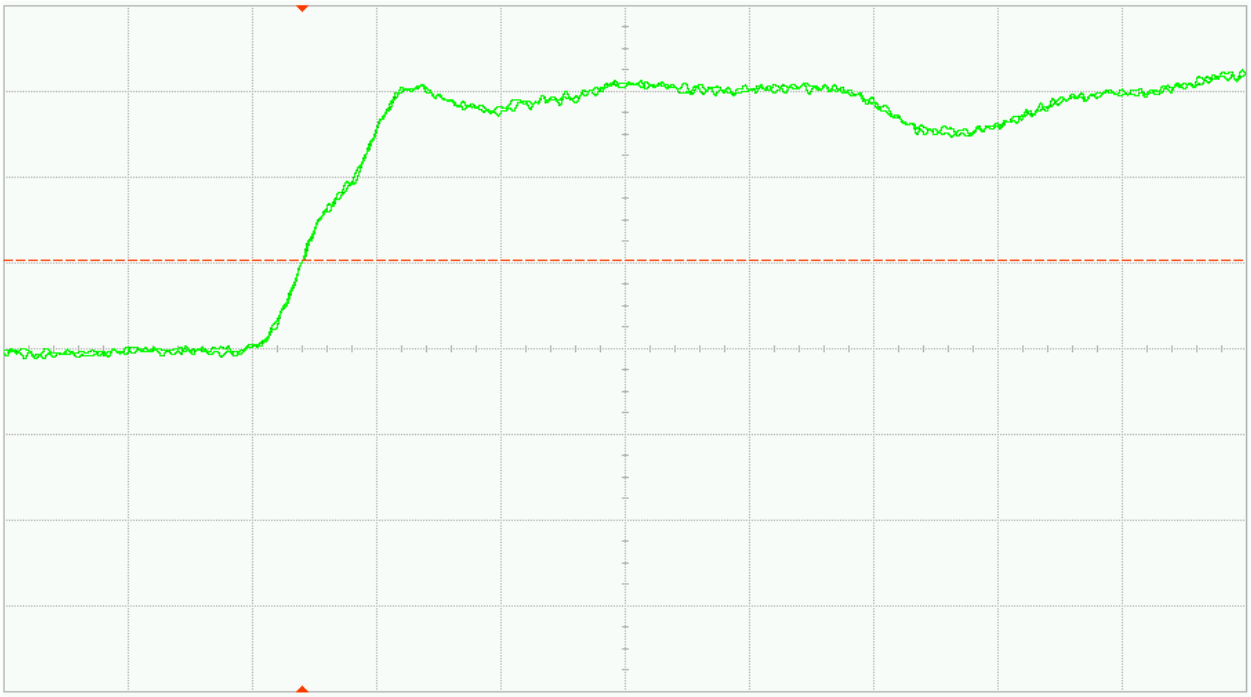

Fig. 27 (b). DUT 09318 post-annealing rising edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

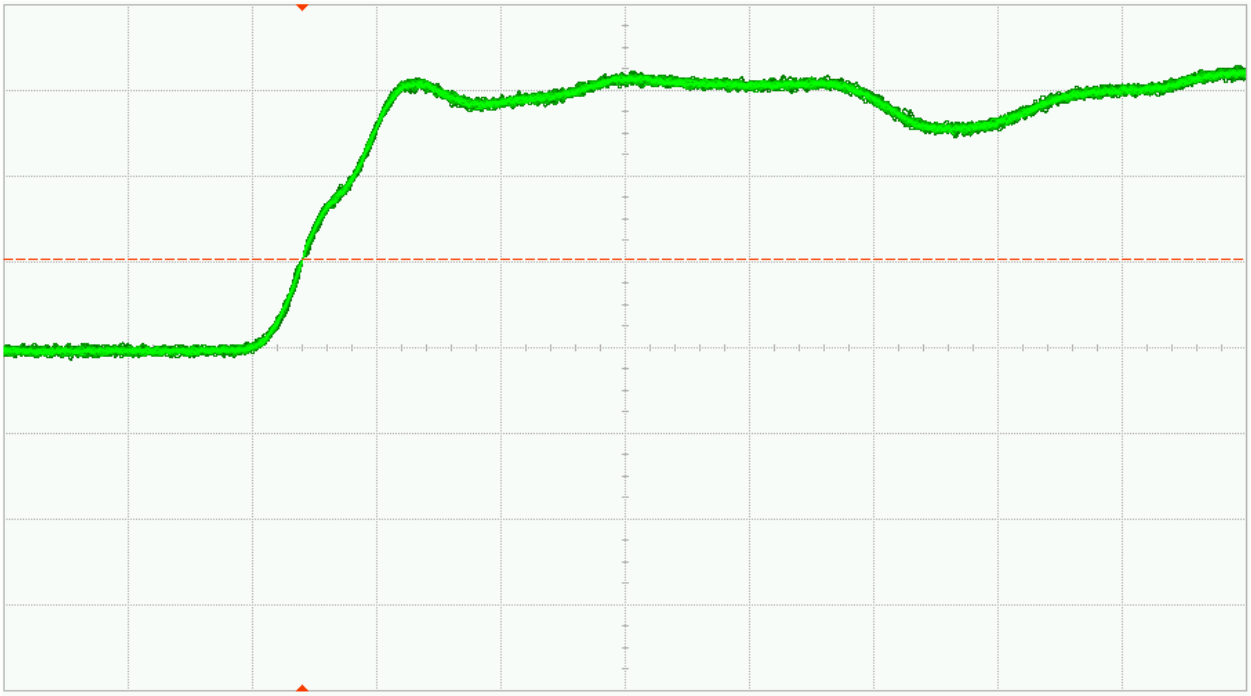

Fig. 28 (a). DUT 09344 pre-irradiation rising edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

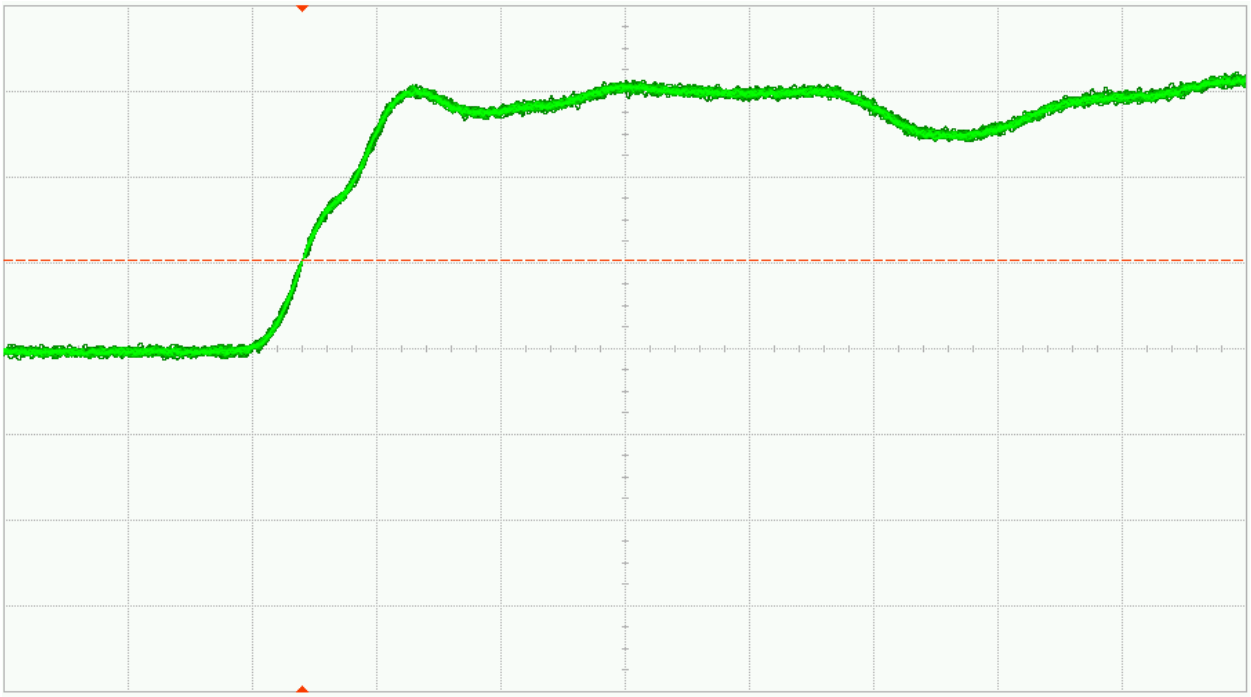

Fig. 28 (b). DUT 09344 post-annealing rising edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

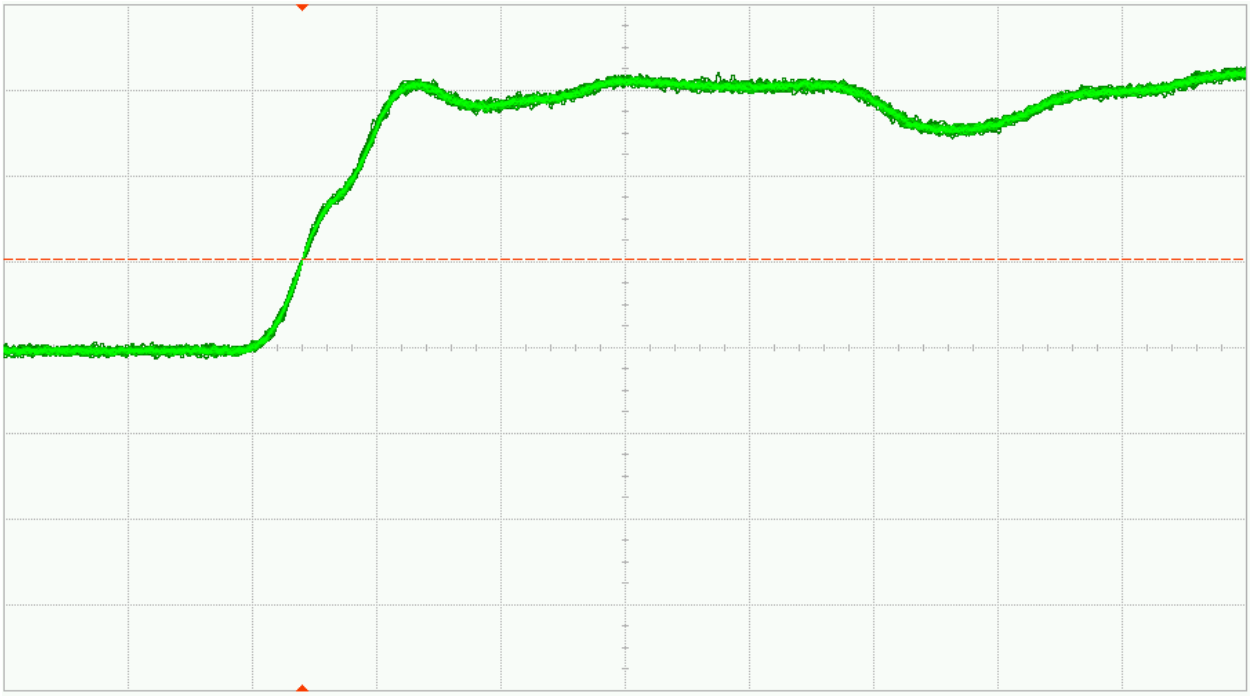

Fig. 29 (a). DUT 09360 pre-irradiation rising edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

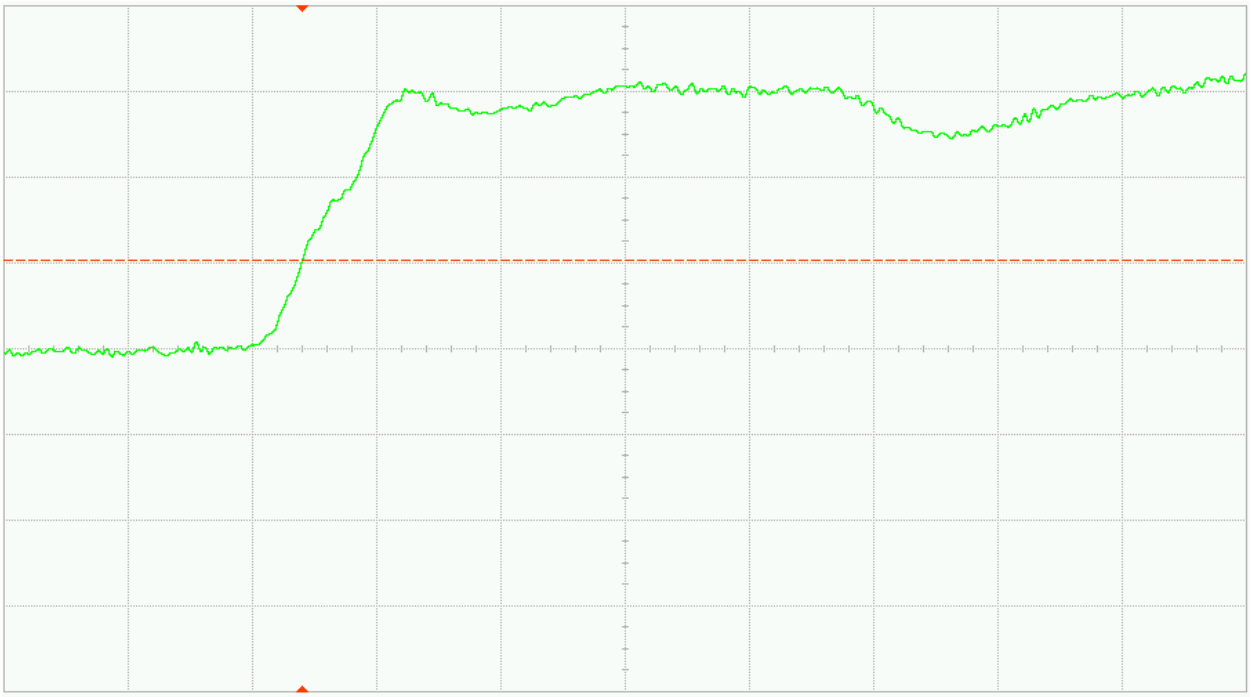

Fig. 29 (b). DUT 09360 post-annealing rising edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

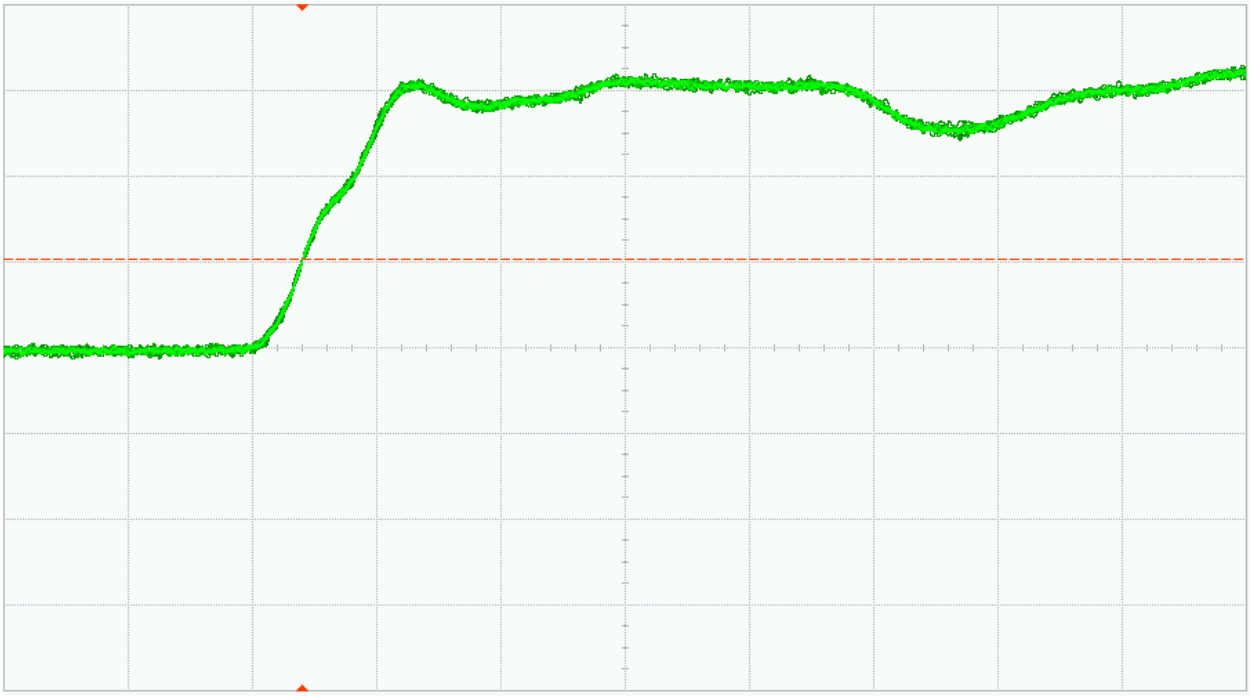

Fig. 30 (a). DUT 09363 pre-irradiation rising edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

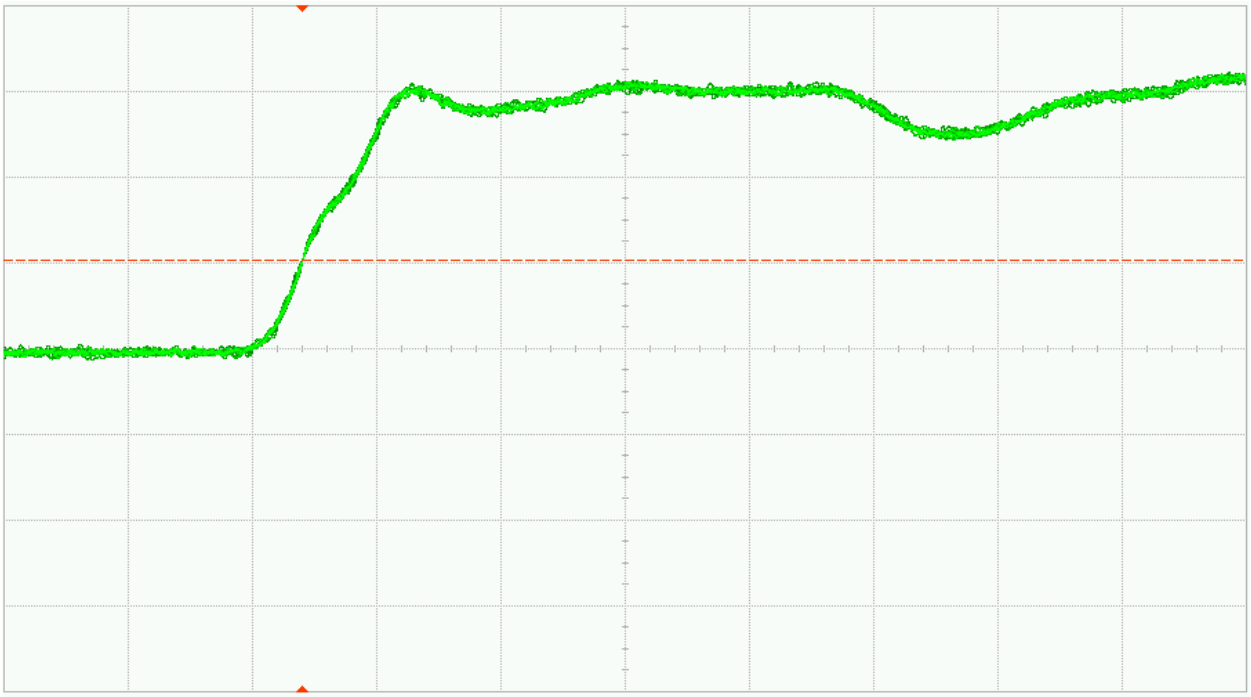

Fig. 30 (b). DUT 09363 post-annealing rising edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

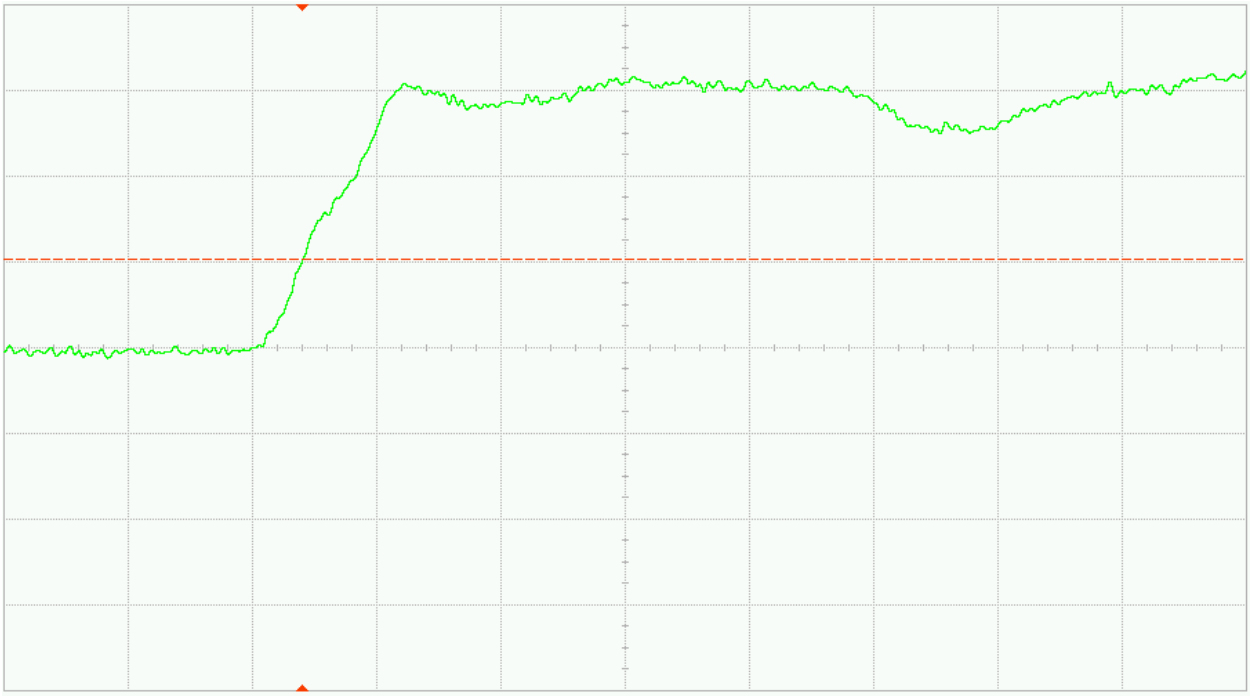

Fig. 31 (a). DUT 09371 pre-irradiation rising edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

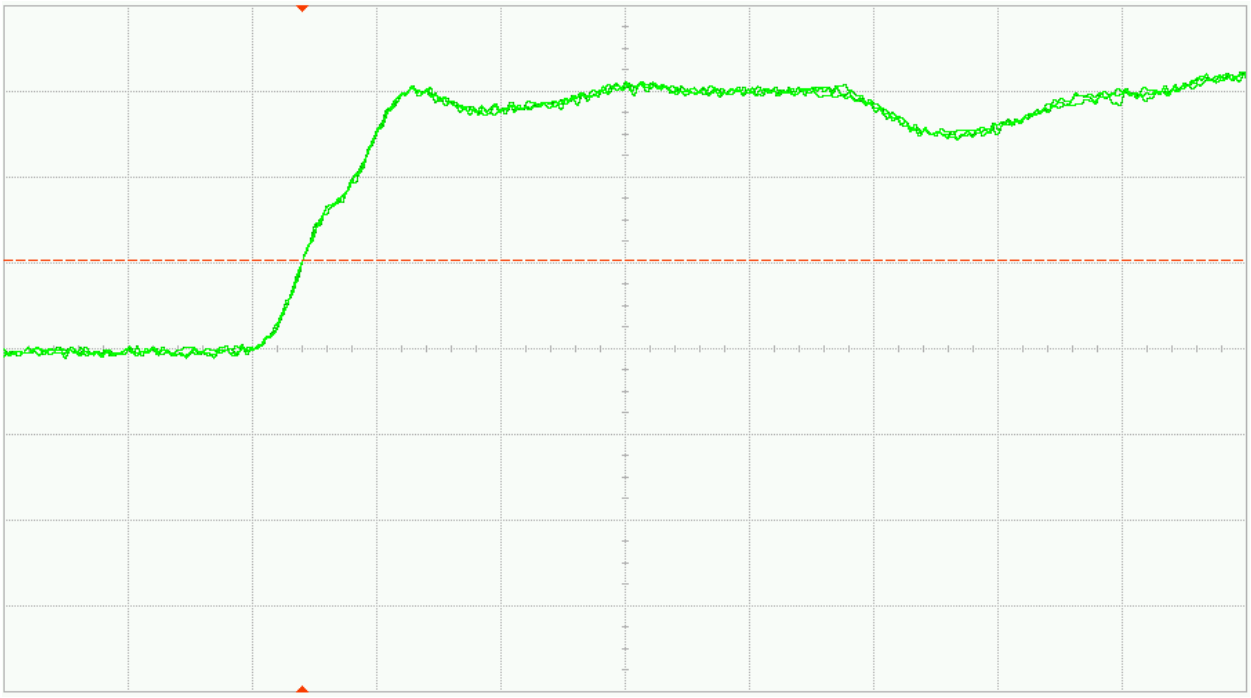

Fig. 31 (b). DUT 09371 post-annealing rising edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

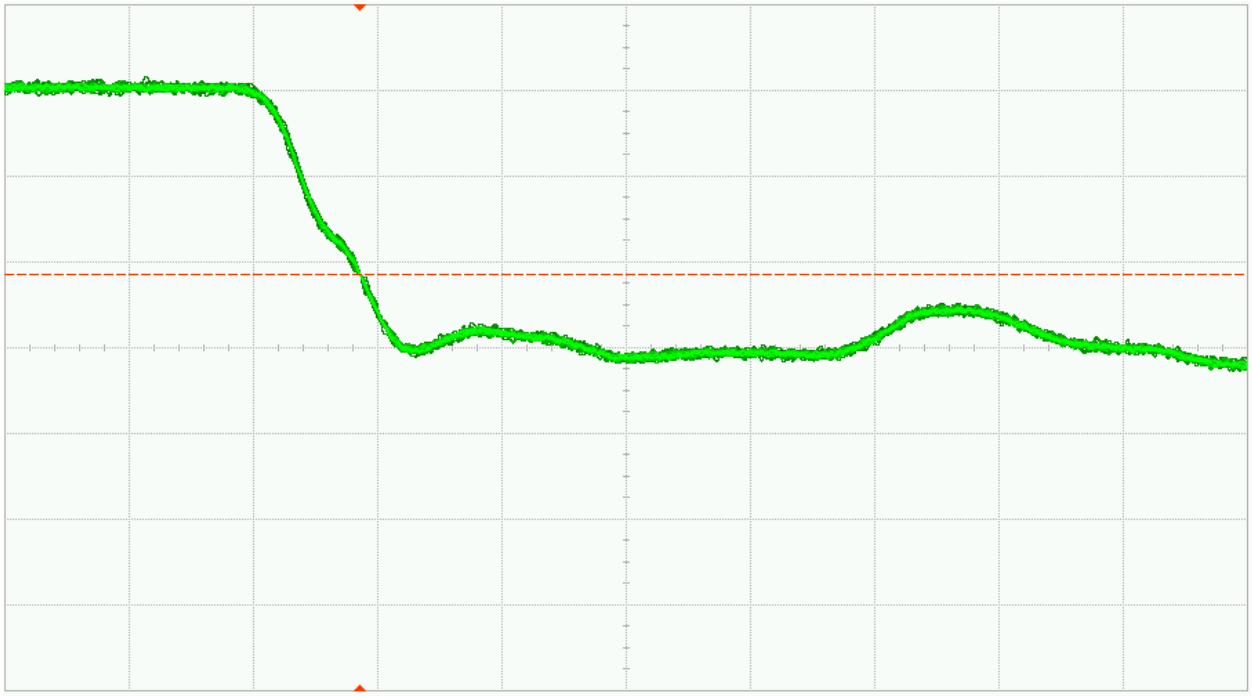

Fig. 32 (a). DUT 09297 pre-irradiation falling edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

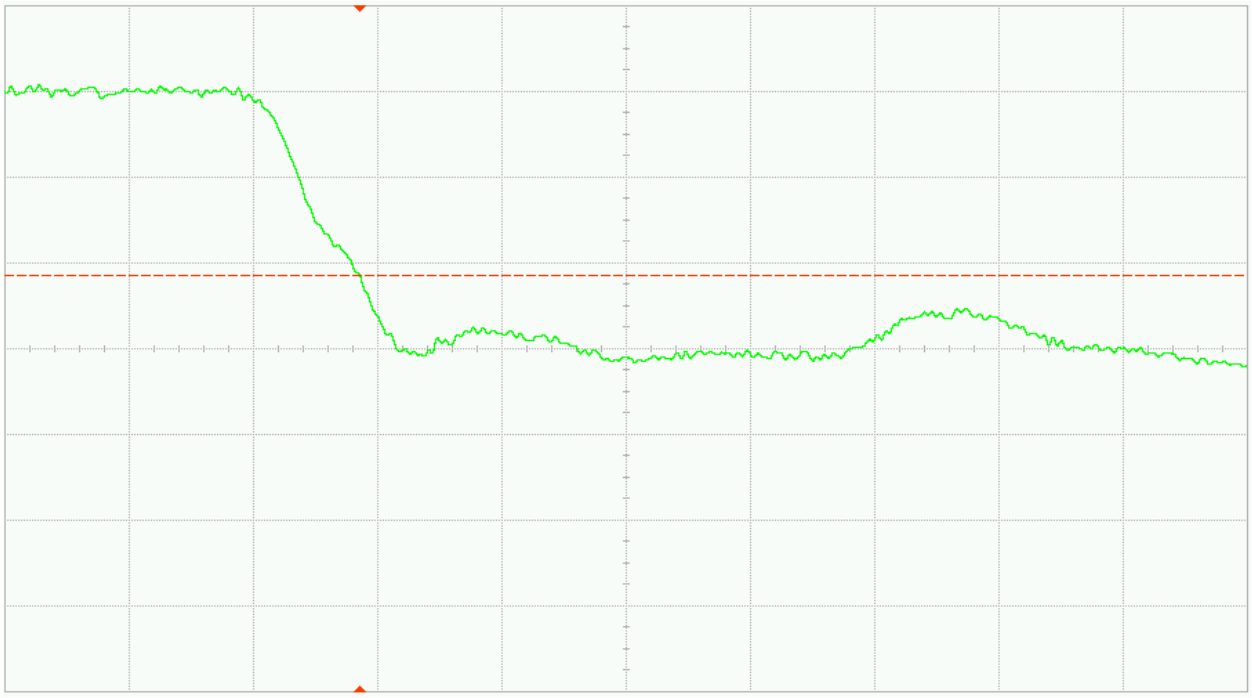

Fig. 32 (b). DUT 09297 post-annealing falling edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

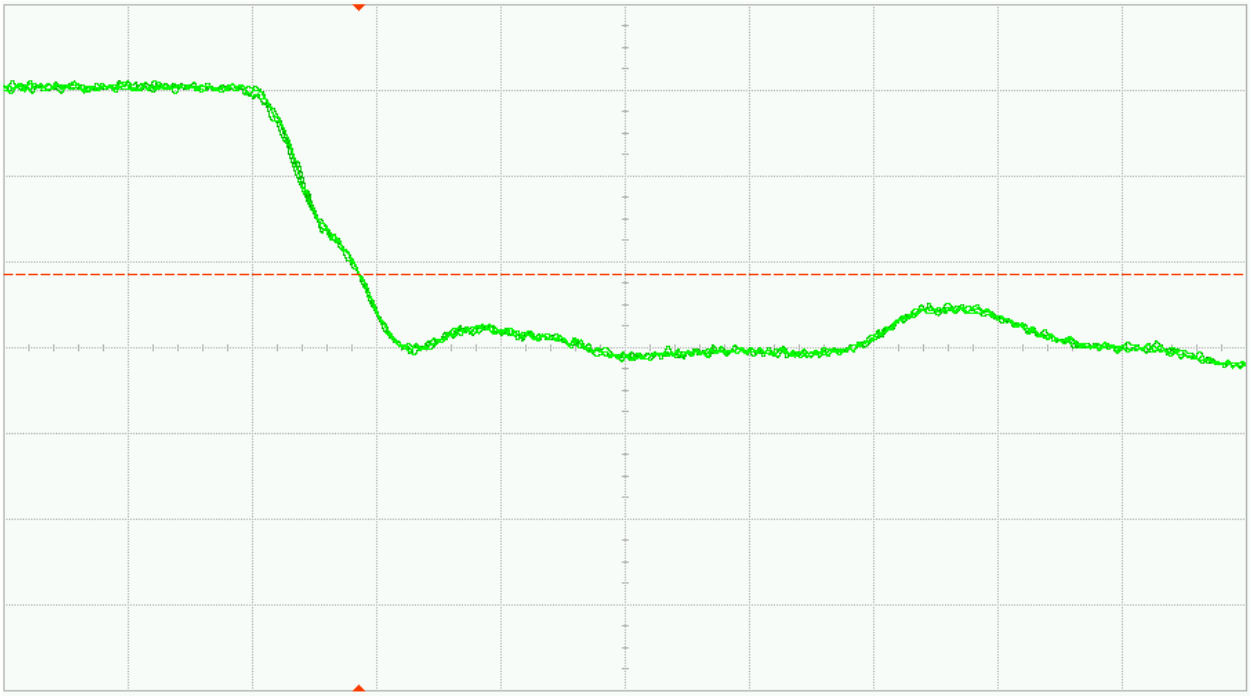

Fig. 33 (a). DUT 09318 pre-irradiation falling edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

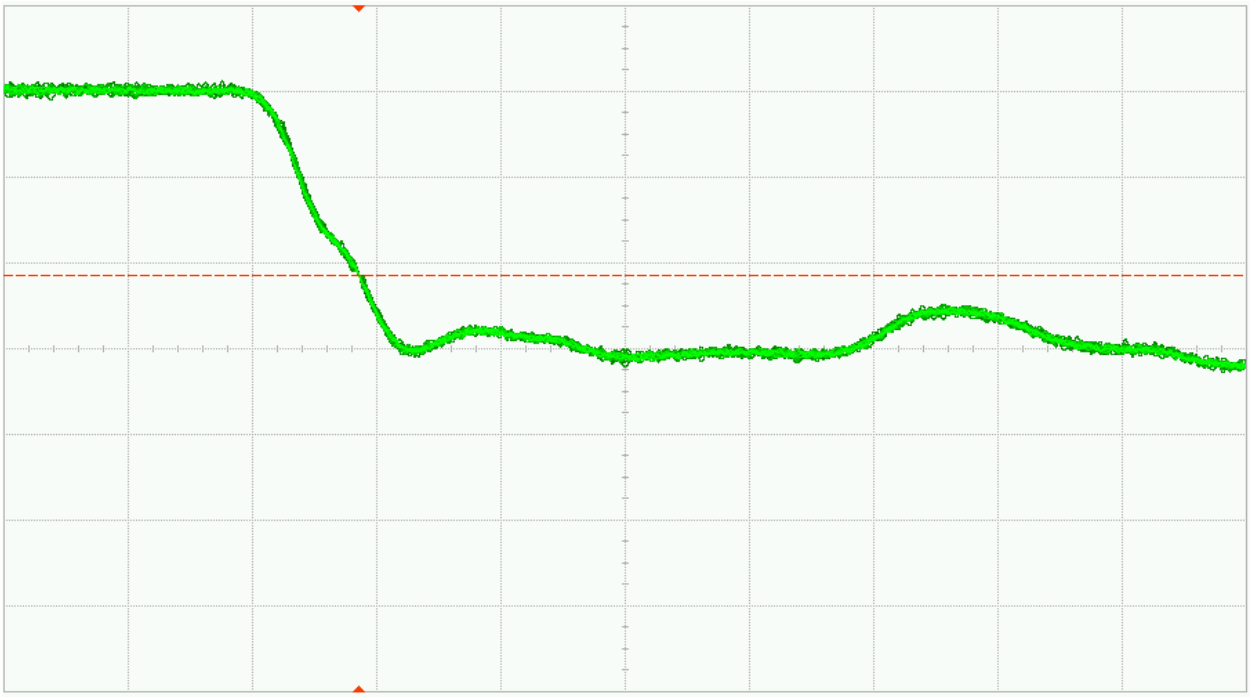

Fig. 33 (b). DUT 09318 post-annealing falling edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

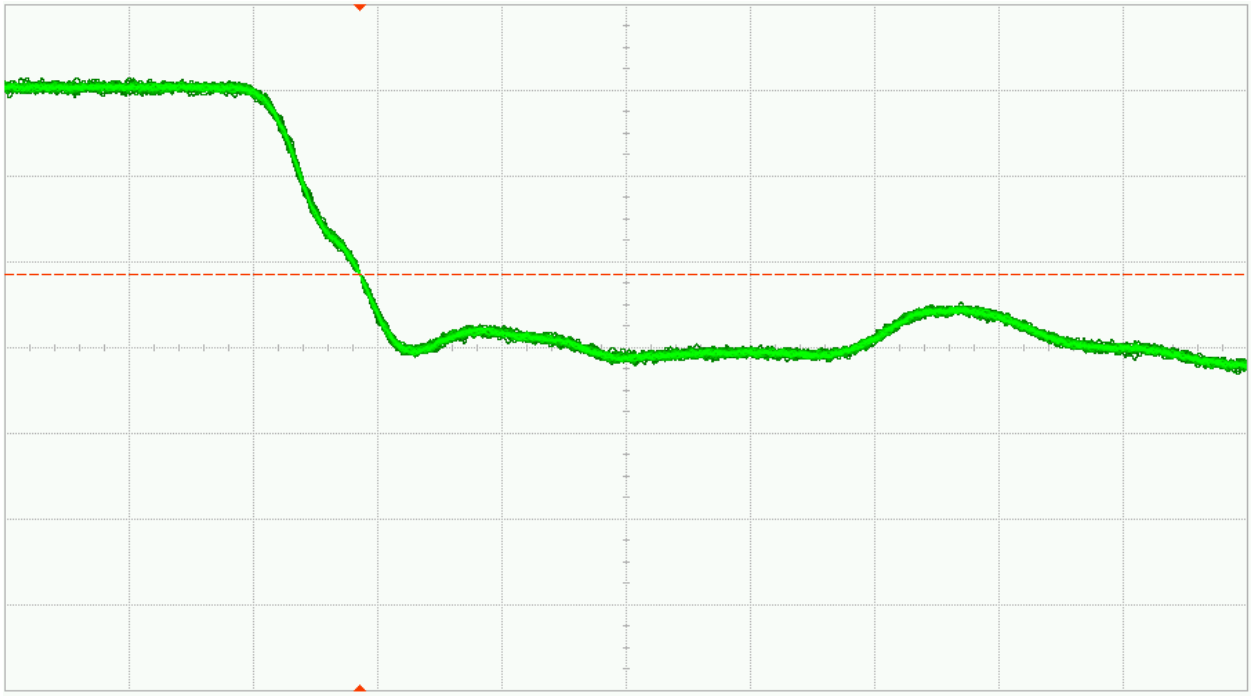

Fig. 34 (a). DUT 09344 pre-irradiation falling edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

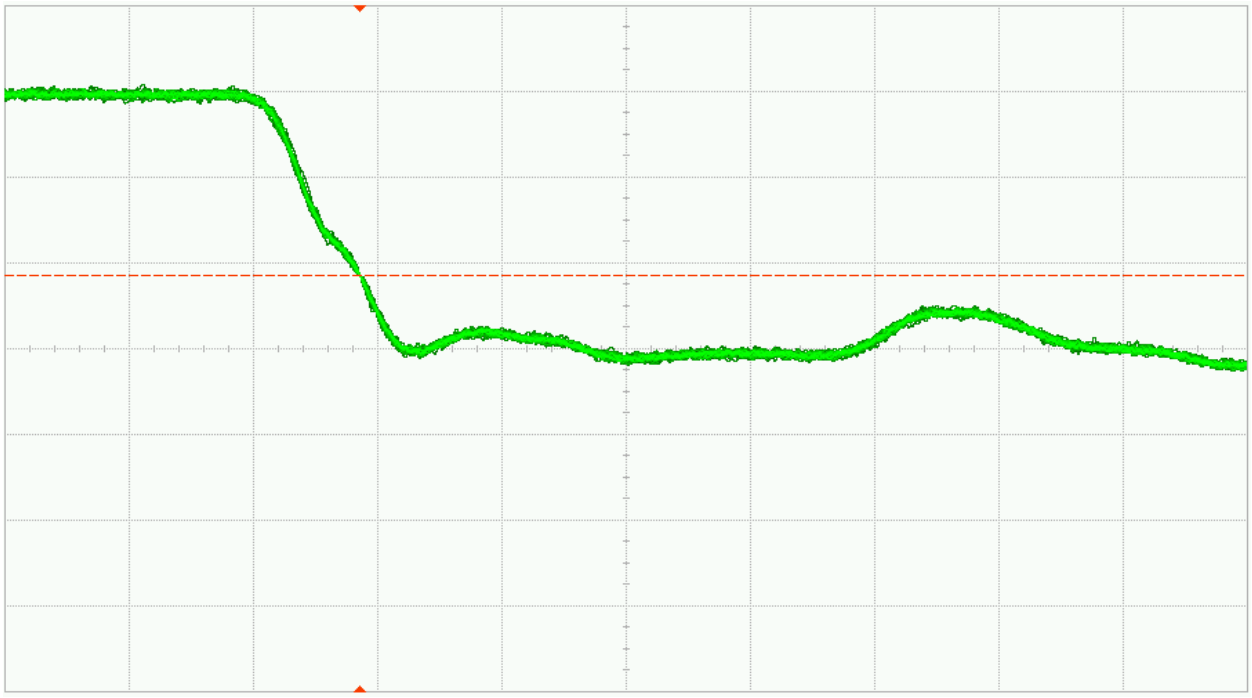

Fig. 34 (b). DUT 09344 post-annealing falling edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

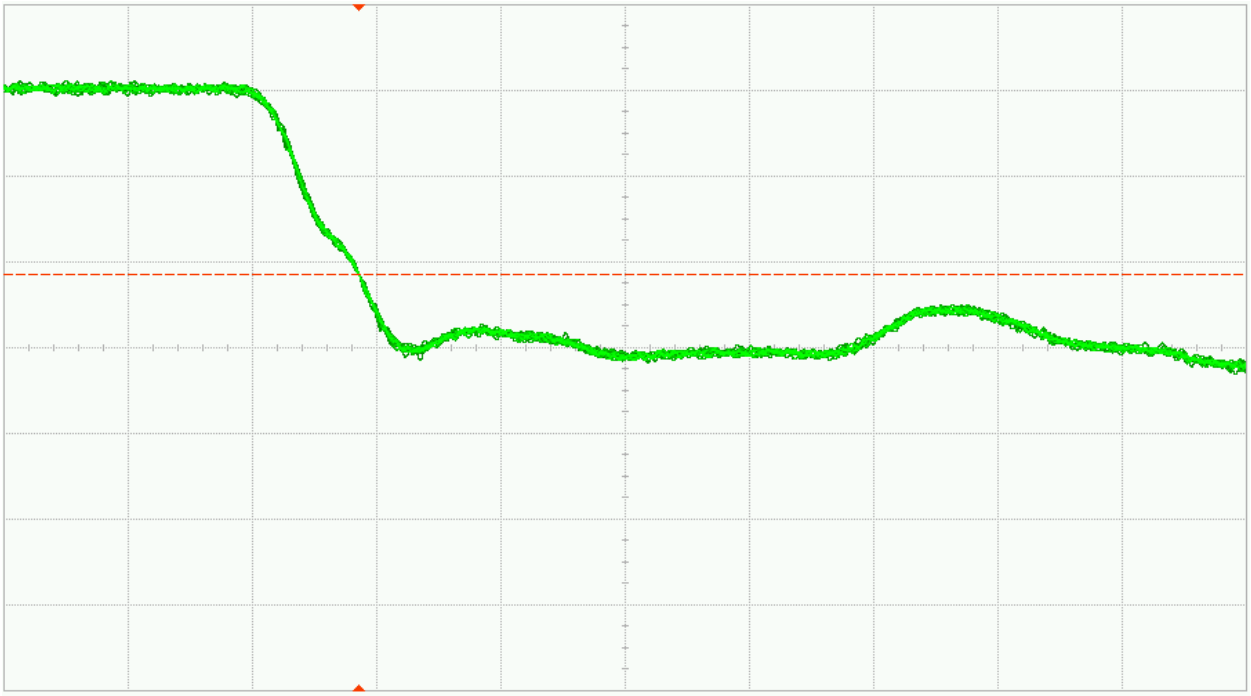

Fig. 35 (a). DUT 09360 pre-irradiation falling edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

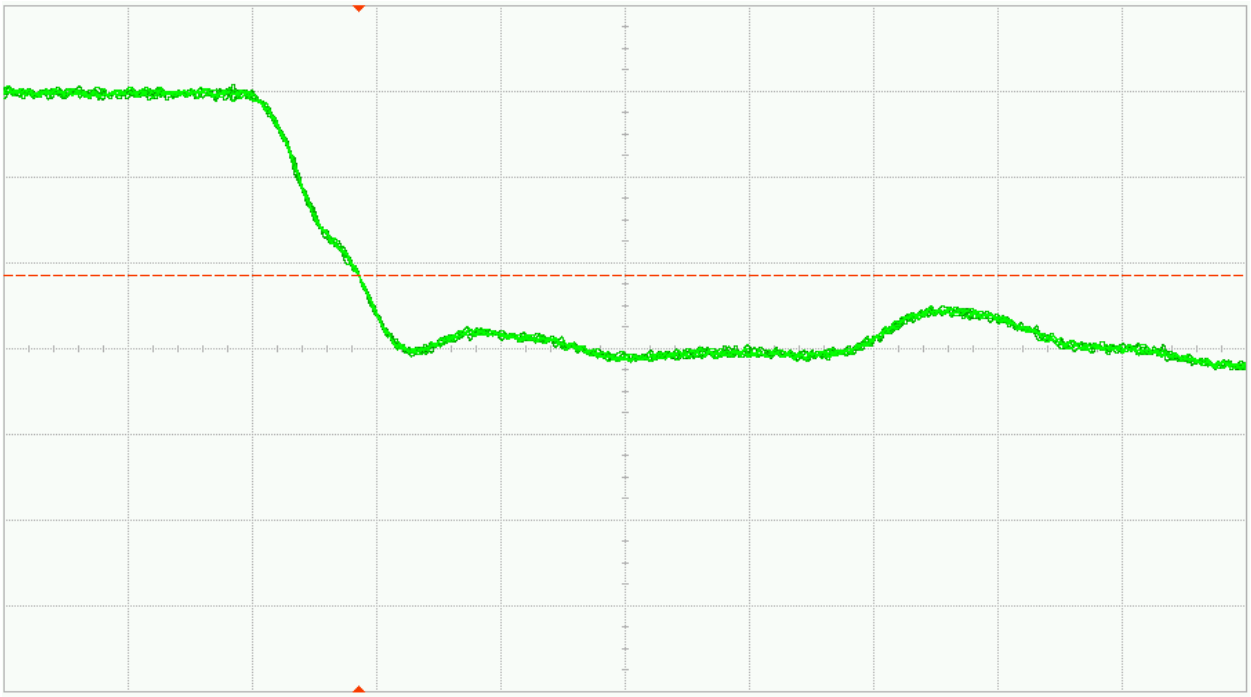

Fig. 35 (b). DUT 09360 post-annealing falling edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

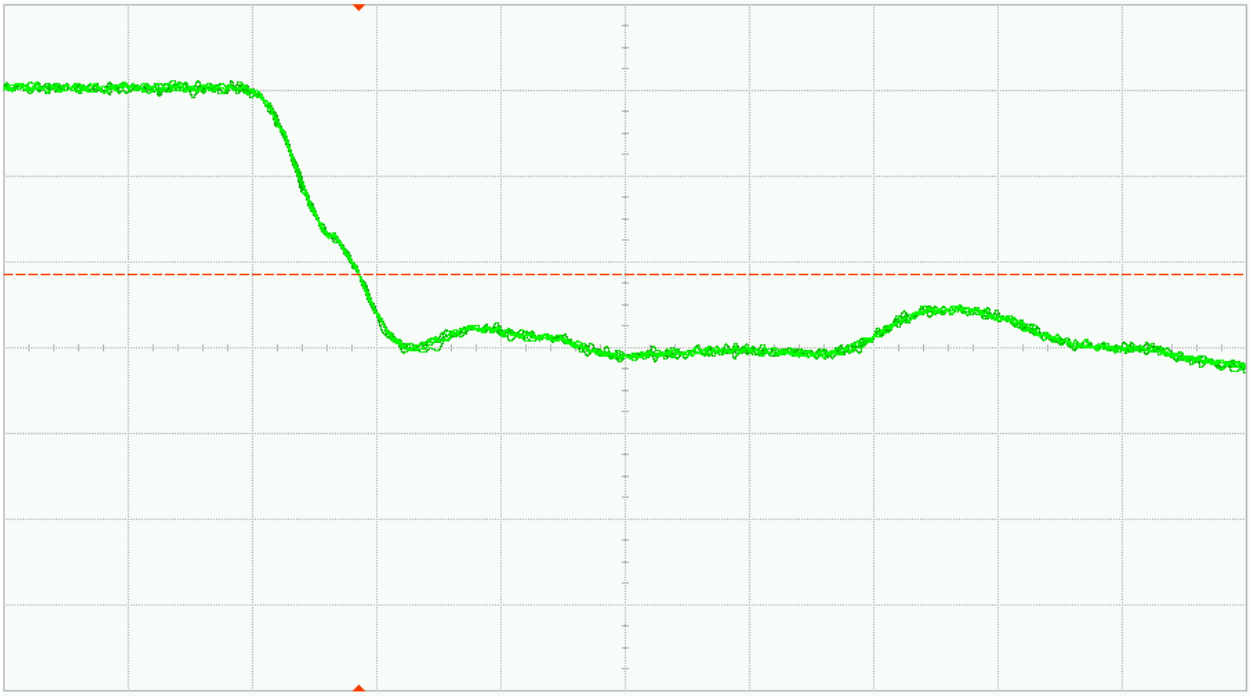

Fig. 36 (a). DUT 09363 pre-irradiation falling edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

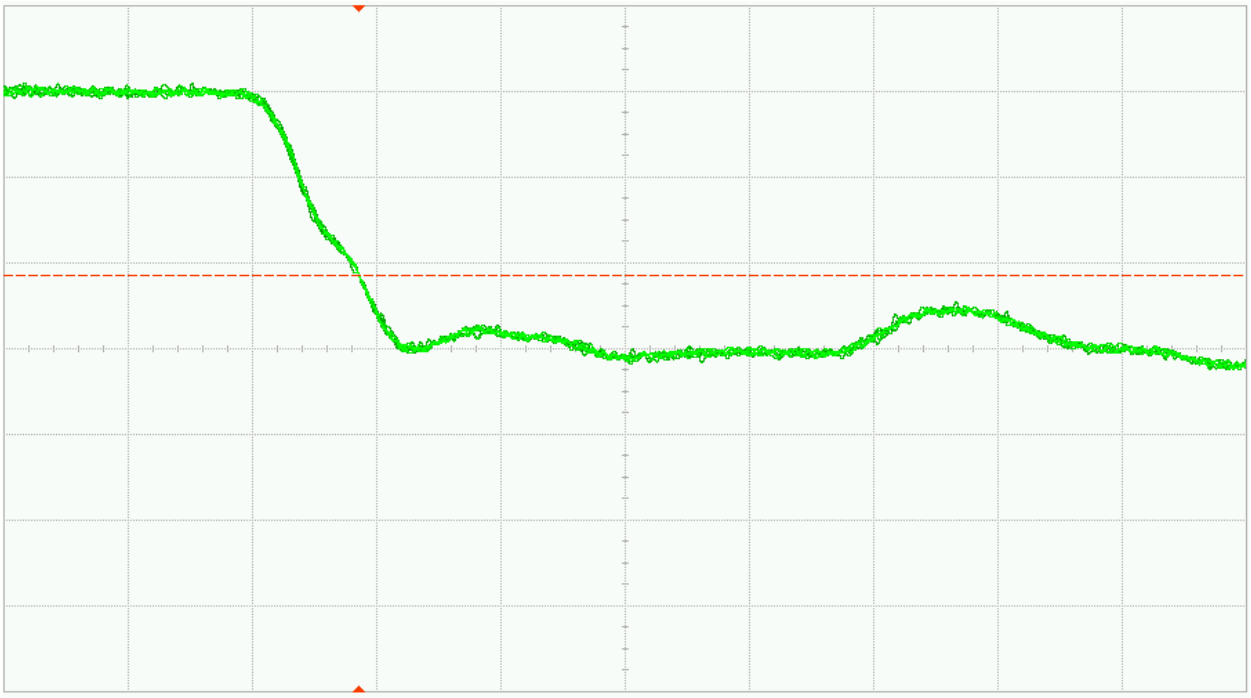

Fig. 36 (b). DUT 09363 post-annealing falling edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

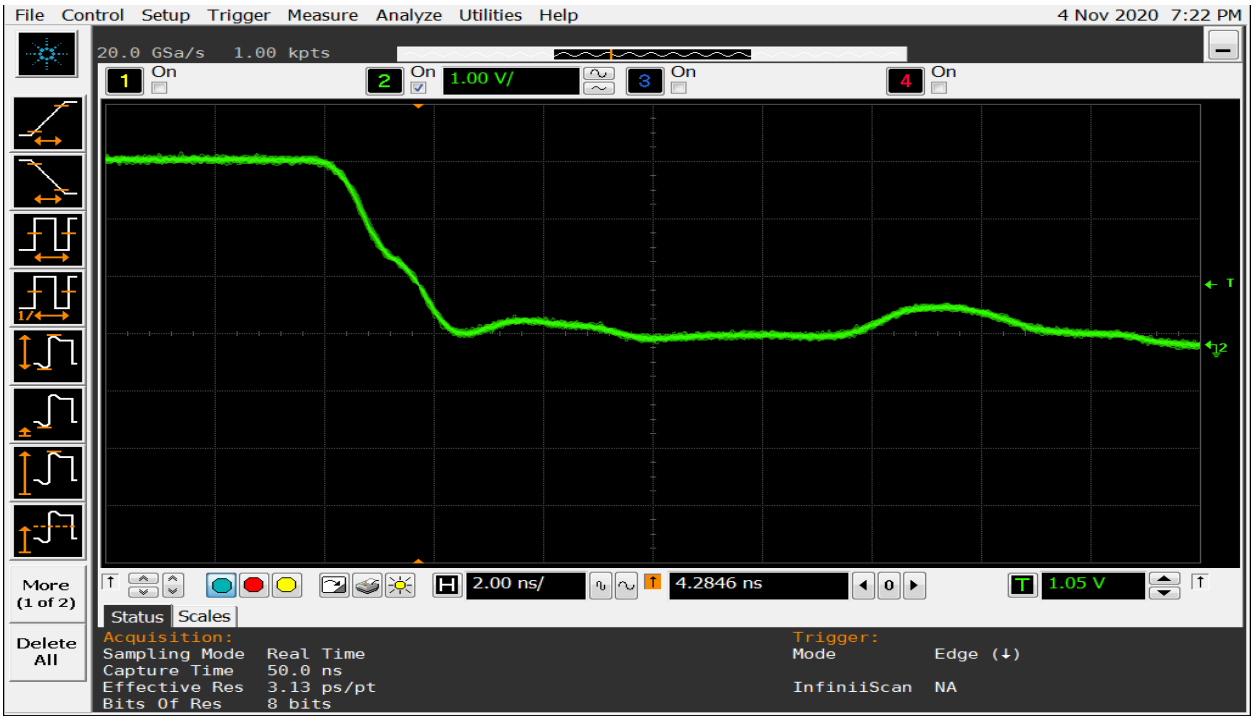

Fig. 37 (a). DUT 09371 pre-irradiation falling edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

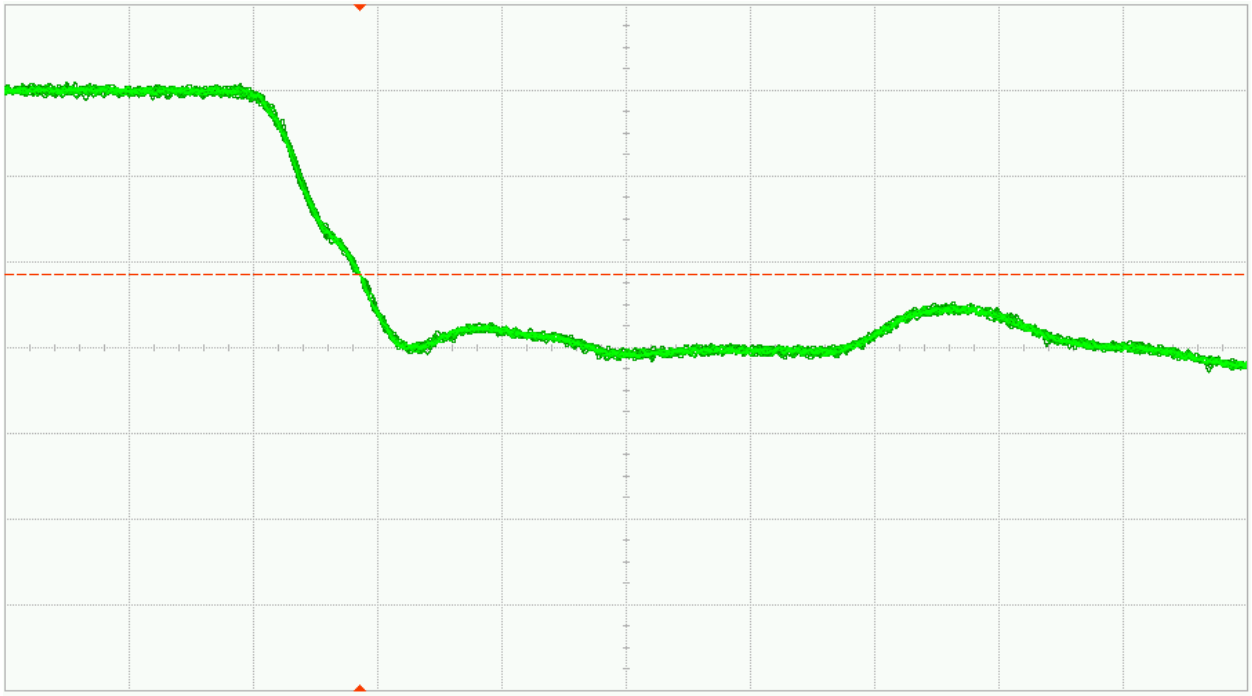

Fig. 37 (b). DUT 09371 post-annealing falling edge, abscissa scale is 1V/div and ordinate scale is 2ns/div

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

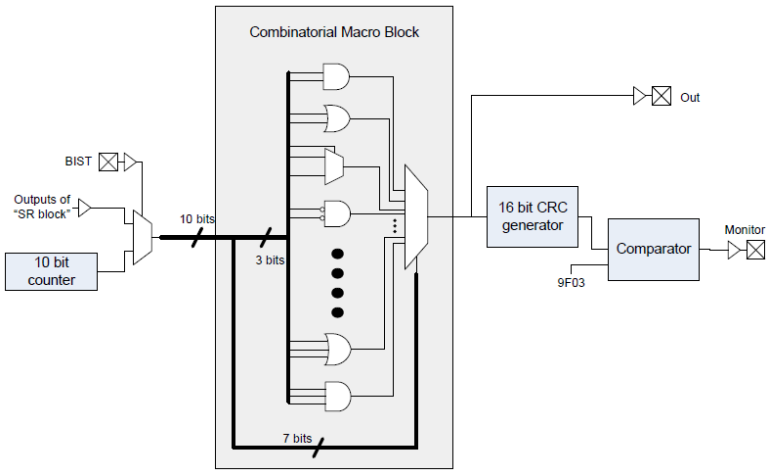

Fig. 38. Combo Block

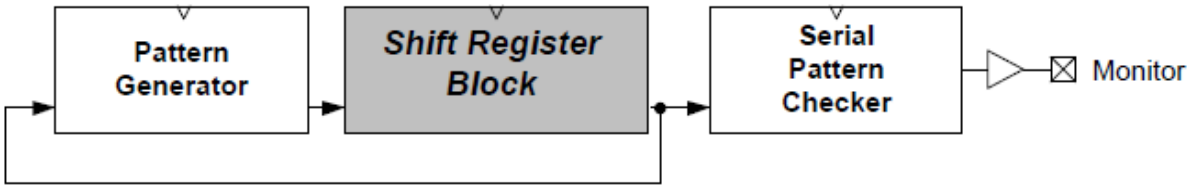

Fig. 39. Shift Register Block

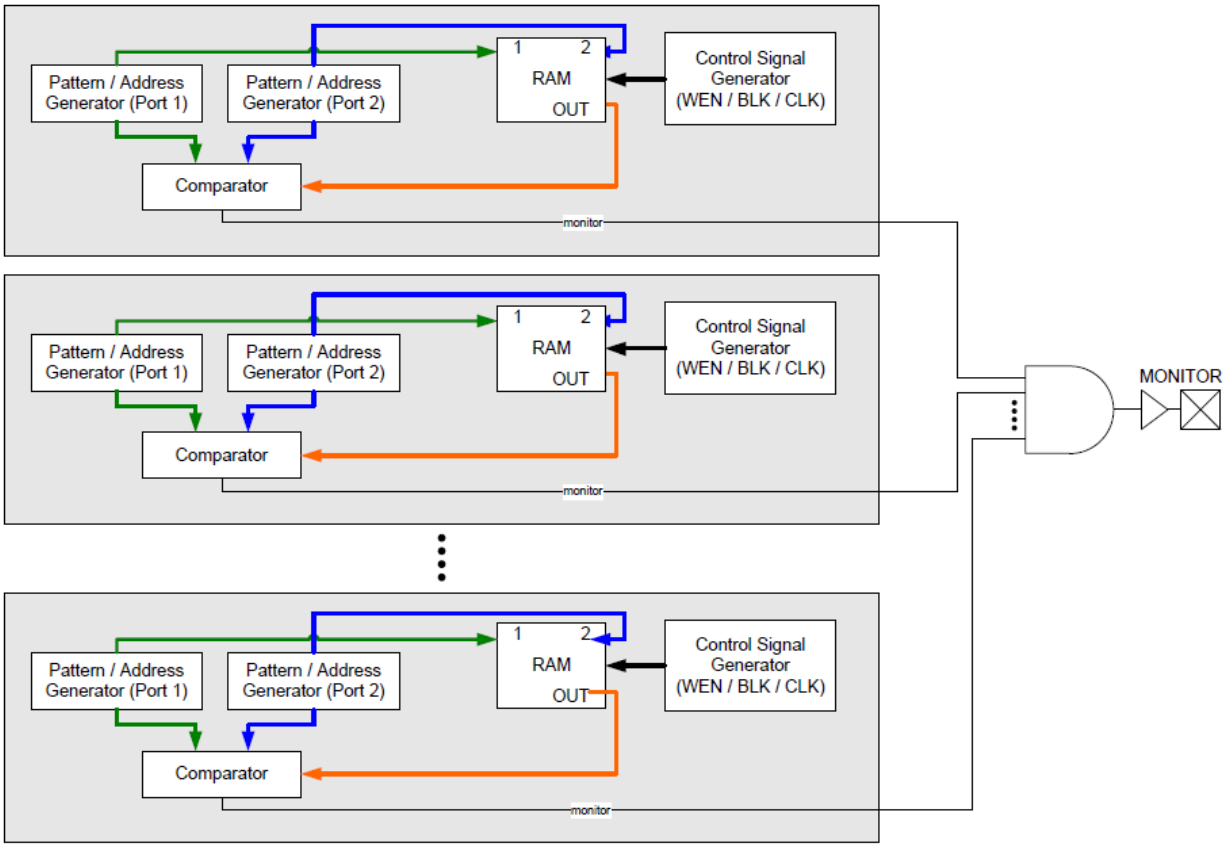

Fig. 40. Embedded Ram Blocks

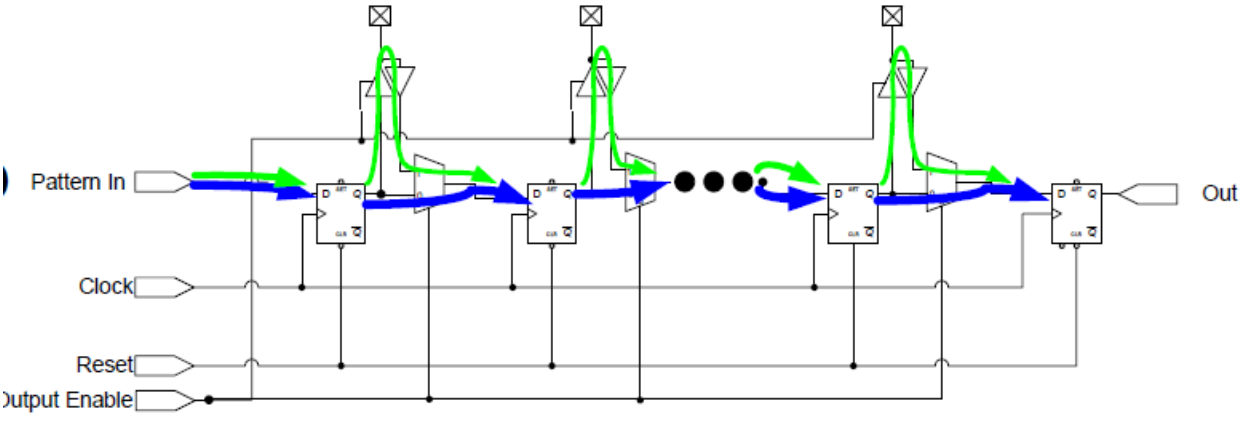

Fig. 41. IO Block

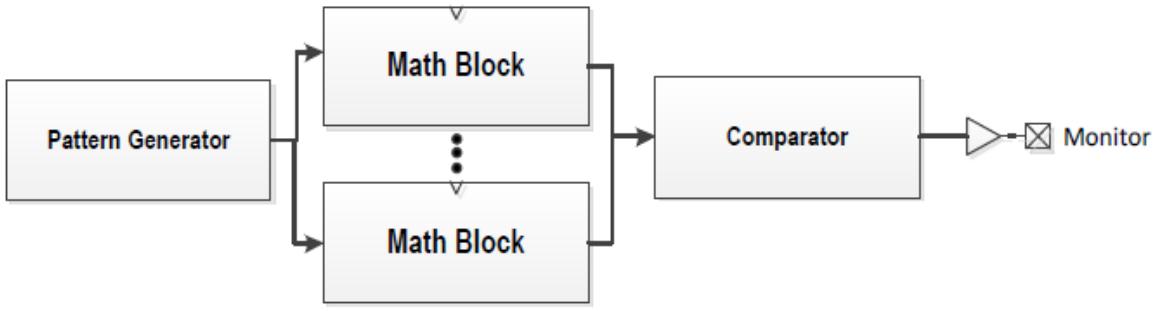

Fig. 42. Math Block

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