



# Total Ionizing Dose Test Report

**No. 11T-RT3PE3000L-CG484-QJA2G**

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February 2011

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## TOTAL IONIZING DOSE TEST REPORT

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### I. Summary Table

Parameter	Tolerance
1. Gross Functionality	Passed 30 krads ( $\text{SiO}_2$ )
2. Power Supply Current ( $I_{CCA}/I_{CCI}$ )	Passed 50 krads ( $\text{SiO}_2$ )
3. Input Threshold (VTIL/VIH)	Passed 50 krads ( $\text{SiO}_2$ )
4. Output Drive (VOL/VOH)	Passed 50 krads ( $\text{SiO}_2$ )
5. Propagation Delay	Passed 25 krads ( $\text{SiO}_2$ ) per 10%-degradation criterion
6. Transition Time	Passed 50 krads ( $\text{SiO}_2$ )

### II. Total Ionizing Dose (TID) Testing

This testing for the flash-based FPGA is developed on the base of an extensive database from the TID testing of many generations of antifuse-based FPGAs. Early TID studies can be found in the public domain; for example, [http://www.klabs.org/index\\_klabs\\_dot\\_org.htm](http://www.klabs.org/index_klabs_dot_org.htm). Other reliability reports are also available on the Microsemi SoC Products Group (formerly Actel) website:

<http://www.actel.com/products/milaero/hireldata.aspx>.

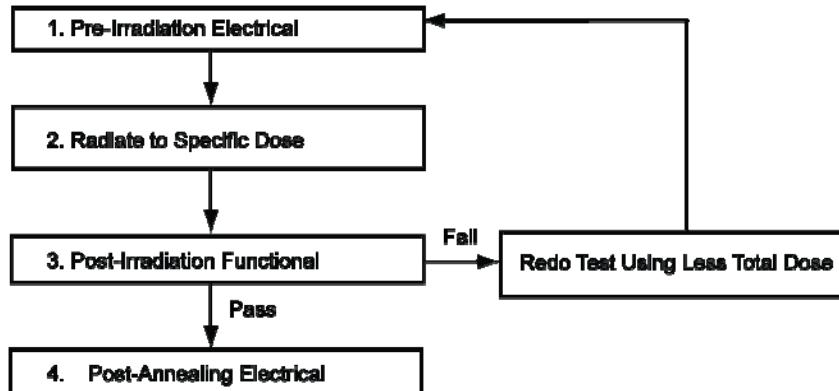
## A. Device-Under-Test (DUT) and Irradiation Parameters

Table 1 lists the DUT and irradiation parameters. During irradiation, each input is grounded through a jumper; during annealing, each input is grounded through a resistor.

**Table 1 DUT and Irradiation Parameters**

<b>Part Number</b>	RT3PE3000L
Package	CCGA-484
Foundry	United Microelectronics Corp.
Technology	0.13 µm CMOS and Embedded Flash
DUT Design	RTA3PE3KL(CG484)_TID
Die Lot Number	QJA2G
Quantity Tested	7
Total Dose: DUT Serial Number	30 krad: 7943, 7973, 7992 50 krad: 7942, 7956, 7972 60 krad: 7926
Radiation Facility	Defense Microelectronics Activity
Radiation Source	Co-60
Dose Rate	5 krad (SiO <sub>2</sub> )/Min. (±5%) or 0.5 krad (SiO <sub>2</sub> )/Min. (±5%)
Irradiation Temperature	Room
Irradiation and Measurement Bias (VCCI/VCCA)	Static at 3.3 V / 1.5 V

## B. Test Method



**Figure 1** Parametric Test Flow Chart

The test method generally follows the guidelines in the military standard TM1019.8. Figure 1 is the flow chart showing the steps for parametric tests, irradiation, and post-irradiation annealing.

The accelerated aging, or rebound test mentioned in TM1019.8 is unnecessary because there is no adverse time-dependent effect (TDE) in Microsemi products manufactured by sub-micron CMOS technology. The test data with a high dose are compared to test data with a low dose rate for devices manufactured by several generations of sub-micron CMOS technologies. The results always show the low dose rate degrades less than the high dose rate; thus indicating that the elevated rebound annealing would artificially reduce the radiation effects. Therefore, only room temperature annealing is performed for tests included in this report. The experiment is repeated on the flash-based FPGA technology and shows similar results.

The duration of the room temperature annealing is approximately 7 days.

## C. Design

DUTs use a high utilization generic design, RTA3PE3KL(CG484\_TID), to test total dose effects in typical space applications.

Below are descriptions by blocks. Appendix A contains block diagrams and schematics illustrating the logic design.

### a. PLL Block

There are six dynamically configurable PLLs in the RTA3PE3000 device. All of them are configured in the following manner with GLA coming from the PLL and GLB/GLC bypassed for other global signals. Five of the PLLs have a default multiplying factor of x4 and the last one is x16.

Dynamic configuration is applied by sending IR = 16 through the UJTAG. The lock signal of each PLL is routed out to an I/O for observation.

### b. UFROM / SRAM Block

There are 112 basic 4608-bit blocks in the RTA3PE3000 device. Each of these blocks is configured in the 512x8 configuration. The stimulus for the SRAM blocks is written into the UFROM during programming.

During test/TID, the contents in the UFROM is read and written into each of the 112 SRAM blocks. The SRAM blocks are configured in a dual port mode where 2 different bytes of data is written/read from 2 different addresses at any given time. The read back data is MUXed and compared with the expected value. To ensure the original data in the UFROM is correct, its content goes through a CRC check during each test cycle.

An additional SRAM disturb mode is available. During the non-disturb mode, the dual port operation for read/write between address (port) A and address (port) B must be greater than 8 to avoid operating SRAM cells in the same physical row. The disturb mode will force address A and B to be adjacent to each other all the time to stimulate the disturb violation.

### c. Pattern Generator Block

A multi-bit shift register with varying feedback length allows for different patterns of configuration, as shown in the table below. The pattern generator block is used to supply the stimulus for the array shift register and I/O test blocks.

### d. I/O Block

The I/O Block is composed of four separate blocks, each with their own pattern generator and checker block. Each block also has its own clock, reset, and OE from a separate PLL block. Separation of these blocks is based on the four quadrants: UL, UR, LL, and LR. The reason for this scheme is to fully utilize the quadrant clocks in the device.

Since the number of bonded I/Os is different in each quadrant, the number of stages in each I/O weave block also varies slightly (from 138 to 146). The SSO of the device can be changed based on the pattern generator's configuration. The existing burn-in mode or TID will use a 25% SSO rate. The SSO can also be completely eliminated by disabling the OE of the device, which will route the signal internally instead of going through the bi-buf.

### e. Array Shift Registers Block

There are 4 individual array shift register chains used as core logic fillers. Each chain is made up of 3500 D-FFs with asynchronous reset/set. The pattern generator supplies the stimulus into the array shift-register, which gets shifted out and compared by the pattern checker. During TID, the internal toggle rate is fixed at 25% SSR.

#### f. Delay Path Block

The delay path block has three individual inverter chains with input stimulus coming from a counter during TID or I/O during test. The inverter chains are 30 stages and travel across the quadrants. The path covers the outer edges and center of the die to provide better sampling of the different areas in the die.

#### g. Monitor Block

This block is used to indicate that all BISTs in the design are passing. The passing monitor signal is one half of the CLK. When a BIST fails, the monitor signal provides a signature that makes it possible to determine which specific block in the design that is failing. The failing Monitor signal consists of up to 9 pulses. Pulse 0 is always present in the failing Monitor signal, while pulses 1-7, which represent passing blocks in the Burn-in design, and are only present when the respective block is passing. The pulse number and the corresponding block that it represents is as follows:

1. UFROM/SRAM Block
2. IO UR Block
3. IO UL Block
4. IO LR Block
5. IO LL Block
6. Array 1 Block
7. Array 2 Block
8. Array 3 Block
9. Array 4 Block

### D. Parametric Measurements

Table 2 lists each tested electrical parameter and the corresponding logic design.

The functionality is measured on the output pins.  $I_{CC}$  is measured on the power supplies of the logic-array ( $I_{CCA}$ ) and I/O ( $I_{CCI}$ ) respectively. The input logic thresholds (VIL/VIH) and output-drive voltages (VOL/VOH) are measured on nets listed in rows 3 and 4 of Table 2.

The propagation delays are measured on the SPEEDOUT output of the inverter chains. The delay is measured as the time delay from the time of triggering edge at the clk input to the time of switching state at the output SPEEDOUT. Both the low-to-high and high-to-low output transitions are measured; the propagation delay is defined as the average of these two transitions.

The transition characteristics, measured on the output SPEEDOUT, are displayed from Figure 5a through Figure 18b as oscilloscope snapshots showing the rising and falling edge during logic transitions.

**Table 2 Logic Design for Parametric Measurements**

Parameters	Logic Design
1. Functionality	All key architectural functions
2. $I_{CC}$ ( $I_{CCA}/I_{CCI}$ )	DUT power supply pins
3. Input Threshold (VIL/VIH)	Input buffers (SPEEDIN, RESETn, INPUT_SRAM_DISTURB, INPUT_SETn, INPUT_oe, INPUT_IO_Shift_En, INPUT_IO_Pattern_Length[0..2], INPUT_IO_Johnson, INPUT_FROM_SRAM_START, INPUT_A_Shift_En, INPUT_A_Pattern_Length[0..2], INPUT_A_Johnson, clk, BIST, FF, IO_Outs.UR[0..76], IO_Outs.UL[0..74], IO_Outs.LR[0..66], IO_Outs.LL[0..79])
4. Output Drive (VOL/VOH)	Output buffer (UFROM_MONITOR, SRAM_OUT[0..7], LOCK[0..5], LED, BIST_MONITOR, Array_Monitor, SPEEDOUT, Array_out[0..3])
5. Propagation Delay	Chains of inverters (clk to SPEEDOUT)
6. Transition Characteristic	Output (SPEEDOUT)

### III. Test Results

#### A. Functionality

Every DUT passes functional tests at 30 krads from results of the pre-irradiation, post-irradiation and post-annealing data.

At 50 krads, one out of four DUTs failed functional tests; and three out of four DUTs failed SRAM in dual port mode owing to the V<sub>t</sub> shift of UFROMs that are used to connect to the blocks.

#### B. Power Supply Current (ICCA and ICCI)

Table 3 shows the pre-irradiation, post-irradiation, and post-annealing I<sub>CCA</sub> and I<sub>CCI</sub>, measured at the high VCC corners at 1.575 V and 3.6 V, respectively. It shows the total dose effects to I<sub>cc</sub> currents up to 60 krads are not significant. And it indicates that the post-annealing I<sub>CCA</sub> and I<sub>CCI</sub> for all DUTs pass the specification with very good margins.

**Table 3 Post Irradiation and Post-Annealing I<sub>cc</sub>**

DUT	Total Dose	I <sub>CCA</sub> (mA)		I <sub>CCI</sub> (uA)	
		Pre-Rad	Post-Ann	Pre-Rad	Post-Ann
7943	30 krad	4.2	4.1	44.2	25.5
7973	30 krad	4.2	4.2	34.0	38.7
7992	30 krad	5.0	4.8	45.2	31.0
7942	50 krad	5.3	5.2	38.6	35.4
7956	50 krad	6.1	6.1	44.5	28.7
7972	50 krad	3.3	3.3	30.8	38.3
7926	60 krad	4.2	4.1	46.8	36.1

## C. Continuity and Input Logic Threshold (VIL/VIH)

Standard I/O parametric tests are applied to check the total dose effects to the I/O drivability.

Table 4a through Table 4c list the pre-irradiation and post-annealing input logic thresholds. All data are within the specification limits (specification minimum and maximum are given in brackets); data are presented with statistics of all I/O pins used (approximately 340 sample size of each DUT).

**Table 4a Pre-Irradiation and Post-Annealing Continuity and Input Thresholds**

Testname		cont_to_vss (V) [-1.5, -0.2]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	-0.313	-0.310	-0.306	0.002	-0.314	-0.310	-0.305	0.002
7973	30 krad	-0.319	-0.317	-0.315	0.001	-0.320	-0.318	-0.315	0.001
7992	30 krad	-0.312	-0.309	-0.306	0.001	-0.313	-0.310	-0.307	0.001
7942	50 krad	-0.318	-0.316	-0.314	0.001	-0.318	-0.316	-0.313	0.001
7956	50 krad	-0.312	-0.309	-0.305	0.002	-0.313	-0.309	-0.305	0.002
7972	50 krad	-0.319	-0.317	-0.314	0.001	-0.319	-0.317	-0.314	0.001
7926	60 krad	-0.310	-0.307	-0.304	0.001	-0.310	-0.307	-0.304	0.001

**Table 4b Pre-Irradiation and Post-Annealing Continuity and Input Thresholds**

Testname		pci_pcix_iil (uA) [-5, 5]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	-0.214	-0.098	0.078	0.047	-0.324	-0.078	0.099	0.062
7973	30 krad	-0.201	-0.064	0.079	0.047	-0.336	-0.051	0.149	0.063
7992	30 krad	-0.192	-0.089	0.121	0.042	-0.311	-0.071	0.131	0.063
7942	50 krad	-0.223	-0.082	0.088	0.046	-0.341	-0.057	0.149	0.064
7956	50 krad	-0.237	-0.098	0.063	0.044	-0.336	-0.069	0.131	0.061
7972	50 krad	-0.183	-0.053	0.075	0.044	-0.311	-0.043	0.173	0.065
7926	60 krad	-0.238	-0.096	0.088	0.047	-0.311	-0.070	0.148	0.065

**Table 4c Pre-Irradiation and Post-Annealing Continuity and Input Thresholds**

Testname		pci_pcix_iih (uA) [-5, 5]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	-0.164	0.023	0.226	0.060	-0.274	0.024	0.200	0.065
7973	30 krad	-0.164	0.022	0.241	0.058	-0.223	0.022	0.198	0.066
7992	30 krad	-0.189	0.026	0.539	0.065	-0.274	0.019	0.480	0.071
7942	50 krad	-0.139	0.023	0.321	0.058	-0.224	0.034	0.247	0.067
7956	50 krad	-0.119	0.027	0.239	0.059	-0.261	0.029	0.200	0.066
7972	50 krad	-0.143	0.023	0.200	0.059	-0.236	0.028	0.250	0.065
7926	60 krad	-0.189	0.023	0.242	0.059	-0.186	0.107	0.327	0.081

## D. Low Output-Drive Voltage (VOL and Ipd)

The pre-irradiation and post-annealing VOL are listed in Table 5a through Table 6j. The post-annealing data are within the specification limits (specification minimum and maximum are shown in brackets); data are presented with statistics of all I/O pins used (~340 sample size of each DUT). In each case, the post-annealing data vary insignificantly.

**Table 5a Pre-Irradiation and Post-Annealing VOL**

Testname		hstli_volt_4x (mV) [0, 400]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	155.826	162.193	174.603	3.327	155.900	161.935	174.354	3.094
7973	30 krad	157.770	163.968	175.524	3.274	157.681	163.486	175.506	3.016
7992	30 krad	156.181	162.319	176.646	3.472	155.900	161.567	172.657	3.079
7942	50 krad	158.209	164.765	184.225	3.474	158.205	163.989	175.171	3.009
7956	50 krad	155.805	161.992	173.702	3.139	155.480	161.491	173.034	2.962
7972	50 krad	157.540	163.795	175.021	3.295	157.471	163.191	174.794	3.027
7926	60 krad	157.352	163.057	175.931	3.230	157.031	162.481	174.333	3.032

**Table 5b Pre-Irradiation and Post-Annealing VOL**

Testname		hstlii_volt_5x (mV) [0, 400]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	220.301	231.427	254.453	6.216	220.275	230.942	254.566	5.793
7973	30 krad	222.412	233.902	255.772	6.106	222.140	233.215	255.864	5.621
7992	30 krad	220.259	231.804	257.391	6.500	220.150	230.268	252.346	5.747
7942	50 krad	223.310	235.261	271.626	6.489	223.461	233.956	255.634	5.605
7956	50 krad	220.029	231.130	253.197	5.893	219.689	230.232	252.178	5.532
7972	50 krad	222.621	233.920	254.872	6.186	222.601	232.765	254.754	5.677
7926	60 krad	222.182	232.602	256.749	6.094	221.889	231.813	254.335	5.665

**Table 5c Pre-Irradiation and Post-Annealing VOL**

Testname		gtl33_volt_5x (mV) [0, 400]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	191.354	205.658	236.657	8.243	191.591	205.616	237.392	7.765
7973	30 krad	191.040	205.575	234.375	8.060	192.090	204.973	235.256	7.510
7992	30 krad	191.375	205.755	240.605	8.746	190.628	204.531	235.885	7.736
7942	50 krad	193.194	207.137	255.060	8.635	192.303	206.133	236.387	7.530
7956	50 krad	191.711	205.949	235.359	8.011	191.633	205.003	234.879	7.451
7972	50 krad	192.591	206.410	235.569	8.290	192.324	205.732	236.115	7.656
7926	60 krad	192.424	206.515	241.137	8.258	192.680	206.081	236.513	7.635

**Table 5d Pre-Irradiation and Post-Annealing VOL**

Testname		gtl25_vol_5x (mV) [0, 400]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	208.553	223.415	253.683	8.320	208.560	223.001	253.550	7.835
7973	30 krad	207.294	223.475	251.798	8.102	208.561	222.703	253.236	7.632
7992	30 krad	208.553	223.729	255.052	8.642	207.598	221.984	251.038	7.794
7942	50 krad	209.813	225.085	272.463	8.567	210.425	223.645	254.178	7.579
7956	50 krad	209.183	223.729	254.312	8.034	209.168	222.208	252.608	7.553
7972	50 krad	209.813	224.423	254.312	8.263	208.854	223.017	252.608	7.758
7926	60 krad	209.813	224.670	258.239	8.250	209.482	223.645	252.922	7.615

**Table 5e Pre-Irradiation and Post-Annealing VOL**

Testname		gtlp33_vol_5x (mV) [0, 600]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	340.239	365.234	419.806	14.473	340.396	364.964	420.749	13.583
7973	30 krad	339.840	364.878	416.122	14.159	341.294	363.916	416.979	13.134
7992	30 krad	340.344	365.088	421.921	15.331	338.826	363.025	417.733	13.531
7942	50 krad	343.168	368.078	451.798	15.156	341.987	366.074	418.781	13.168
7956	50 krad	340.721	365.653	417.441	14.065	340.459	363.805	416.163	13.042
7972	50 krad	342.462	366.541	417.755	14.547	341.861	365.299	418.466	13.405
7926	60 krad	342.210	366.447	425.825	14.515	342.322	365.655	419.095	13.355

**Table 5f Pre-Irradiation and Post-Annealing VOL**

Testname		gtlp25_vol_5x (mV) [0, 600]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	354.026	377.243	428.715	13.620	354.431	377.218	429.325	12.771
7973	30 krad	354.530	378.188	426.454	13.351	355.167	377.296	427.158	12.396
7992	30 krad	354.600	377.649	435.563	14.411	352.735	375.570	426.341	12.726
7942	50 krad	357.076	381.360	460.406	14.268	356.880	379.071	428.289	12.392
7956	50 krad	354.913	378.276	426.736	13.164	354.085	376.095	425.116	12.263
7972	50 krad	357.014	379.410	427.364	13.687	356.001	377.705	427.849	12.609
7926	60 krad	356.543	379.033	433.756	13.621	356.597	378.073	428.289	12.547

**Table 5g Pre-Irradiation and Post-Annealing VOL**

Testname		sstl2i_vol_4x (mV) [0, 540]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	210.144	220.785	243.964	6.189	210.290	220.595	244.262	5.787
7973	30 krad	210.426	221.053	243.022	6.086	210.636	220.646	243.476	5.612
7992	30 krad	209.799	220.801	242.551	6.440	209.593	219.626	242.471	5.757
7942	50 krad	211.554	222.625	258.939	6.486	211.916	221.570	243.791	5.618
7956	50 krad	210.018	221.110	242.928	5.988	209.976	220.093	242.188	5.544
7972	50 krad	211.366	221.863	243.556	6.217	211.445	221.015	243.665	5.694
7926	60 krad	211.789	221.933	245.160	6.148	211.665	221.193	243.979	5.672

**Table 5h Pre-Irradiation and Post-Annealing VOL**

Testname		sstl2ii_vol_5x (mV) [0, 350]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	187.192	199.873	227.822	7.433	187.583	199.859	228.366	6.953
7973	30 krad	187.380	200.180	226.378	7.279	187.815	199.659	226.921	6.732
7992	30 krad	187.165	199.992	226.849	7.785	186.547	198.933	226.764	6.921
7942	50 krad	188.325	201.679	244.974	7.793	188.493	200.691	227.706	6.740
7956	50 krad	187.353	200.243	226.723	7.202	187.426	199.153	225.947	6.666
7972	50 krad	188.293	200.752	227.069	7.466	188.274	200.030	227.392	6.855
7926	60 krad	188.450	200.805	228.608	7.421	188.650	200.283	227.738	6.836

**Table 5i Pre-Irradiation and Post-Annealing VOL**

Testname		sstl3i_vol_2x (mV) [0, 700.0001]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	406.326	422.472	452.111	8.700	405.829	423.179	452.572	8.666
7973	30 krad	407.392	422.799	451.012	8.193	406.204	421.900	450.813	8.116
7992	30 krad	404.758	422.157	449.755	8.676	403.003	421.163	448.237	8.499
7942	50 krad	409.118	426.878	461.255	8.475	407.524	425.578	451.630	8.169
7956	50 krad	407.995	423.333	452.079	8.442	405.075	422.049	450.373	8.426
7972	50 krad	408.207	424.530	452.268	8.502	406.771	424.121	451.693	8.353
7926	60 krad	408.970	425.051	454.791	8.464	407.587	425.157	452.541	8.509

**Table 5j Pre-Irradiation and Post-Annealing VOL**

Testname		sstl3ii_vol_3x (mV) [0, 500]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	309.078	323.618	355.826	8.621	308.904	323.269	356.255	8.112
7973	30 krad	308.700	323.652	353.910	8.470	309.085	322.671	354.559	7.872
7992	30 krad	308.669	323.342	353.659	9.005	307.334	321.604	353.522	8.082
7942	50 krad	311.620	326.171	376.611	9.014	310.725	324.236	355.313	7.877
7956	50 krad	309.392	324.076	354.726	8.364	308.457	322.610	353.836	7.799
7972	50 krad	310.745	324.841	355.040	8.662	310.254	323.772	355.438	8.005
7926	60 krad	310.682	325.163	358.644	8.569	310.756	324.226	355.878	7.957

**Table 5k Pre-Irradiation and Post-Annealing VOL**

Testname		cmos25_vol_1x (mV) [0, 630.0001]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	228.451	232.539	238.248	1.699	228.050	232.262	237.728	1.617
7973	30 krad	229.643	233.545	239.002	1.903	229.181	233.141	238.984	1.755
7992	30 krad	227.320	232.118	237.588	1.812	227.107	231.483	236.031	1.688
7942	50 krad	230.270	235.286	245.099	1.950	229.810	234.460	238.645	1.748
7956	50 krad	228.890	233.028	238.060	1.609	228.113	232.199	237.351	1.535
7972	50 krad	230.207	233.941	239.693	1.775	230.062	233.394	238.859	1.625
7926	60 krad	230.583	234.040	239.486	1.683	230.125	233.518	238.733	1.645

**Table 5l Pre-Irradiation and Post-Annealing VOL**

Testname		cmos25_vol_2x (mV) [0, 630.0001]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	237.605	244.050	256.086	3.311	237.668	243.892	255.948	3.097
7973	30 krad	238.546	245.019	256.337	3.360	238.549	244.521	256.325	3.075
7992	30 krad	237.229	243.701	255.395	3.449	236.914	242.854	254.000	3.079
7942	50 krad	239.737	246.546	266.111	3.516	239.492	245.835	256.388	3.073
7956	50 krad	237.543	244.470	255.960	3.148	237.040	243.571	254.817	2.950
7972	50 krad	239.361	245.647	256.714	3.347	239.177	244.947	256.199	3.039
7926	60 krad	239.815	245.509	256.854	3.196	239.801	244.898	256.576	3.021

**Table 5m Pre-Irradiation and Post-Annealing  $V_{OL}$  (Continued)**

Testname		cmos25_vol_3x (mV) [0, 630.0001]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	191.021	199.740	218.401	4.961	191.336	199.694	218.313	4.634
7973	30 krad	191.334	200.144	217.773	4.885	191.650	199.690	217.874	4.502
7992	30 krad	191.021	199.740	217.145	5.188	190.628	198.621	216.617	4.607
7942	50 krad	192.588	201.491	230.442	5.194	192.805	200.570	218.188	4.502
7956	50 krad	191.083	199.987	217.710	4.787	190.958	199.187	217.057	4.447
7972	50 krad	192.337	200.746	218.213	4.988	192.279	200.048	218.188	4.548
7926	60 krad	192.570	200.689	218.275	4.865	192.763	200.200	218.502	4.532

**Table 5n Pre-Irradiation and Post-Annealing VOL**

Testname		cmos25_vol_4x (mV) [0, 700.0001]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	225.254	236.582	261.550	6.601	225.535	236.543	261.603	6.181
7973	30 krad	225.661	237.085	260.483	6.474	225.849	236.635	260.849	5.988
7992	30 krad	224.815	236.645	263.678	6.991	224.789	235.405	259.843	6.135
7942	50 krad	226.884	238.719	277.435	6.926	227.170	237.666	261.351	5.980
7956	50 krad	225.191	236.978	260.545	6.374	225.221	235.908	259.781	5.922
7972	50 krad	226.633	237.839	261.111	6.632	226.667	236.977	261.226	6.052
7926	60 krad	226.947	237.809	261.299	6.497	226.924	237.200	261.226	6.050

**Table 5o Pre-Irradiation and Post-Annealing VOL**

Testname		cmos25_vol_5x (mV) [0, 700.0001]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	252.963	269.777	307.212	9.891	253.236	269.919	308.348	9.317
7973	30 krad	253.403	270.343	305.265	9.673	253.574	269.669	305.897	9.011
7992	30 krad	253.343	270.246	318.563	10.603	252.294	268.725	305.960	9.268
7942	50 krad	255.286	272.356	329.964	10.364	255.120	271.139	307.154	9.019
7956	50 krad	253.341	270.515	305.705	9.567	253.236	269.115	304.766	8.911
7972	50 krad	255.102	271.270	305.956	9.930	254.680	270.210	306.777	9.142
7926	60 krad	254.473	270.972	306.647	9.805	254.994	270.524	307.342	9.139

**Table 5p Pre-Irradiation and Post-Annealing VOL**

Testname		cmos18_vol_1x (mV) [0, 405]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	138.509	141.364	144.099	0.935	138.967	141.294	143.620	0.881
7973	30 krad	140.298	142.777	145.860	1.092	140.036	142.601	145.541	1.026
7992	30 krad	137.943	141.334	147.181	1.075	137.829	141.106	143.732	0.984
7942	50 krad	140.079	143.547	148.408	1.101	140.154	143.229	145.667	1.013
7956	50 krad	138.823	141.551	144.162	0.877	138.709	141.268	143.431	0.859
7972	50 krad	140.549	142.589	145.355	0.955	140.350	142.362	145.117	0.889
7926	60 krad	139.577	142.369	145.168	0.932	139.777	142.150	145.039	0.940

**Table 5q Pre-Irradiation and Post-Annealing VOL**

Testname		cmos18_vol_2x (mV) [0, 405]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	143.558	147.061	152.892	1.689	143.745	147.111	152.782	1.594
7973	30 krad	144.875	148.379	154.085	1.743	144.877	148.179	154.102	1.610
7992	30 krad	143.245	147.051	156.863	1.819	143.117	146.750	151.652	1.599
7942	50 krad	145.377	149.264	158.788	1.804	145.380	148.869	153.725	1.595
7956	50 krad	143.370	147.306	152.892	1.584	143.179	146.889	152.280	1.519
7972	50 krad	144.875	148.345	154.085	1.701	144.877	148.178	153.788	1.541
7926	60 krad	145.063	148.094	153.527	1.621	144.814	147.824	153.411	1.559

**Table 5r Pre-Irradiation and Post-Annealing VOL**

Testname		cmos18_vol_3x (mV) [0, 405]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	154.029	160.013	172.425	3.311	154.118	159.921	172.197	3.091
7973	30 krad	154.969	161.118	172.677	3.278	154.998	160.821	173.076	3.010
7992	30 krad	153.903	160.013	175.473	3.507	153.804	159.549	171.317	3.083
7942	50 krad	155.596	161.996	181.373	3.465	155.816	161.453	172.699	3.003
7956	50 krad	153.966	159.944	171.923	3.159	153.867	159.670	171.568	2.973
7972	50 krad	155.220	161.306	172.551	3.300	155.187	160.801	172.825	3.015
7926	60 krad	155.157	160.994	172.488	3.220	155.313	160.573	172.260	3.019

**Table 5s Pre-Irradiation and Post-Annealing VOL**

Testname		cmos18_vol_5x (mV) [0, 405]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	148.762	157.467	175.943	4.965	149.278	157.539	176.658	4.634
7973	30 krad	149.577	158.357	175.880	4.865	149.781	158.142	176.218	4.496
7992	30 krad	148.762	157.743	182.703	5.298	148.744	156.907	175.212	4.608
7942	50 krad	150.204	159.361	188.544	5.199	150.816	158.626	176.343	4.496
7956	50 krad	149.076	157.478	175.126	4.757	148.963	157.010	174.898	4.441
7972	50 krad	150.016	158.498	175.817	4.969	150.409	158.042	176.092	4.543
7926	60 krad	150.107	158.251	176.005	4.882	150.409	157.942	176.218	4.545

**Table 5t Pre-Irradiation and Post-Annealing VOL**

Testname		cmos15_vol_2x (mV) [0, 320]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	81.793	83.682	86.441	0.878	81.633	83.625	86.372	0.813
7973	30 krad	82.741	84.685	87.320	0.914	82.639	84.504	87.503	0.846
7992	30 krad	81.353	83.712	88.398	0.934	81.570	83.456	85.618	0.841
7942	50 krad	82.986	85.124	89.903	0.932	82.827	84.819	87.252	0.825
7956	50 krad	81.801	83.746	86.378	0.808	81.507	83.519	86.246	0.780
7972	50 krad	82.804	84.559	87.446	0.876	82.764	84.378	87.063	0.799
7926	60 krad	82.490	84.245	87.067	0.835	82.324	84.065	86.623	0.797

**Table 5u Pre-Irradiation and Post-Annealing V<sub>OL</sub> (Continued)**

Testname		cmos15_vol_3x (mV) [0, 320]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	86.879	90.128	96.050	1.656	86.725	90.093	96.236	1.555
7973	30 krad	87.882	91.072	96.616	1.632	87.982	90.874	96.802	1.511
7992	30 krad	87.130	90.155	99.526	1.775	86.976	89.842	95.231	1.552
7942	50 krad	88.259	91.476	101.101	1.733	88.257	91.189	96.864	1.508
7956	50 krad	87.005	90.092	95.799	1.565	86.725	89.868	95.733	1.496
7972	50 krad	87.945	90.946	96.427	1.657	87.731	90.658	96.425	1.520
7926	60 krad	87.632	90.595	96.347	1.604	87.857	90.434	96.425	1.523

**Table 5v Pre-Irradiation and Post-Annealing VOL**

Testname		cmos15_vol_4x (mV) [0, 320]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	115.031	119.818	129.088	2.506	115.204	119.730	129.159	2.333
7973	30 krad	116.410	121.139	129.778	2.456	116.147	120.783	129.724	2.261
7992	30 krad	115.219	119.944	133.036	2.648	115.078	119.444	127.902	2.313
7942	50 krad	116.849	121.677	136.267	2.602	116.838	121.176	129.598	2.258
7956	50 krad	115.219	119.722	128.711	2.350	114.952	119.416	128.091	2.217
7972	50 krad	116.347	121.018	129.402	2.480	116.335	120.551	129.284	2.276
7926	60 krad	116.285	120.548	129.200	2.422	116.084	120.217	129.159	2.278

**Table 5w Pre-Irradiation and Post-Annealing VOL**

Testname		cmos15_vol_5x (mV) [0, 320]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	173.026	181.721	200.312	4.983	173.230	181.465	200.407	4.632
7973	30 krad	174.406	183.700	201.129	4.877	174.236	183.091	201.098	4.503
7992	30 krad	172.901	182.137	203.890	5.247	172.794	181.039	198.711	4.618
7942	50 krad	175.221	184.437	213.645	5.186	175.242	183.548	201.161	4.491
7956	50 krad	172.650	181.588	199.244	4.724	172.601	180.963	198.396	4.429
7972	50 krad	174.657	183.520	200.563	4.967	174.613	182.626	200.533	4.526
7926	60 krad	174.343	182.657	200.249	4.864	174.361	182.169	200.093	4.539

**Table 5x Pre-Irradiation and Post-Annealing VOL**

Testname		cmos12_vol_2x (mV) [0, 285]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	104.718	107.193	110.015	0.987	105.019	107.391	110.373	0.929
7973	30 krad	106.692	109.221	112.144	1.034	106.905	109.290	112.132	0.959
7992	30 krad	103.839	107.203	110.528	1.055	104.153	107.236	109.855	0.999
7942	50 krad	106.602	109.711	114.500	1.048	107.106	109.649	112.008	0.947
7956	50 krad	104.404	107.167	109.786	0.887	104.516	107.091	109.807	0.912
7972	50 krad	106.629	108.810	111.690	0.942	106.717	108.854	111.252	0.865
7926	60 krad	105.158	107.883	110.454	0.907	105.396	107.864	110.313	0.876

**Table 5y Pre-Irradiation and Post-Annealing VOL**

Testname		cmos12_vol_3x (mV) [0, 285]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	53.148	54.889	57.737	0.851	53.343	55.040	58.224	0.806
7973	30 krad	53.963	55.727	58.679	0.833	54.223	55.806	58.664	0.770
7992	30 krad	53.022	54.903	58.473	0.902	53.387	54.954	57.282	0.802
7942	50 krad	54.276	55.943	60.713	0.890	54.286	55.920	58.664	0.781
7956	50 krad	53.210	54.826	57.486	0.786	52.965	54.836	57.722	0.770
7972	50 krad	53.837	55.530	58.177	0.846	54.078	55.618	58.413	0.766
7926	60 krad	53.587	55.154	57.975	0.806	53.720	55.209	58.224	0.780

**Table 5z Pre-Irradiation and Post-Annealing VOL**

Testname		cmos12_vol_3xE1 (mV) [-100, 100]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	2.529	2.906	3.260	0.145	2.621	3.058	3.615	0.159
7973	30 krad	2.529	2.963	3.323	0.151	2.677	3.083	3.498	0.141
7992	30 krad	2.466	2.946	3.365	0.157	2.677	3.021	3.398	0.143
7942	50 krad	2.466	2.980	3.365	0.152	2.798	3.112	3.437	0.144
7956	50 krad	2.466	2.927	3.303	0.145	2.614	3.049	3.398	0.146
7972	50 krad	2.529	2.946	3.303	0.145	2.614	3.060	3.623	0.152
7926	60 krad	2.466	2.917	3.260	0.145	2.672	3.060	3.498	0.154

**Table 5aa Pre-Irradiation and Post-Annealing VOL**

Testname		cmos12_vol_3xE2 (mV) [-100, 100]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	2.026	2.459	2.801	0.132	2.175	2.558	3.058	0.146
7973	30 krad	2.026	2.466	2.883	0.145	2.112	2.556	2.932	0.134
7992	30 krad	1.838	2.459	2.854	0.155	2.118	2.556	2.932	0.149
7942	50 krad	2.026	2.477	2.883	0.151	2.175	2.597	3.058	0.148
7956	50 krad	2.082	2.456	2.801	0.134	2.118	2.558	2.932	0.145
7972	50 krad	1.775	2.459	2.883	0.146	2.175	2.556	2.986	0.146
7926	60 krad	1.963	2.456	2.801	0.152	2.283	2.597	2.958	0.142

**Table 5ab Pre-Irradiation and Post-Annealing VOL**

Testname		lvttl_vol_1x12 (mV) [0, 360]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	202.308	205.638	211.398	1.646	201.993	205.478	210.513	1.569
7973	30 krad	202.621	205.905	211.711	1.768	202.116	205.556	211.373	1.639
7992	30 krad	201.293	205.043	210.832	1.777	200.787	204.434	209.571	1.615
7942	50 krad	203.558	207.468	217.167	1.833	202.898	206.906	211.525	1.637
7956	50 krad	202.543	206.000	211.555	1.613	201.803	205.351	210.669	1.486
7972	50 krad	203.528	206.608	212.572	1.726	202.976	206.259	211.685	1.556
7926	60 krad	203.481	206.860	212.337	1.609	203.244	206.445	211.607	1.567

**Table 5ac Pre-Irradiation and Post-Annealing VOL**

Testname		lvttl_vol_1x (mV) [0, 360]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	202.230	205.591	211.633	1.644	201.960	205.478	210.826	1.564
7973	30 krad	202.542	205.843	211.633	1.770	202.194	205.556	211.373	1.630
7992	30 krad	201.215	204.967	210.989	1.764	200.709	204.462	209.493	1.617
7942	50 krad	203.246	207.486	217.245	1.855	202.976	206.886	211.760	1.637
7956	50 krad	202.387	205.980	211.477	1.606	201.725	205.294	210.591	1.486
7972	50 krad	203.480	206.577	212.494	1.737	203.055	206.183	212.076	1.583
7926	60 krad	203.480	206.922	212.337	1.620	203.289	206.415	211.529	1.563

**Table 5ad Pre-Irradiation and Post-Annealing VOL**

Testname		lvttl_vol_1xE1 (mV) [0, 200]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	4.448	4.996	5.534	0.182	4.480	5.142	5.737	0.212
7973	30 krad	4.527	4.999	5.613	0.185	4.480	5.133	5.681	0.234
7992	30 krad	4.370	4.999	5.468	0.181	4.558	5.133	5.737	0.219
7942	50 krad	4.648	5.064	5.613	0.178	4.558	5.202	5.689	0.217
7956	50 krad	4.595	5.023	5.468	0.178	4.402	5.147	5.767	0.223
7972	50 krad	4.570	5.023	5.613	0.180	4.480	5.147	5.694	0.230
7926	60 krad	4.448	4.999	5.534	0.175	4.402	5.202	5.845	0.230

**Table 5ae Pre-Irradiation and Post-Annealing VOL**

Testname		lvttl_vol_1xE2 (mV) [0, 200]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	4.605	5.153	5.691	0.185	4.636	5.303	5.815	0.221
7973	30 krad	4.605	5.153	5.624	0.184	4.714	5.299	5.845	0.219
7992	30 krad	4.492	5.143	5.848	0.190	4.636	5.280	5.815	0.225
7942	50 krad	4.761	5.221	5.702	0.177	4.714	5.358	5.924	0.234
7956	50 krad	4.527	5.153	5.691	0.188	4.636	5.303	5.845	0.218
7972	50 krad	4.605	5.179	5.848	0.196	4.558	5.303	5.845	0.226
7926	60 krad	4.492	5.155	5.769	0.195	4.714	5.339	5.845	0.229

**Table 5af Pre-Irradiation and Post-Annealing VOL**

Testname		lvttl_vol_2x (mV) [0, 360]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	212.162	218.340	229.785	3.290	211.578	217.745	229.819	3.079
7973	30 krad	211.849	218.497	229.159	3.330	212.204	217.745	229.584	3.045
7992	30 krad	211.711	217.599	229.997	3.424	211.060	216.762	227.865	3.080
7942	50 krad	213.746	220.118	238.675	3.438	212.858	218.950	229.506	3.031
7956	50 krad	212.318	218.731	229.707	3.193	211.735	217.469	229.194	2.959
7972	50 krad	213.179	219.259	230.020	3.319	212.701	218.448	229.975	3.044
7926	60 krad	212.944	219.554	231.678	3.240	213.014	218.538	230.366	2.992

**Table 5ag Pre-Irradiation and Post-Annealing VOL**

Testname		lvttl_vol_3x (mV) [0, 360]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	172.782	181.143	199.975	4.940	172.896	181.200	199.805	4.636
7973	30 krad	172.510	181.107	198.567	4.864	173.143	180.809	198.789	4.476
7992	30 krad	172.314	180.872	199.724	5.245	172.193	180.036	198.163	4.616
7942	50 krad	173.954	182.358	211.302	5.196	173.621	181.785	199.336	4.506
7956	50 krad	172.782	181.456	199.271	4.812	172.713	180.583	198.085	4.444
7972	50 krad	173.370	181.873	199.584	4.990	173.599	181.364	199.414	4.539
7926	60 krad	173.761	182.186	199.349	4.864	173.912	181.599	199.414	4.538

**Table 5ah Pre-Irradiation and Post-Annealing VOL**

Testname		lvttl_vol_4x (mV) [0, 400]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	203.637	214.900	239.878	6.614	203.993	214.890	240.136	6.175
7973	30 krad	203.481	214.743	238.001	6.490	203.993	214.393	238.417	5.982
7992	30 krad	203.402	214.785	240.401	7.011	202.821	213.768	238.417	6.162
7942	50 krad	204.730	216.212	254.942	6.914	204.540	215.410	238.807	6.005
7956	50 krad	203.714	215.212	239.018	6.402	203.759	214.237	237.791	5.932
7972	50 krad	204.654	215.838	239.174	6.670	204.931	215.166	239.120	6.064
7926	60 krad	204.810	215.900	239.722	6.516	204.931	215.342	239.198	6.061

**Table 5ai Pre-Irradiation and Post-Annealing VOL**

Testname		lvttl_vol_5x (mV) [0, 400]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	229.759	247.150	284.242	9.879	229.934	246.846	284.844	9.270
7973	30 krad	229.602	246.810	281.503	9.645	230.815	246.050	282.578	8.989
7992	30 krad	230.072	247.072	283.659	10.449	229.309	245.560	282.890	9.266
7942	50 krad	231.600	248.635	306.013	10.353	231.106	247.446	283.594	9.021
7956	50 krad	230.228	247.280	282.677	9.604	230.246	246.118	281.718	8.912
7972	50 krad	231.401	247.853	282.990	9.921	231.418	246.977	283.359	9.128
7926	60 krad	231.010	247.859	283.381	9.811	231.653	247.514	283.906	9.131

**Table 6a Pre-Irradiation and Post-Annealing IpD**

Testname		cmos25_ipd_weak (cmos25_ipd_weak_Min.) (uA) [9.5, 33]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	21.582	21.869	22.562	0.163	21.567	22.018	22.675	0.164
7973	30 krad	21.161	21.484	21.989	0.199	21.191	21.645	22.195	0.205
7992	30 krad	21.127	21.529	22.086	0.165	21.354	21.702	22.291	0.172
7942	50 krad	20.659	20.976	21.512	0.176	20.884	21.205	21.807	0.178
7956	50 krad	20.685	21.255	22.001	0.223	21.019	21.474	22.166	0.224
7972	50 krad	21.435	21.868	22.576	0.247	21.540	22.058	22.756	0.258
7926	60 krad	21.320	21.765	22.411	0.223	21.482	21.994	22.575	0.225

**Table 6b Pre-Irradiation and Post-Annealing Ipd**

Testname		cmos25_ipd_weak (cmos25_ipd_weak_Max.) (uA) [9.5, 39]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	25.868	26.190	26.999	0.184	25.829	26.368	27.115	0.188
7973	30 krad	25.426	25.793	26.395	0.225	25.503	25.992	26.563	0.233
7992	30 krad	25.428	25.826	26.471	0.188	25.610	26.039	26.679	0.194
7942	50 krad	24.833	25.168	25.845	0.199	25.074	25.455	26.180	0.200
7956	50 krad	24.925	25.498	26.320	0.255	25.284	25.760	26.579	0.255
7972	50 krad	25.745	26.211	27.007	0.281	25.857	26.422	27.232	0.290
7926	60 krad	25.568	26.079	26.823	0.252	25.798	26.374	27.065	0.253

**Table 6c Pre-Irradiation and Post-Annealing Ipd**

Testname		cmos18_ipd_weak (cmos18_ipd_weak_Min.) (uA) [4.1, 16]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	9.620	9.855	10.172	0.084	9.556	9.938	10.263	0.097
7973	30 krad	9.420	9.658	9.903	0.094	9.380	9.741	10.031	0.108
7992	30 krad	9.470	9.678	9.988	0.086	9.513	9.778	10.115	0.099
7942	50 krad	9.198	9.425	9.698	0.096	9.263	9.552	9.865	0.104
7956	50 krad	9.244	9.565	9.920	0.111	9.385	9.693	10.004	0.116
7972	50 krad	9.581	9.836	10.181	0.120	9.571	9.942	10.319	0.133
7926	60 krad	9.512	9.786	10.121	0.108	9.546	9.931	10.269	0.119

**Table 6d Pre-Irradiation and Post-Annealing Ipd**

Testname		cmos18_ipd_weak (cmos18_ipd_weak_Max.) (uA) [4.1, 20]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	12.259	12.441	12.849	0.099	12.163	12.550	12.908	0.107
7973	30 krad	11.998	12.222	12.519	0.115	11.963	12.343	12.651	0.124
7992	30 krad	12.026	12.244	12.573	0.099	12.067	12.367	12.738	0.112
7942	50 krad	11.650	11.929	12.267	0.109	11.757	12.099	12.513	0.116
7956	50 krad	11.678	12.087	12.532	0.133	11.934	12.253	12.623	0.137
7972	50 krad	12.172	12.443	12.873	0.146	12.191	12.586	13.013	0.153
7926	60 krad	12.099	12.364	12.758	0.129	12.141	12.539	12.948	0.141

**Table 6e Pre-Irradiation and Post-Annealing Ipd (Continued)**

Testname		cmos15_ipd_weak (cmos15_ipd_weak_minU) (uA) [2.4, 21.7]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	5.964	6.104	6.329	0.060	5.844	6.181	6.372	0.078
7973	30 krad	5.771	5.969	6.157	0.065	5.765	6.057	6.237	0.080
7992	30 krad	5.827	5.993	6.245	0.065	5.853	6.077	6.321	0.080
7942	50 krad	5.625	5.825	6.062	0.069	5.672	5.936	6.217	0.079
7956	50 krad	5.657	5.921	6.129	0.078	5.775	6.031	6.267	0.088
7972	50 krad	5.883	6.091	6.308	0.078	5.803	6.178	6.446	0.098
7926	60 krad	5.827	6.055	6.299	0.075	5.889	6.180	6.387	0.084

**Table 6f Pre-Irradiation and Post-Annealing Ipd**

Testname		cmos15_ipd_weak (cmos15_ipd_weak_maxU) (uA) [2.4, 21.7]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	8.327	8.524	8.790	0.073	8.227	8.600	8.866	0.088
7973	30 krad	8.141	8.350	8.586	0.082	8.051	8.426	8.716	0.094
7992	30 krad	8.191	8.374	8.658	0.078	8.199	8.461	8.741	0.090
7942	50 krad	7.958	8.152	8.388	0.085	8.016	8.258	8.541	0.090
7956	50 krad	7.940	8.275	8.535	0.098	8.124	8.385	8.642	0.107
7972	50 krad	8.316	8.517	8.801	0.105	8.298	8.608	8.966	0.120
7926	60 krad	8.201	8.462	8.765	0.095	8.210	8.587	8.886	0.107

**Table 6g Pre-Irradiation and Post-Annealing Ipd**

Testname		cmos12_ipd_weak (cmos12_ipd_weak_minU) (uA) [0.85, 21.7]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	3.349	3.492	3.664	0.048	3.187	3.531	3.732	0.070
7973	30 krad	3.223	3.398	3.513	0.046	3.136	3.436	3.704	0.070
7992	30 krad	3.304	3.433	3.642	0.051	3.212	3.474	3.708	0.070
7942	50 krad	3.148	3.318	3.482	0.056	3.124	3.380	3.569	0.069
7956	50 krad	3.212	3.386	3.539	0.055	3.220	3.451	3.644	0.070
7972	50 krad	3.324	3.475	3.616	0.055	3.262	3.524	3.769	0.076
7926	60 krad	3.299	3.459	3.591	0.052	3.283	3.536	3.805	0.071

**Table 6h Pre-Irradiation and Post-Annealing IpD**

Testname		cmos12_ipd_weak (cmos12_ipd_weak_maxU) ( $\mu$ A) [1.4, 15.8]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	4.487	4.631	4.793	0.051	4.365	4.679	4.875	0.071
7973	30 krad	4.352	4.518	4.688	0.054	4.315	4.566	4.784	0.074
7992	30 krad	4.402	4.546	4.743	0.057	4.356	4.598	4.811	0.070
7942	50 krad	4.241	4.414	4.568	0.058	4.265	4.476	4.669	0.074
7956	50 krad	4.252	4.490	4.671	0.063	4.331	4.570	4.743	0.078
7972	50 krad	4.458	4.619	4.793	0.066	4.356	4.675	4.943	0.086
7926	60 krad	4.377	4.591	4.768	0.064	4.393	4.680	4.884	0.077

**Table 6i Pre-Irradiation and Post-Annealing IpD**

Testname		lvttl_ipd_weak_ (lvttl_ipd_weak_Min.) ( $\mu$ A) [8.9, 27]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	17.131	17.407	17.957	0.122	17.128	17.508	18.011	0.130
7973	30 krad	16.921	17.195	17.593	0.146	16.853	17.301	17.745	0.156
7992	30 krad	16.902	17.183	17.631	0.124	16.973	17.305	17.760	0.131
7942	50 krad	16.495	16.782	17.205	0.129	16.670	16.943	17.410	0.132
7956	50 krad	16.570	16.975	17.555	0.162	16.757	17.119	17.661	0.165
7972	50 krad	17.107	17.444	18.010	0.185	17.132	17.567	18.110	0.191
7926	60 krad	16.972	17.333	17.768	0.158	17.091	17.518	17.941	0.165

**Table 6j Pre-Irradiation and Post-Annealing IpD**

Testname		lvttl_ipd_weak_ (lvttl_ipd_weak_Max.) ( $\mu$ A) [8.9, 29]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	18.908	19.174	19.740	0.124	18.833	19.283	19.832	0.137
7973	30 krad	18.708	18.986	19.378	0.152	18.708	19.119	19.524	0.163
7992	30 krad	18.727	18.974	19.475	0.125	18.780	19.121	19.609	0.136
7942	50 krad	18.268	18.532	18.943	0.132	18.454	18.714	19.259	0.137
7956	50 krad	18.402	18.760	19.414	0.167	18.589	18.914	19.457	0.173
7972	50 krad	18.920	19.213	19.766	0.185	18.944	19.364	19.884	0.194
7926	60 krad	18.765	19.137	19.625	0.164	18.912	19.323	19.782	0.169

## E. High Output-Drive Voltage (VOH and I<sub>p</sub>)

The pre-irradiation and post-annealing VOH are listed in Table 7a through Table 8j. The post-annealing data are within the specification limits (specification minimum and maximum are shown in brackets); data are presented with statistics of all I/O pins used (~340 sample size of each DUT). In each case, the post-annealing data vary insignificantly.

**Table 7a Pre-Irradiation and Post-Annealing VOH (V)**

Testname		hstli_voh_4x (V) [1, 1.5]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	1.094	1.118	1.130	0.005	1.096	1.120	1.131	0.005
7973	30 krad	1.088	1.114	1.125	0.005	1.091	1.116	1.127	0.005
7992	30 krad	1.095	1.120	1.132	0.005	1.098	1.123	1.133	0.005
7942	50 krad	1.090	1.117	1.130	0.005	1.093	1.120	1.132	0.005
7956	50 krad	1.097	1.122	1.134	0.005	1.100	1.125	1.136	0.005
7972	50 krad	1.086	1.113	1.124	0.005	1.090	1.115	1.125	0.005
7926	60 krad	1.092	1.117	1.127	0.005	1.095	1.119	1.129	0.005

**Table 7b Pre-Irradiation and Post-Annealing VOH (V)**

Testname		hstlii_voh_5x (V) [1, 1.5]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	1.095	1.120	1.133	0.007	1.097	1.122	1.135	0.006
7973	30 krad	1.094	1.116	1.129	0.006	1.096	1.118	1.131	0.006
7992	30 krad	1.096	1.121	1.135	0.007	1.099	1.124	1.136	0.006
7942	50 krad	1.084	1.119	1.133	0.007	1.097	1.121	1.134	0.006
7956	50 krad	1.101	1.123	1.136	0.006	1.104	1.126	1.138	0.006
7972	50 krad	1.092	1.115	1.128	0.006	1.094	1.117	1.129	0.006
7926	60 krad	1.095	1.119	1.132	0.007	1.098	1.121	1.133	0.006

**Table 7c Pre-Irradiation and Post-Annealing VOH (V)**

Testname		sstl2i_voh_4x (V) [1.68, 3]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	1.925	1.950	1.964	0.007	1.924	1.949	1.963	0.006
7973	30 krad	1.925	1.947	1.960	0.006	1.925	1.947	1.960	0.006
7992	30 krad	1.928	1.952	1.966	0.007	1.927	1.952	1.965	0.006
7942	50 krad	1.914	1.950	1.964	0.007	1.926	1.950	1.964	0.006
7956	50 krad	1.931	1.954	1.968	0.006	1.932	1.954	1.967	0.006
7972	50 krad	1.922	1.946	1.958	0.007	1.922	1.945	1.958	0.006
7926	60 krad	1.925	1.949	1.963	0.007	1.926	1.949	1.962	0.006

**Table 7d Pre-Irradiation and Post-Annealing VOH (V)**

Testname		sstl2ii_voh_5x (V) [1.87, 2.5]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	2.040	2.070	2.083	0.007	2.039	2.069	2.082	0.007
7973	30 krad	2.041	2.068	2.082	0.007	2.040	2.068	2.081	0.007
7992	30 krad	2.041	2.070	2.085	0.008	2.041	2.070	2.083	0.007
7942	50 krad	2.027	2.070	2.084	0.008	2.040	2.070	2.083	0.007
7956	50 krad	2.044	2.072	2.086	0.007	2.044	2.072	2.085	0.007
7972	50 krad	2.039	2.067	2.081	0.007	2.038	2.067	2.080	0.007
7926	60 krad	2.040	2.069	2.083	0.007	2.040	2.068	2.082	0.007

**Table 7e Pre-Irradiation and Post-Annealing VOH (V)**

Testname		sstl3i_voh_2x (V) [1.9, 3]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	2.286	2.318	2.336	0.008	2.285	2.318	2.335	0.008
7973	30 krad	2.279	2.313	2.330	0.008	2.279	2.313	2.329	0.008
7992	30 krad	2.289	2.323	2.343	0.008	2.291	2.325	2.342	0.008
7942	50 krad	2.282	2.318	2.341	0.009	2.283	2.319	2.340	0.008
7956	50 krad	2.292	2.328	2.347	0.008	2.294	2.329	2.346	0.008
7972	50 krad	2.276	2.309	2.328	0.008	2.277	2.309	2.326	0.007
7926	60 krad	2.284	2.317	2.335	0.008	2.285	2.317	2.335	0.008

**Table 7f Pre-Irradiation and Post-Annealing VOH (V)**

Testname		sstl3ii_voh_3x (V) [2.1, 3]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	2.432	2.467	2.488	0.009	2.432	2.467	2.486	0.009
7973	30 krad	2.432	2.464	2.484	0.009	2.433	2.464	2.483	0.008
7992	30 krad	2.436	2.471	2.492	0.010	2.437	2.471	2.490	0.009
7942	50 krad	2.417	2.468	2.490	0.010	2.434	2.468	2.488	0.009
7956	50 krad	2.441	2.474	2.495	0.009	2.443	2.475	2.493	0.008
7972	50 krad	2.428	2.461	2.481	0.009	2.428	2.461	2.479	0.009
7926	60 krad	2.433	2.467	2.488	0.009	2.434	2.466	2.486	0.009

**Table 7g Pre-Irradiation and Post-Annealing VOH (V)**

Testname		cmos25_voh_1x (V) [1.7, 2.5]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	1.838	1.860	1.872	0.005	1.839	1.860	1.872	0.004
7973	30 krad	1.832	1.855	1.867	0.005	1.832	1.855	1.868	0.005
7992	30 krad	1.840	1.863	1.878	0.005	1.841	1.864	1.877	0.004
7942	50 krad	1.834	1.859	1.875	0.005	1.836	1.860	1.875	0.005
7956	50 krad	1.842	1.866	1.879	0.005	1.843	1.867	1.880	0.005
7972	50 krad	1.830	1.853	1.866	0.004	1.830	1.853	1.866	0.004
7926	60 krad	1.836	1.859	1.870	0.005	1.837	1.859	1.871	0.005

**Table 7h Pre-Irradiation and Post-Annealing VOH (V)**

Testname		cmos25_voh_2x (V) [1.7, 2.5]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	1.822	1.847	1.860	0.005	1.822	1.847	1.859	0.005
7973	30 krad	1.816	1.843	1.856	0.005	1.817	1.843	1.855	0.005
7992	30 krad	1.825	1.850	1.865	0.005	1.825	1.851	1.864	0.005
7942	50 krad	1.819	1.846	1.862	0.006	1.820	1.847	1.862	0.006
7956	50 krad	1.827	1.853	1.867	0.005	1.827	1.854	1.867	0.005
7972	50 krad	1.814	1.841	1.854	0.005	1.815	1.840	1.853	0.005
7926	60 krad	1.821	1.846	1.858	0.005	1.821	1.846	1.857	0.005

**Table 7i Pre-Irradiation and Post-Annealing VOH (V)**

Testname		cmos25_voh_3x (V) [1.8, 2.5]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	1.931	1.951	1.963	0.006	1.930	1.950	1.962	0.005
7973	30 krad	1.927	1.948	1.959	0.005	1.927	1.948	1.959	0.005
7992	30 krad	1.932	1.953	1.965	0.006	1.933	1.953	1.965	0.005
7942	50 krad	1.922	1.951	1.963	0.006	1.929	1.951	1.963	0.006
7956	50 krad	1.934	1.955	1.967	0.005	1.934	1.955	1.967	0.005
7972	50 krad	1.925	1.947	1.958	0.006	1.925	1.946	1.957	0.005
7926	60 krad	1.930	1.950	1.962	0.006	1.929	1.950	1.961	0.005

**Table 7j Pre-Irradiation and Post-Annealing VOH (V)**

Testname		cmos25_voh_4x (V) [1.7, 2.5]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	1.898	1.924	1.939	0.007	1.897	1.923	1.938	0.007
7973	30 krad	1.898	1.921	1.935	0.007	1.897	1.921	1.935	0.006
7992	30 krad	1.900	1.926	1.942	0.007	1.900	1.926	1.940	0.007
7942	50 krad	1.886	1.924	1.939	0.007	1.897	1.924	1.939	0.007
7956	50 krad	1.904	1.929	1.943	0.007	1.904	1.929	1.943	0.006
7972	50 krad	1.895	1.920	1.933	0.007	1.894	1.919	1.932	0.006
7926	60 krad	1.899	1.923	1.938	0.007	1.898	1.923	1.937	0.007

**Table 7k Pre-Irradiation and Post-Annealing VOH (V)**

Testname		cmos25_voh_5x (V) [1.7, 2.5]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	1.949	1.989	2.008	0.010	1.948	1.988	2.006	0.009
7973	30 krad	1.951	1.987	2.006	0.009	1.950	1.987	2.004	0.009
7992	30 krad	1.946	1.990	2.010	0.011	1.951	1.990	2.008	0.009
7942	50 krad	1.932	1.989	2.009	0.010	1.950	1.989	2.007	0.009
7956	50 krad	1.955	1.992	2.011	0.010	1.955	1.992	2.010	0.009
7972	50 krad	1.948	1.985	2.004	0.010	1.947	1.985	2.002	0.009
7926	60 krad	1.950	1.988	2.008	0.010	1.950	1.987	2.005	0.009

**Table 7l Pre-Irradiation and Post-Annealing VOH (V)**

Testname		cmos18_voh_1x (V) [1.28, 2]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	1.360	1.381	1.391	0.004	1.361	1.380	1.391	0.003
7973	30 krad	1.355	1.376	1.387	0.004	1.355	1.377	1.387	0.004
7992	30 krad	1.361	1.383	1.394	0.004	1.362	1.383	1.394	0.004
7942	50 krad	1.357	1.380	1.392	0.004	1.358	1.380	1.392	0.004
7956	50 krad	1.363	1.385	1.395	0.004	1.363	1.385	1.396	0.004
7972	50 krad	1.354	1.376	1.386	0.004	1.354	1.376	1.386	0.004
7926	60 krad	1.358	1.380	1.389	0.004	1.359	1.379	1.389	0.004

**Table 7m Pre-Irradiation and Post-Annealing  $V_{OH}$  (V) (Continued)**

Testname		cmos18_voh_2x (V) [1.27, 2]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	1.352	1.374	1.385	0.004	1.352	1.374	1.384	0.004
7973	30 krad	1.347	1.370	1.381	0.004	1.348	1.370	1.380	0.004
7992	30 krad	1.354	1.376	1.387	0.004	1.354	1.376	1.387	0.004
7942	50 krad	1.349	1.373	1.386	0.004	1.350	1.373	1.386	0.004
7956	50 krad	1.355	1.378	1.389	0.004	1.356	1.378	1.389	0.004
7972	50 krad	1.346	1.369	1.380	0.004	1.347	1.369	1.380	0.004
7926	60 krad	1.351	1.373	1.383	0.004	1.351	1.373	1.382	0.004

**Table 7n Pre-Irradiation and Post-Annealing VOH (V)**

Testname		cmos18_voh_3x (V) [1.25, 2]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	1.336	1.361	1.372	0.005	1.336	1.360	1.370	0.005
7973	30 krad	1.332	1.357	1.368	0.005	1.331	1.357	1.367	0.005
7992	30 krad	1.338	1.363	1.375	0.005	1.338	1.363	1.373	0.005
7942	50 krad	1.333	1.360	1.373	0.005	1.334	1.360	1.372	0.005
7956	50 krad	1.339	1.365	1.377	0.005	1.340	1.365	1.375	0.005
7972	50 krad	1.330	1.356	1.367	0.005	1.330	1.355	1.366	0.005
7926	60 krad	1.335	1.360	1.370	0.005	1.335	1.359	1.369	0.005

**Table 7o Pre-Irradiation and Post-Annealing VOH (V)**

Testname		cmos18_voh_5x V [1.26, 2]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	1.452	1.472	1.482	0.005	1.451	1.472	1.481	0.005
7973	30 krad	1.453	1.471	1.480	0.005	1.452	1.470	1.479	0.005
7992	30 krad	1.449	1.473	1.483	0.005	1.453	1.473	1.482	0.005
7942	50 krad	1.444	1.472	1.482	0.005	1.452	1.472	1.481	0.005
7956	50 krad	1.456	1.475	1.484	0.005	1.456	1.474	1.483	0.005
7972	50 krad	1.452	1.470	1.479	0.005	1.451	1.469	1.478	0.005
7926	60 krad	1.453	1.472	1.481	0.005	1.452	1.471	1.480	0.005

**Table 7p Pre-Irradiation and Post-Annealing VOH (V)**

Testname		cmos15_voh_2x (V) [1.05, 2]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	1.224	1.238	1.245	0.002	1.226	1.240	1.246	0.002
7973	30 krad	1.221	1.236	1.242	0.002	1.224	1.238	1.245	0.002
7992	30 krad	1.225	1.239	1.246	0.002	1.228	1.242	1.248	0.002
7942	50 krad	1.222	1.237	1.246	0.003	1.225	1.240	1.247	0.003
7956	50 krad	1.226	1.240	1.247	0.002	1.228	1.243	1.249	0.002
7972	50 krad	1.220	1.235	1.242	0.002	1.223	1.237	1.244	0.002
7926	60 krad	1.223	1.237	1.244	0.002	1.226	1.239	1.245	0.002

**Table 7q Pre-Irradiation and Post-Annealing VOH (V)**

Testname		cmos15_voh_3x (V) [1.05, 2]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	1.216	1.231	1.239	0.003	1.219	1.233	1.240	0.003
7973	30 krad	1.213	1.229	1.236	0.003	1.215	1.231	1.238	0.003
7992	30 krad	1.217	1.232	1.240	0.003	1.219	1.235	1.242	0.003
7942	50 krad	1.214	1.231	1.239	0.003	1.217	1.233	1.240	0.003
7956	50 krad	1.218	1.234	1.241	0.003	1.221	1.236	1.243	0.003
7972	50 krad	1.212	1.229	1.236	0.003	1.215	1.231	1.238	0.003
7926	60 krad	1.215	1.231	1.237	0.003	1.218	1.233	1.239	0.003

**Table 7r Pre-Irradiation and Post-Annealing VOH (V)**

Testname		cmos15_voh_4x (V) [1.05, 2]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	1.180	1.196	1.203	0.003	1.182	1.198	1.205	0.003
7973	30 krad	1.176	1.193	1.201	0.003	1.179	1.195	1.202	0.003
7992	30 krad	1.181	1.197	1.205	0.004	1.183	1.200	1.207	0.003
7942	50 krad	1.178	1.195	1.204	0.004	1.181	1.198	1.206	0.003
7956	50 krad	1.182	1.199	1.207	0.003	1.185	1.201	1.209	0.003
7972	50 krad	1.175	1.192	1.200	0.003	1.178	1.194	1.201	0.003
7926	60 krad	1.179	1.195	1.202	0.003	1.181	1.197	1.204	0.003

**Table 7s Pre-Irradiation and Post-Annealing VOH (V)**

Testname		cmos15_voh_5x (V) [1.05, 2]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	1.161	1.181	1.191	0.005	1.162	1.183	1.193	0.005
7973	30 krad	1.160	1.178	1.188	0.005	1.162	1.180	1.190	0.005
7992	30 krad	1.160	1.182	1.192	0.005	1.165	1.184	1.194	0.005
7942	50 krad	1.152	1.180	1.191	0.005	1.163	1.182	1.192	0.005
7956	50 krad	1.165	1.184	1.194	0.005	1.167	1.186	1.196	0.005
7972	50 krad	1.159	1.177	1.187	0.005	1.161	1.179	1.189	0.005
7926	60 krad	1.162	1.180	1.190	0.005	1.163	1.182	1.192	0.005

**Table 7t Pre-Irradiation and Post-Annealing VOH (V)**

Testname		cmos12_voh_2x (V) [0.855, 2]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	0.894	0.925	0.938	0.005	0.894	0.924	0.937	0.005
7973	30 krad	0.887	0.920	0.933	0.005	0.887	0.919	0.932	0.005
7992	30 krad	0.896	0.927	0.941	0.005	0.896	0.926	0.940	0.005
7942	50 krad	0.889	0.923	0.938	0.006	0.890	0.923	0.938	0.005
7956	50 krad	0.897	0.929	0.942	0.005	0.897	0.929	0.941	0.005
7972	50 krad	0.886	0.920	0.933	0.005	0.886	0.919	0.932	0.005
7926	60 krad	0.891	0.924	0.937	0.005	0.892	0.923	0.935	0.005

**Table 7u Pre-Irradiation and Post-Annealing VOH (V)**

Testname		cmos12_voh_3x (V) [0.855, 2]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	1.027	1.039	1.045	0.002	1.026	1.038	1.043	0.002
7973	30 krad	1.024	1.037	1.042	0.002	1.024	1.036	1.041	0.002
7992	30 krad	1.028	1.039	1.045	0.002	1.027	1.039	1.044	0.002
7942	50 krad	1.025	1.038	1.044	0.002	1.025	1.037	1.043	0.002
7956	50 krad	1.028	1.040	1.045	0.002	1.028	1.039	1.044	0.002
7972	50 krad	1.024	1.037	1.042	0.002	1.024	1.036	1.041	0.002
7926	60 krad	1.026	1.038	1.043	0.002	1.026	1.037	1.042	0.002

**Table 7v Pre-Irradiation and Post-Annealing VOH (V)**

Testname		cmos12_voh_3xE1 (V) [1.04, 2]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	1.134	1.135	1.136	0.000	1.133	1.135	1.135	0.000
7973	30 krad	1.134	1.135	1.136	0.000	1.133	1.134	1.135	0.000
7992	30 krad	1.134	1.135	1.136	0.000	1.134	1.135	1.136	0.000
7942	50 krad	1.134	1.135	1.136	0.000	1.133	1.134	1.135	0.000
7956	50 krad	1.134	1.135	1.136	0.000	1.134	1.135	1.135	0.000
7972	50 krad	1.134	1.135	1.136	0.000	1.133	1.134	1.135	0.000
7926	60 krad	1.134	1.135	1.136	0.000	1.134	1.134	1.135	0.000

**Table 7w Pre-Irradiation and Post-Annealing VOH (V)**

Testname		cmos12_voh_3xE2 (V) [1.3, 2]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	1.394	1.395	1.395	0.000	1.395	1.396	1.397	0.000
7973	30 krad	1.394	1.394	1.395	0.000	1.395	1.396	1.397	0.000
7992	30 krad	1.394	1.395	1.395	0.000	1.395	1.396	1.397	0.000
7942	50 krad	1.394	1.394	1.395	0.000	1.396	1.396	1.397	0.000
7956	50 krad	1.394	1.395	1.395	0.000	1.395	1.396	1.397	0.000
7972	50 krad	1.394	1.394	1.395	0.000	1.395	1.396	1.397	0.000
7926	60 krad	1.394	1.394	1.395	0.000	1.395	1.396	1.397	0.000

**Table 7x Pre-Irradiation and Post-Annealing VOH (V)**

Testname		lvttl_voh_1x12 (V) [2.48, 3]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	2.632	2.644	2.652	0.003	2.632	2.645	2.652	0.003
7973	30 krad	2.628	2.642	2.649	0.003	2.629	2.642	2.650	0.003
7992	30 krad	2.633	2.647	2.656	0.003	2.634	2.648	2.656	0.003
7942	50 krad	2.630	2.644	2.654	0.003	2.631	2.645	2.654	0.003
7956	50 krad	2.635	2.649	2.657	0.003	2.636	2.650	2.657	0.003
7972	50 krad	2.627	2.640	2.648	0.003	2.627	2.640	2.647	0.003
7926	60 krad	2.631	2.644	2.652	0.003	2.632	2.644	2.653	0.003

**Table 7y Pre-Irradiation and Post-Annealing VOH (V)**

Testname		lvttl_voh_1x (V) [2.48, 3]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	2.632	2.644	2.652	0.003	2.632	2.645	2.652	0.003
7973	30 krad	2.628	2.642	2.650	0.003	2.629	2.642	2.650	0.003
7992	30 krad	2.634	2.647	2.656	0.003	2.634	2.648	2.656	0.003
7942	50 krad	2.630	2.645	2.654	0.003	2.631	2.645	2.654	0.003
7956	50 krad	2.635	2.649	2.657	0.003	2.636	2.650	2.657	0.003
7972	50 krad	2.627	2.640	2.648	0.003	2.627	2.640	2.648	0.003
7926	60 krad	2.631	2.644	2.653	0.003	2.632	2.644	2.653	0.003

**Table 7z Pre-Irradiation and Post-Annealing VOH (V)**

Testname		lvttl_voh_1xE1 (V) [2.8, 3]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	2.991	2.992	2.992	0.000	2.991	2.992	2.992	0.000
7973	30 krad	2.991	2.992	2.992	0.000	2.991	2.992	2.993	0.000
7992	30 krad	2.991	2.992	2.992	0.000	2.991	2.992	2.992	0.000
7942	50 krad	2.991	2.992	2.992	0.000	2.991	2.992	2.992	0.000
7956	50 krad	2.991	2.992	2.992	0.000	2.991	2.992	2.993	0.000
7972	50 krad	2.991	2.992	2.992	0.000	2.991	2.992	2.992	0.000
7926	60 krad	2.991	2.992	2.992	0.000	2.991	2.992	2.992	0.000

**Table 7aa Pre-Irradiation and Post-Annealing VOH (V)**

Testname		lvttl_voh_1xE2 (V) [2.5, 3]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	2.689	2.689	2.690	0.000	2.691	2.692	2.692	0.000
7973	30 krad	2.689	2.689	2.690	0.000	2.691	2.692	2.692	0.000
7992	30 krad	2.689	2.689	2.690	0.000	2.691	2.692	2.692	0.000
7942	50 krad	2.689	2.689	2.690	0.000	2.691	2.692	2.693	0.000
7956	50 krad	2.689	2.689	2.690	0.000	2.691	2.692	2.692	0.000
7972	50 krad	2.688	2.689	2.690	0.000	2.691	2.692	2.692	0.000
7926	60 krad	2.689	2.689	2.690	0.000	2.691	2.692	2.692	0.000

**Table 7ab Pre-Irradiation and Post-Annealing VOH (V)**

Testname		lvttl_voh_2x (V) [2.5, 3]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	2.616	2.631	2.643	0.004	2.616	2.631	2.640	0.004
7973	30 krad	2.612	2.629	2.640	0.004	2.613	2.629	2.638	0.004
7992	30 krad	2.617	2.634	2.646	0.005	2.619	2.635	2.643	0.004
7942	50 krad	2.612	2.632	2.644	0.005	2.616	2.632	2.642	0.004
7956	50 krad	2.620	2.637	2.648	0.004	2.620	2.637	2.646	0.004
7972	50 krad	2.611	2.627	2.638	0.004	2.612	2.627	2.635	0.004
7926	60 krad	2.615	2.631	2.643	0.005	2.615	2.631	2.640	0.004

**Table 7ac Pre-Irradiation and Post-Annealing VOH (V)**

Testname		lvttl_voh_3x (V) [2.4, 3]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	2.687	2.707	2.718	0.005	2.687	2.707	2.717	0.005
7973	30 krad	2.687	2.706	2.716	0.005	2.687	2.706	2.716	0.005
7992	30 krad	2.689	2.709	2.720	0.005	2.689	2.709	2.719	0.005
7942	50 krad	2.679	2.707	2.719	0.006	2.688	2.707	2.718	0.005
7956	50 krad	2.692	2.710	2.721	0.005	2.692	2.711	2.721	0.005
7972	50 krad	2.685	2.704	2.714	0.005	2.685	2.704	2.714	0.005
7926	60 krad	2.688	2.707	2.718	0.005	2.688	2.706	2.717	0.005

**Table 7ad Pre-Irradiation and Post-Annealing VOH (V)**

Testname		lvttl_voh_4x (V) [2.4, 3]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	2.657	2.683	2.697	0.007	2.656	2.683	2.696	0.006
7973	30 krad	2.657	2.682	2.694	0.006	2.657	2.681	2.694	0.006
7992	30 krad	2.659	2.685	2.698	0.007	2.659	2.685	2.698	0.006
7942	50 krad	2.645	2.683	2.698	0.007	2.657	2.683	2.696	0.006
7956	50 krad	2.662	2.687	2.700	0.006	2.662	2.687	2.700	0.006
7972	50 krad	2.655	2.680	2.693	0.007	2.655	2.680	2.692	0.006
7926	60 krad	2.658	2.683	2.696	0.007	2.657	2.682	2.695	0.006

**Table 7ae Pre-Irradiation and Post-Annealing VOH (V)**

Testname		lvttl_voh_5x (V) [2.4, 3]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	2.689	2.728	2.747	0.010	2.689	2.728	2.745	0.009
7973	30 krad	2.691	2.728	2.746	0.009	2.691	2.728	2.745	0.009
7992	30 krad	2.691	2.729	2.748	0.010	2.691	2.730	2.747	0.009
7942	50 krad	2.672	2.729	2.748	0.010	2.690	2.729	2.745	0.009
7956	50 krad	2.694	2.731	2.750	0.010	2.695	2.731	2.748	0.009
7972	50 krad	2.689	2.726	2.744	0.010	2.688	2.726	2.742	0.009
7926	60 krad	2.691	2.728	2.747	0.010	2.691	2.728	2.745	0.009

**Table 8a Pre-Irradiation and Post-Annealing Ipu**

Testname		cmos25_ipu_weak (cmos25_ipu_weak_Min.) (uA) [-80, -10]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	-28.399	-27.672	-27.030	0.240	-28.191	-27.522	-26.936	0.244
7973	30 krad	-27.940	-27.109	-26.241	0.333	-27.866	-27.021	-26.216	0.332
7992	30 krad	-28.334	-27.635	-26.904	0.247	-28.298	-27.533	-26.864	0.245
7942	50 krad	-27.907	-27.264	-26.252	0.269	-27.874	-27.125	-26.267	0.264
7956	50 krad	-28.706	-27.805	-26.825	0.277	-28.432	-27.667	-26.734	0.281
7972	50 krad	-27.901	-27.027	-26.392	0.256	-27.750	-26.883	-26.272	0.257
7926	60 krad	-28.199	-27.506	-26.771	0.228	-28.032	-27.277	-26.593	0.234

**Table 8b Pre-Irradiation and Post-Annealing Ipu**

Testname		cmos25_ipu_weak (cmos25_ipu_weak_Max.) (uA) [-85, -10]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	-49.359	-48.167	-47.139	0.408	-49.332	-48.072	-47.100	0.413
7973	30 krad	-48.618	-47.248	-45.799	0.555	-48.571	-47.233	-45.937	0.550
7992	30 krad	-49.133	-48.083	-46.917	0.406	-49.188	-48.074	-46.977	0.409
7942	50 krad	-48.689	-47.461	-45.916	0.451	-48.656	-47.374	-45.973	0.446
7956	50 krad	-49.808	-48.413	-46.811	0.471	-49.682	-48.310	-46.708	0.473
7972	50 krad	-48.623	-47.072	-46.026	0.441	-48.537	-46.964	-45.947	0.434
7926	60 krad	-49.041	-47.893	-46.765	0.384	-48.982	-47.676	-46.543	0.386

**Table 8c Pre-Irradiation and Post-Annealing Ipu**

Testname		cmos18_ipu_weak (cmos18_ipu_weak_minU) (uA) [-23, -6.5]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	-15.240	-14.833	-14.392	0.145	-15.160	-14.733	-14.326	0.153
7973	30 krad	-14.950	-14.445	-13.875	0.198	-14.897	-14.389	-13.927	0.198
7992	30 krad	-15.172	-14.777	-14.346	0.147	-15.145	-14.701	-14.256	0.155
7942	50 krad	-15.011	-14.573	-13.980	0.164	-15.005	-14.466	-13.989	0.165
7956	50 krad	-15.396	-14.881	-14.289	0.166	-15.254	-14.775	-14.175	0.168
7972	50 krad	-14.905	-14.441	-14.018	0.151	-14.819	-14.343	-13.947	0.152
7926	60 krad	-15.114	-14.685	-14.323	0.140	-15.022	-14.557	-14.167	0.142

**Table 8d Pre-Irradiation and Post-Annealing Ipu**

Testname		cmos18_ipu_weak (cmos18_ipu_weak_maxU) (uA) [-28, -6.5]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	-18.536	-18.059	-17.538	0.166	-18.524	-18.058	-17.605	0.174
7973	30 krad	-18.187	-17.637	-17.030	0.230	-18.252	-17.689	-17.157	0.231
7992	30 krad	-18.462	-18.013	-17.463	0.169	-18.578	-18.044	-17.562	0.174
7942	50 krad	-18.296	-17.775	-17.073	0.186	-18.328	-17.769	-17.190	0.186
7956	50 krad	-18.742	-18.129	-17.335	0.192	-18.724	-18.131	-17.446	0.194
7972	50 krad	-18.217	-17.612	-17.179	0.180	-18.203	-17.615	-17.122	0.176
7926	60 krad	-18.362	-17.927	-17.475	0.156	-18.428	-17.855	-17.371	0.165

**Table 8e Pre-Irradiation and Post-Annealing Ipu**

Testname		cmos15_ipu_weak (cmos15_ipu_weak_minU) (uA) [-21.7, -3.75]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	-9.881	-9.588	-9.304	0.105	-9.903	-9.591	-9.299	0.114
7973	30 krad	-9.653	-9.320	-8.954	0.133	-9.691	-9.345	-9.002	0.141
7992	30 krad	-9.869	-9.537	-9.196	0.106	-9.882	-9.561	-9.244	0.111
7942	50 krad	-9.720	-9.413	-9.052	0.112	-9.783	-9.397	-9.028	0.121
7956	50 krad	-9.952	-9.617	-9.204	0.117	-9.938	-9.606	-9.157	0.122
7972	50 krad	-9.640	-9.320	-9.004	0.106	-9.667	-9.319	-9.047	0.110
7926	60 krad	-9.760	-9.490	-9.247	0.098	-9.818	-9.444	-9.151	0.110

**Table 8f Pre-Irradiation and Post-Annealing Ipu**

Testname		cmos15_ipu_weak (cmos15_ipu_weak_maxU) (uA) [-21.7, -3.75]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	-13.278	-12.922	-12.528	0.128	-13.192	-12.838	-12.452	0.138
7973	30 krad	-13.007	-12.594	-12.083	0.177	-12.976	-12.539	-12.146	0.178
7992	30 krad	-13.212	-12.887	-12.463	0.135	-13.281	-12.812	-12.415	0.136
7942	50 krad	-13.080	-12.715	-12.220	0.145	-13.031	-12.609	-12.141	0.144
7956	50 krad	-13.448	-12.983	-12.401	0.148	-13.318	-12.880	-12.303	0.150
7972	50 krad	-13.032	-12.585	-12.209	0.135	-12.950	-12.505	-12.122	0.134
7926	60 krad	-13.137	-12.805	-12.438	0.123	-13.106	-12.679	-12.324	0.131

**Table 8g Pre-Irradiation and Post-Annealing Ipu**

Testname		cmos12_ipu_weak (cmos12_ipu_weak_minU) (uA) [-21.7, -1.43]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	-6.132	-5.938	-5.751	0.078	-6.167	-5.877	-5.651	0.087
7973	30 krad	-5.999	-5.750	-5.471	0.092	-6.025	-5.709	-5.449	0.104
7992	30 krad	-6.121	-5.902	-5.542	0.080	-6.159	-5.853	-5.562	0.088
7942	50 krad	-6.059	-5.817	-5.529	0.084	-6.059	-5.742	-5.489	0.092
7956	50 krad	-6.231	-5.958	-5.680	0.085	-6.149	-5.891	-5.611	0.094
7972	50 krad	-6.023	-5.744	-5.522	0.076	-5.941	-5.690	-5.472	0.084
7926	60 krad	-6.069	-5.868	-5.694	0.074	-6.058	-5.768	-5.553	0.085

**Table 8h Pre-Irradiation and Post-Annealing Ipu**

Testname		cmos12_ipu_weak (cmos12_ipu_weak_maxU) (uA) [-15.8, -3.75]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	-7.767	-7.555	-7.318	0.089	-7.785	-7.492	-7.223	0.099
7973	30 krad	-7.615	-7.329	-7.011	0.109	-7.600	-7.284	-6.993	0.120
7992	30 krad	-7.837	-7.512	-7.219	0.093	-7.858	-7.459	-7.147	0.102
7942	50 krad	-7.689	-7.410	-7.115	0.098	-7.684	-7.329	-6.986	0.103
7956	50 krad	-7.879	-7.580	-7.215	0.100	-7.813	-7.509	-7.179	0.107
7972	50 krad	-7.619	-7.330	-7.086	0.088	-7.545	-7.272	-7.009	0.096
7926	60 krad	-7.706	-7.470	-7.238	0.086	-7.729	-7.368	-7.162	0.097

**Table 8i Pre-Irradiation and Post-Annealing Ipu**

Testname		lvttl_ipu_weak_ (lvttl_ipu_weak_Min.) (uA) [-102, -12.7]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	-37.005	-36.093	-35.274	0.291	-36.806	-35.920	-35.192	0.296
7973	30 krad	-36.516	-35.505	-34.562	0.378	-36.417	-35.404	-34.500	0.377
7992	30 krad	-36.850	-36.069	-35.178	0.295	-36.869	-35.971	-35.210	0.292
7942	50 krad	-36.452	-35.613	-34.474	0.316	-36.369	-35.426	-34.445	0.311
7956	50 krad	-37.397	-36.319	-35.282	0.339	-37.208	-36.156	-35.123	0.338
7972	50 krad	-36.355	-35.312	-34.571	0.307	-36.287	-35.170	-34.472	0.308
7926	60 krad	-36.731	-35.942	-35.139	0.268	-36.597	-35.671	-34.884	0.277

**Table 8j Pre-Irradiation and Post-Annealing Ipu**

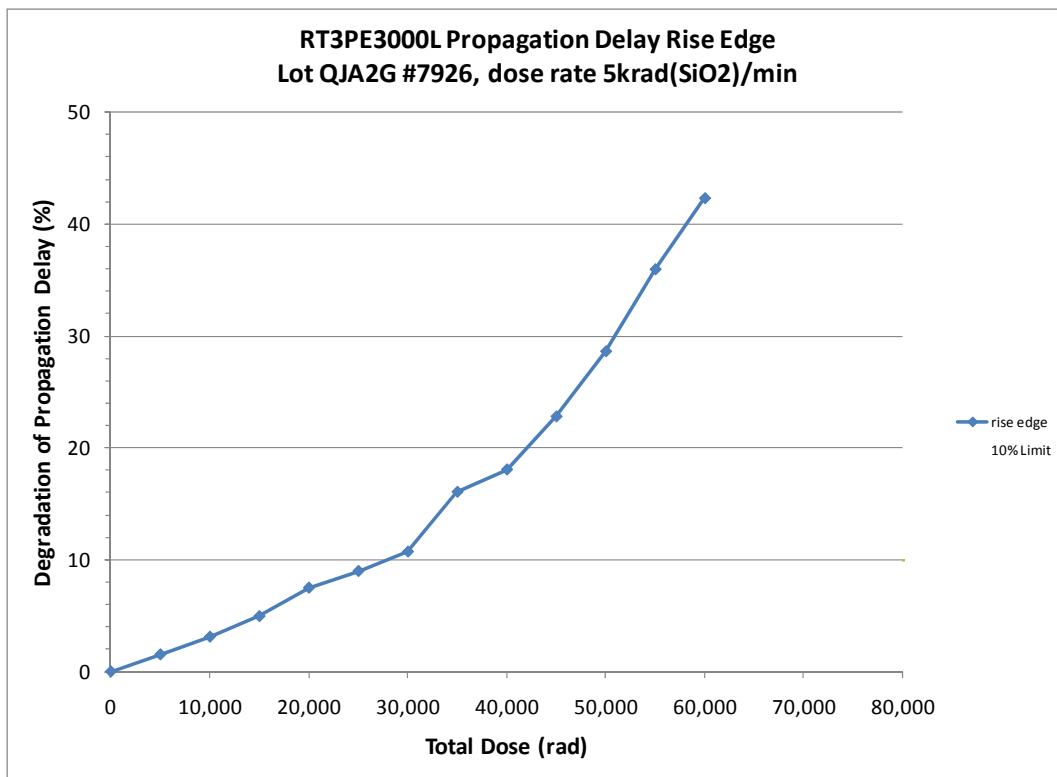
Testname		lvttl_ipu_weak_ (lvttl_ipu_weak_Max.) (uA) [-112, -12.7]							
DUT	Total Dose	Pre-Radiation				Post-Anneal			
		Min.	Median	Max.	Std. Dev.	Min.	Median	Max.	Std. Dev.
7943	30 krad	-75.576	-73.776	-72.328	0.578	-75.209	-73.514	-72.091	0.576
7973	30 krad	-74.733	-72.672	-70.977	0.736	-74.570	-72.520	-70.788	0.733
7992	30 krad	-75.307	-73.767	-72.152	0.566	-75.150	-73.603	-72.061	0.571
7942	50 krad	-74.668	-72.858	-70.785	0.619	-74.372	-72.561	-70.656	0.615
7956	50 krad	-76.355	-74.277	-72.286	0.662	-75.937	-73.981	-72.045	0.663
7972	50 krad	-74.413	-72.292	-70.905	0.617	-74.147	-72.024	-70.772	0.606
7926	60 krad	-75.086	-73.552	-72.122	0.536	-74.826	-73.110	-71.644	0.537

## F. Propagation Delay

DUTs are irradiated up to 30 or 50 krads after a characterization on DUT 7926 for logistic planning, where the delay degradation shows a near linear trend to the total dose below 30 krads, and the interpolated 10% degradation is at around 27.5 krads, as shown in Figure 2. The dose rate at 0.5 krads per minute on DUTs 7942 and 7943 does not bring on obvious difference other than 5 krads per minutes done on others. Only the total dose is labeled in data summary.

Table 9 lists the pre-irradiation, post-irradiation and post-annealing propagation delays, and also lists the radiation-induced degradations in percentage. Figures 3 and 4 with the data of all DUTs plotted show that they are expected to tolerate 25 krads before the interpolated 10% degradation is reached. It indicates all DUTs would pass 25 krads based on the 10% degradation criterion.

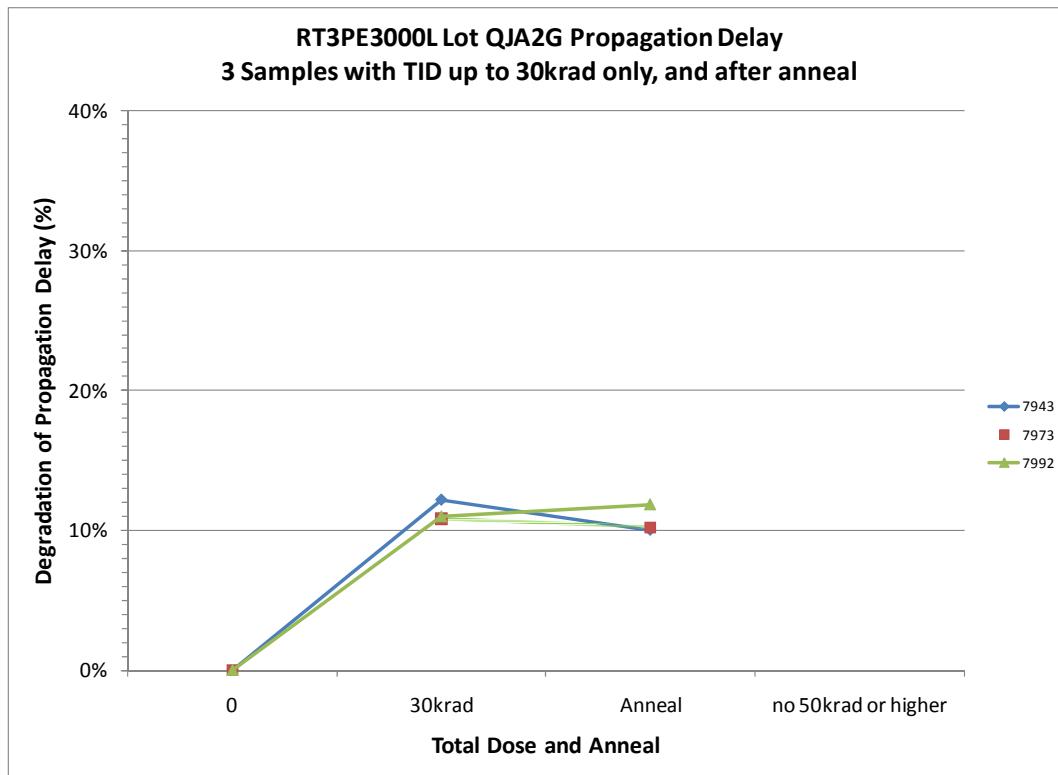
Microsemi recommends tying VPP to ground during operation. VCC at 1.2 V is expected to have a longer propagation delay compared to that at 1.5 V. However, the degradation in percentage is at around the same level.

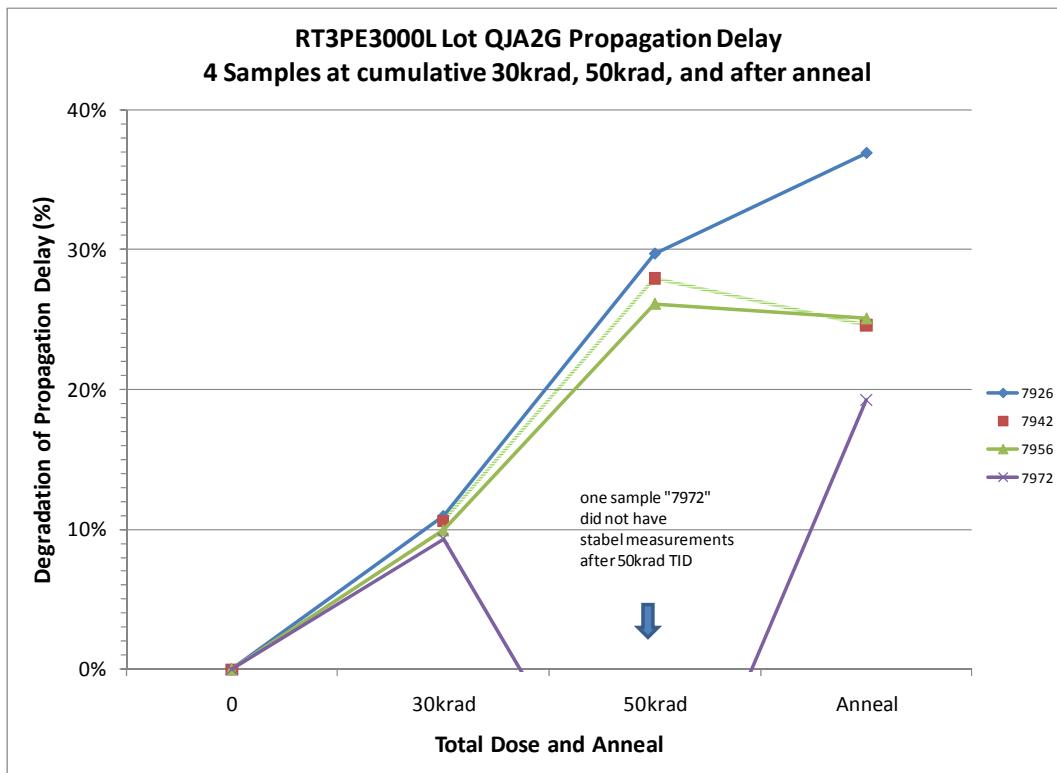


**Figure 2 Characterization on the Propagation Delay Degradation versus TID**

**Table 9 Radiation-Induced Propagation Delay Degradation**

DUT	Total Dose	Pre-Irradiation (ns)	Post-Irradiation (ns)	Post-Annealing (ns)	Degradation (%)
7943	30 krad	649	729	715	10.0%
7973	30 krad	640	709	705	10.2%
7992	30 krad	639	710	715	11.8%
7942	50 krad	646	827	806	24.6%
7956	50 krad	617	779	772	25.1%
7972	50 krad	656	549	782	19.2%
7926	60 krad	653	847	894	36.9%


**Figure 3 Propagation Delay Degradation versus TID and Anneal (3 DUTs up to 30 krads)**



**Figure 4 Propagation Delay Degradation versus TID and Anneal (4 DUTs up to 60 krads)**

## G. Transition Time

Figure 5a through Figure 18b show pre-irradiation and post-annealing transition edges. In each case, the radiation effect is not significant.

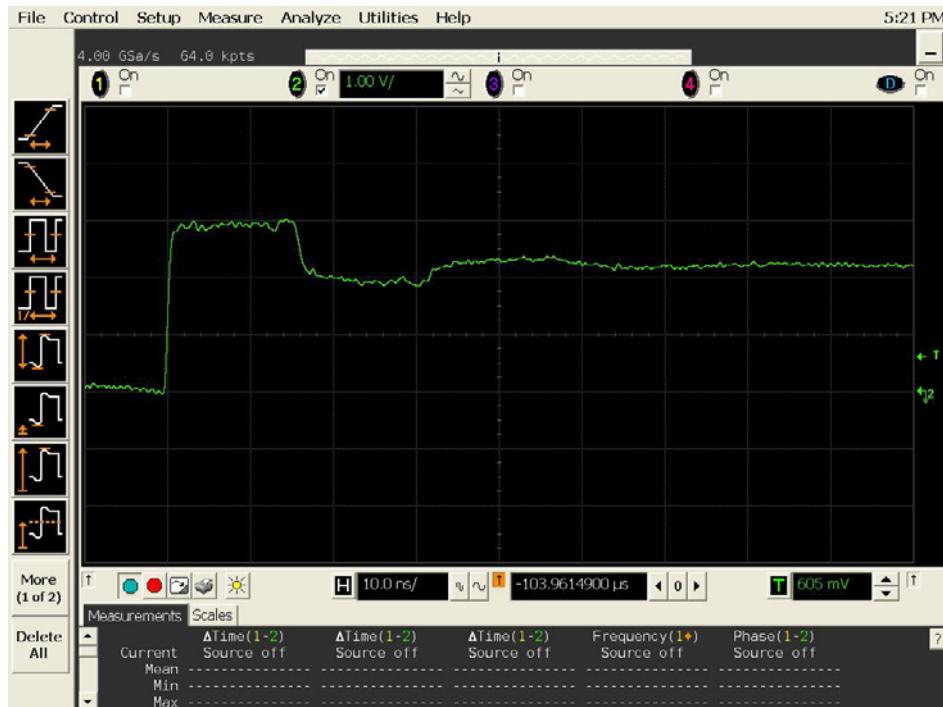


Figure 5a DUT 7943 Pre-Irradiation Rising Edge,  
abscissa scale is 1 V/div and ordinate scale is 10 ns/div.



Figure 5b DUT 7943 Post-Annealing Rising Edge,  
abscissa scale is 1 V/div and ordinate scale is 10 ns/div.

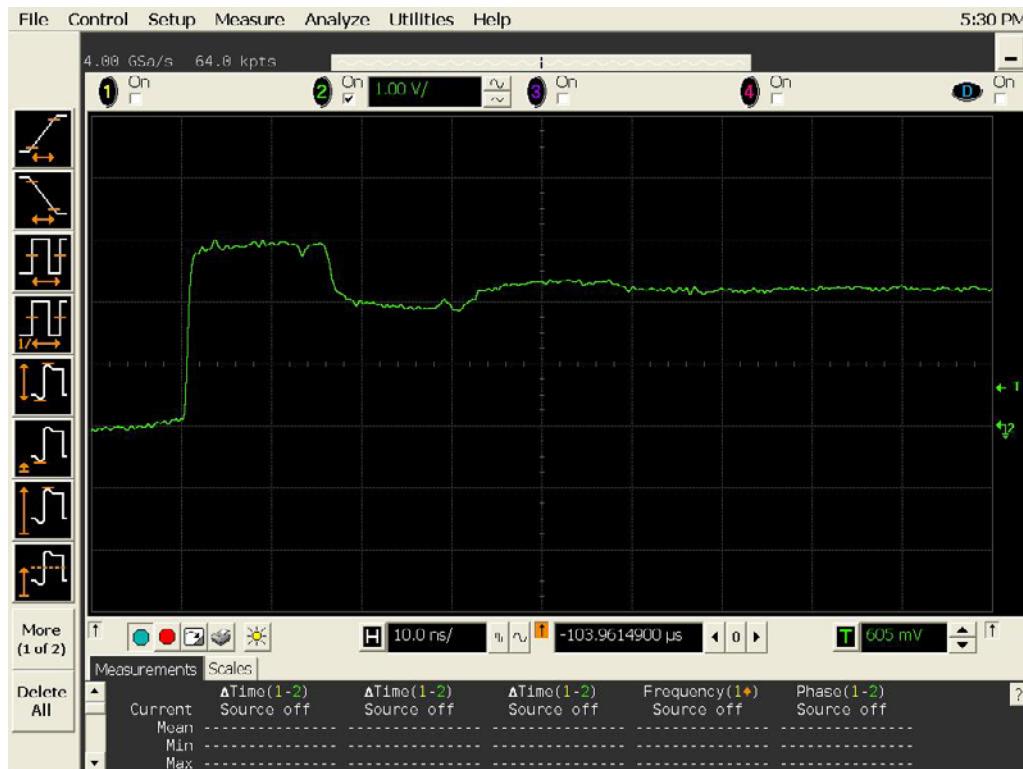


Figure 6a DUT 7973 Pre-Irradiation Rising Edge,  
abscissa scale is 1 V/div and ordinate scale is 10 ns/div.

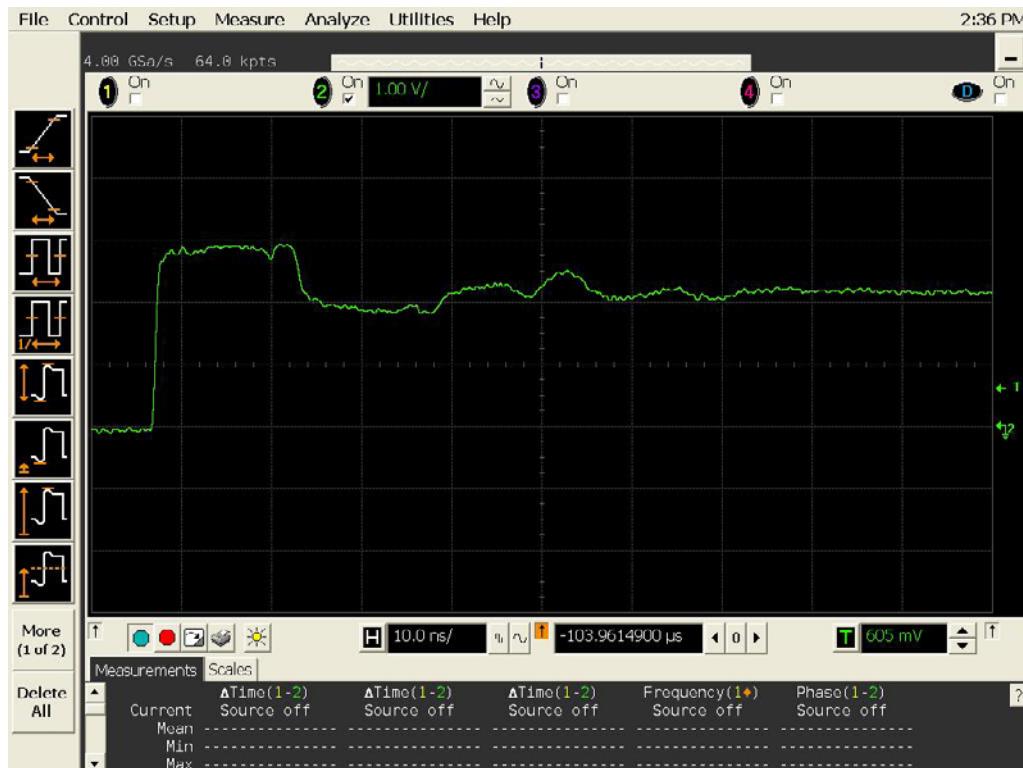


Figure 6b DUT 7973 Post-Annealing Rising Edge,  
abscissa scale is 1 V/div and ordinate scale is 10 ns/div.

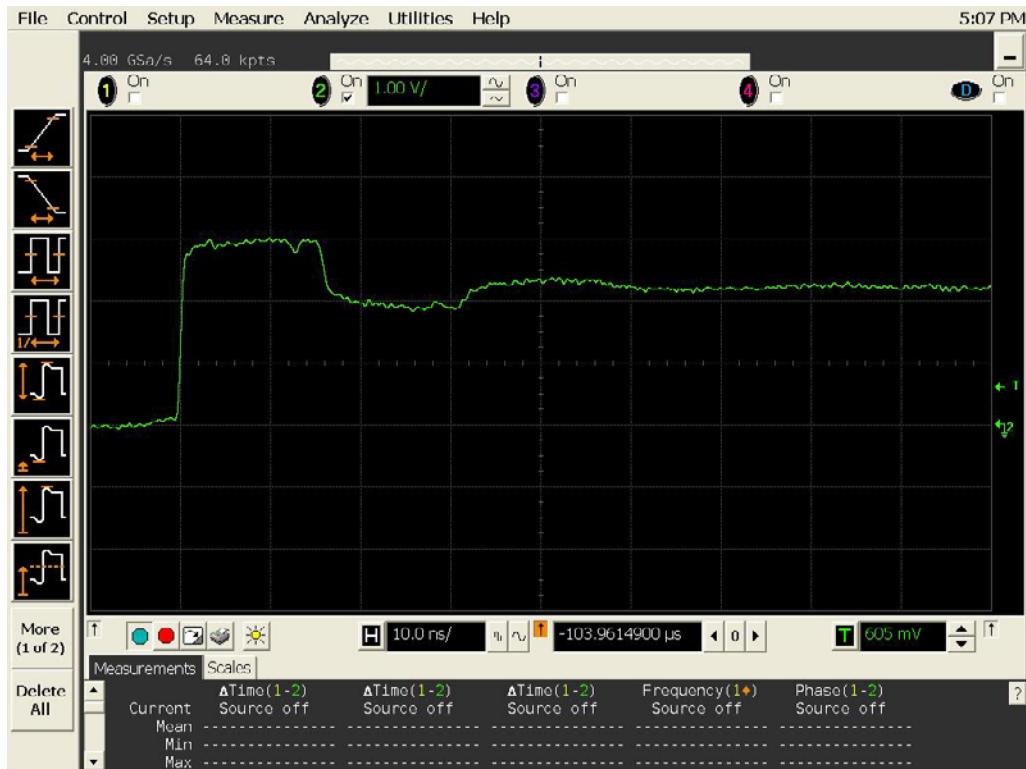


Figure 7a DUT 7992 Pre-Irradiation Rising Edge,  
abscissa scale is 1 V/div and ordinate scale is 10 ns/div.

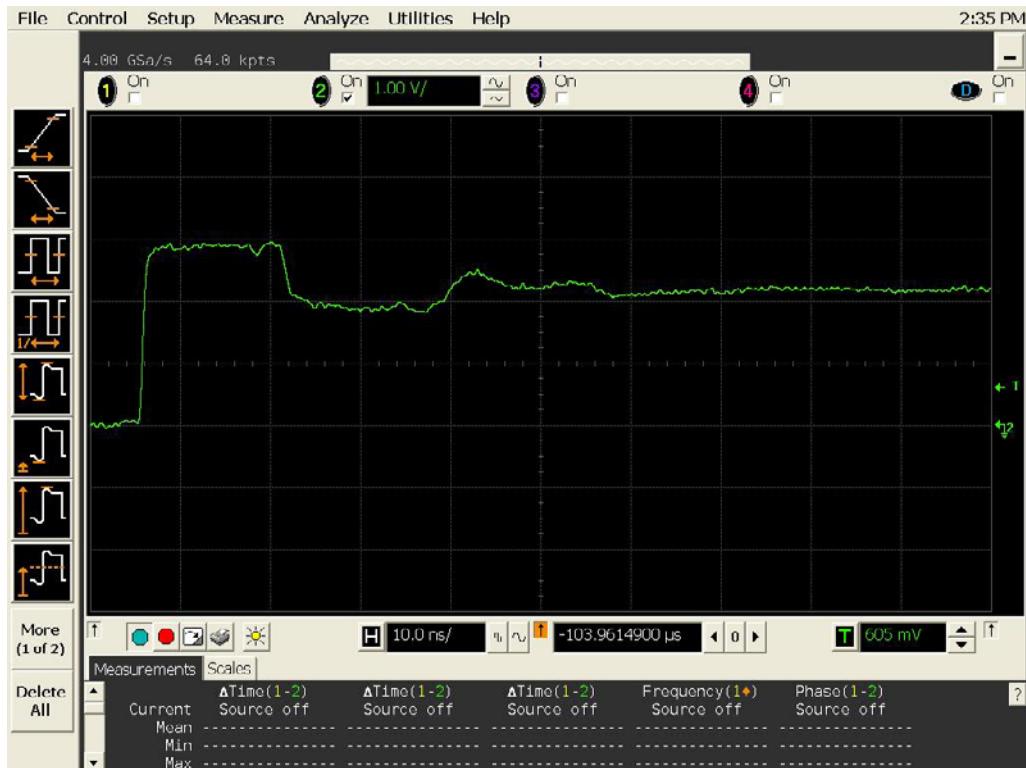


Figure 7b DUT 7992 Post-Annealing Rising Edge,  
abscissa scale is 1 V/div and ordinate scale is 10 ns/div.

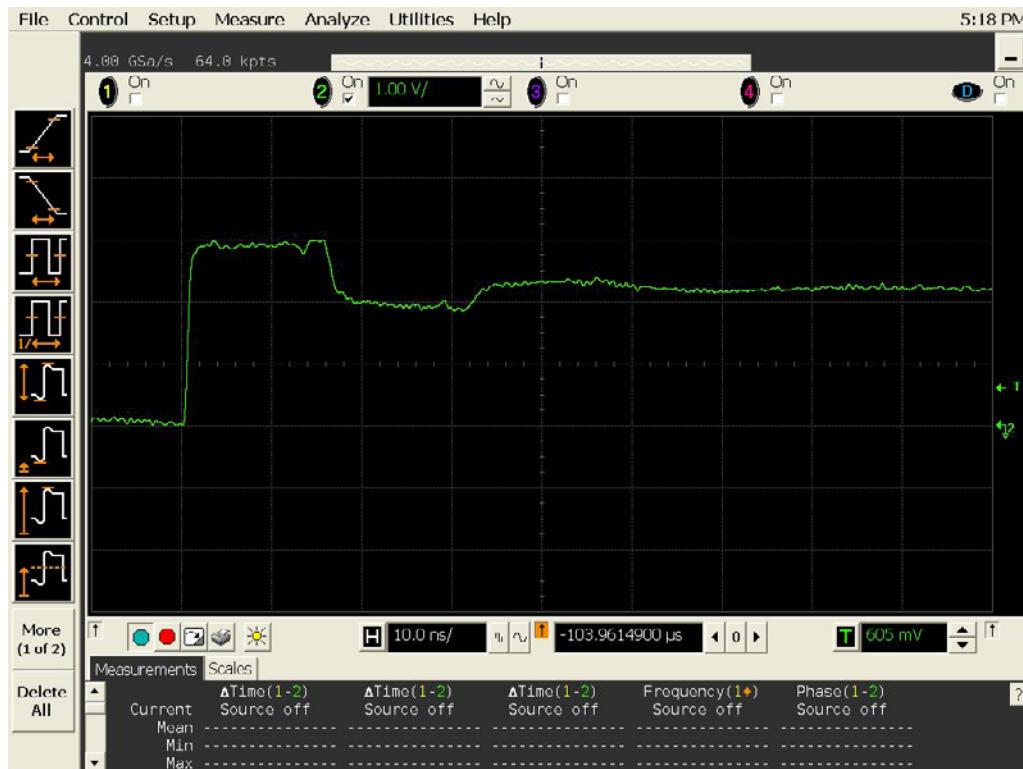


Figure 8a DUT 7942 Pre-Irradiation Rising Edge,  
abscissa scale is 1 V/div and ordinate scale is 10 ns/div.

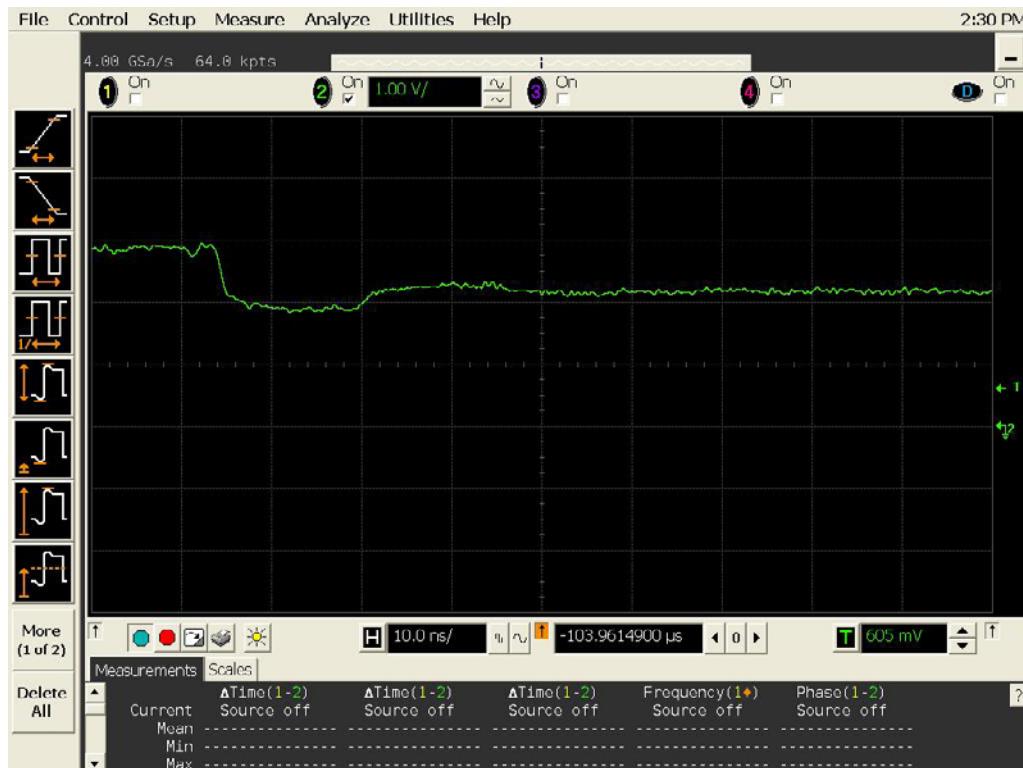


Figure 8b DUT 7942 Post-Annealing Rising Edge,  
abscissa scale is 1 V/div and ordinate scale is 10 ns/div.

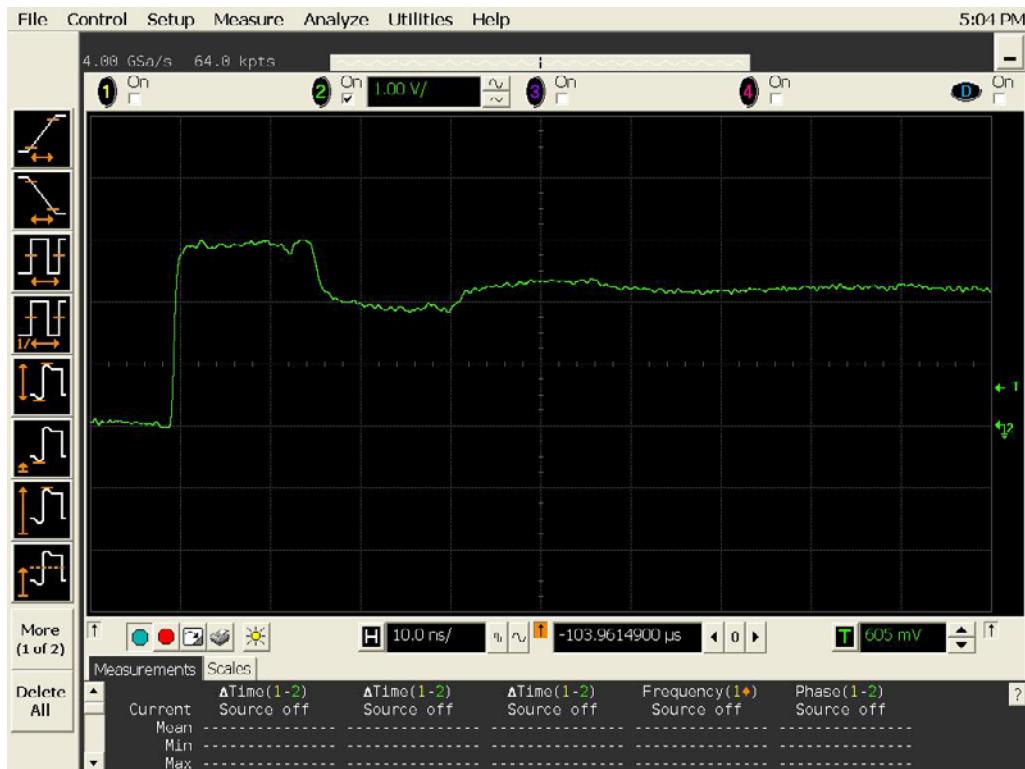


Figure 9a DUT 7956 Pre-Irradiation Rising Edge,  
abscissa scale is 1 V/div and ordinate scale is 10 ns/div.

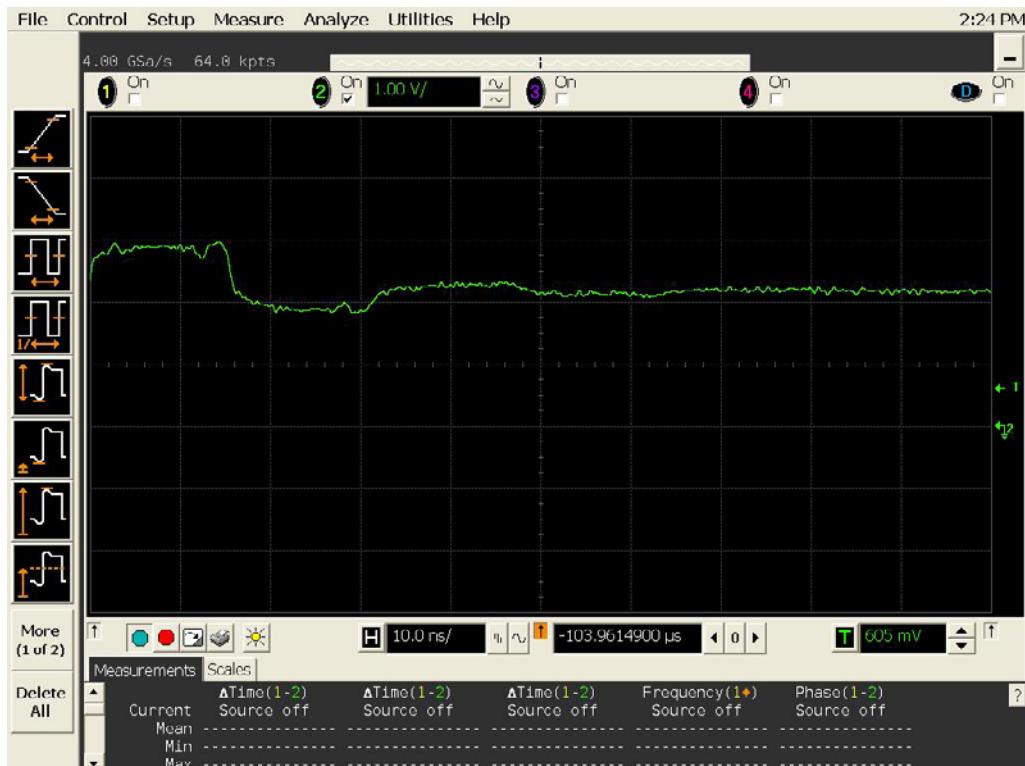


Figure 9b DUT 7956 Post-Annealing Rising Edge,  
abscissa scale is 1 V/div and ordinate scale is 10 ns/div.

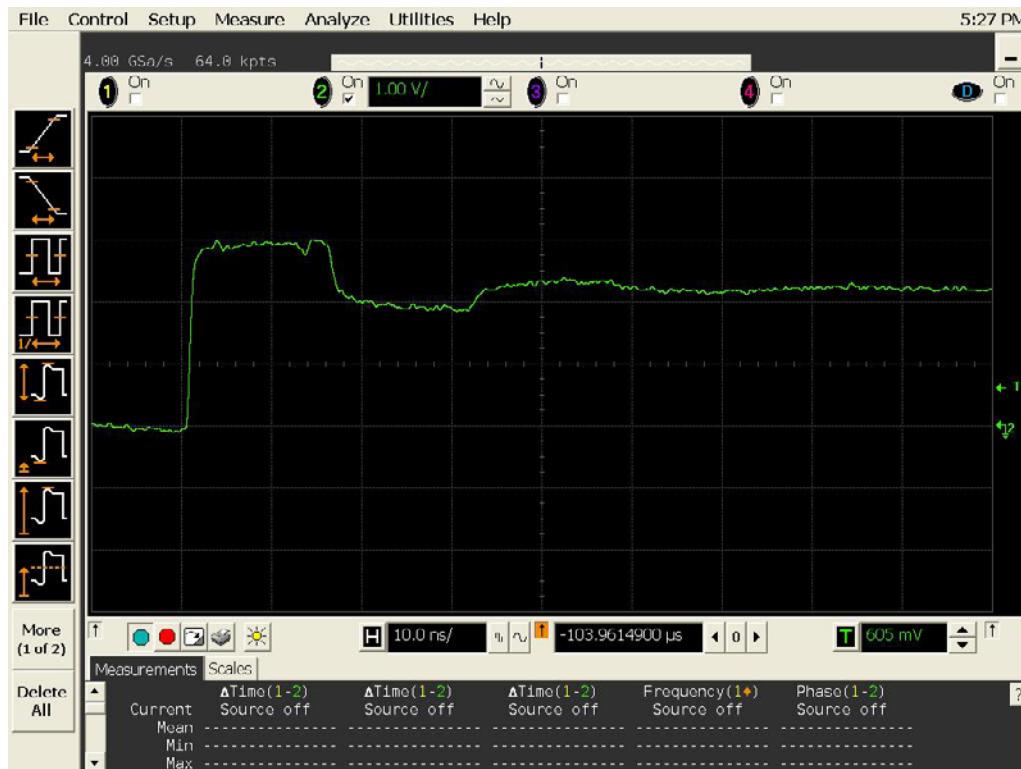


Figure 10a DUT 7972 Pre-Irradiation Rising Edge,  
abscissa scale is 1 V/div and ordinate scale is 10 ns/div.

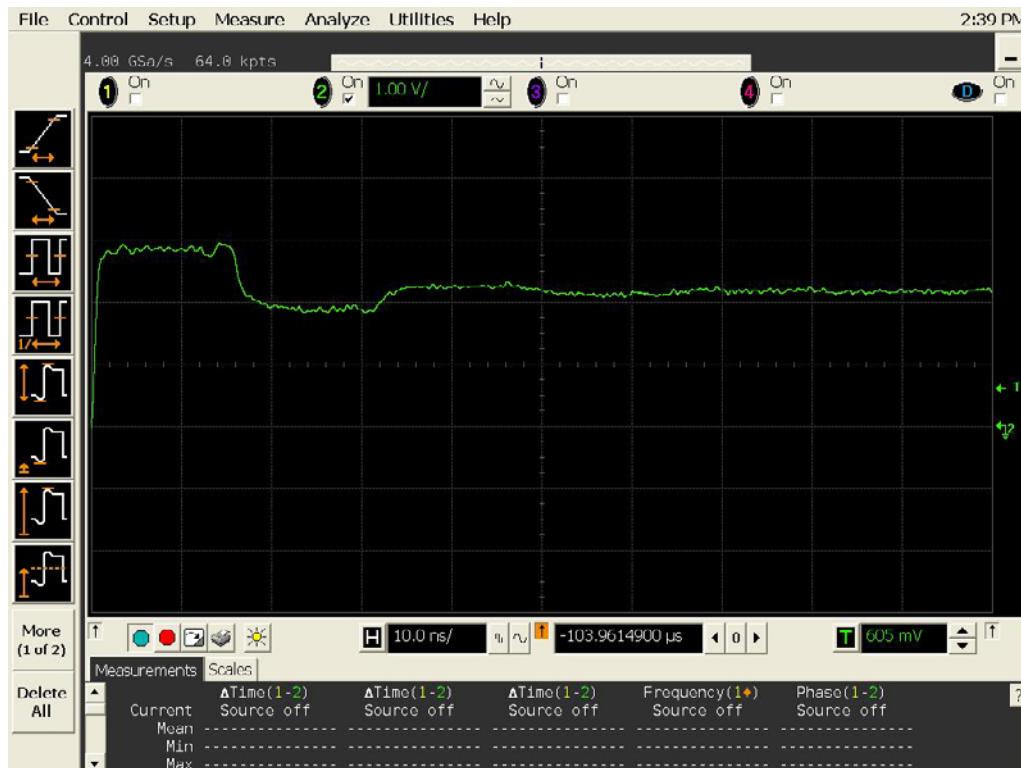


Figure 10b DUT 7972 Post-Annealing Rising Edge,  
abscissa scale is 1 V/div and ordinate scale is 10 ns/div.



Figure 11a DUT 7926 Pre-Irradiation Rising Edge,  
abscissa scale is 1 V/div and ordinate scale is 10 ns/div.

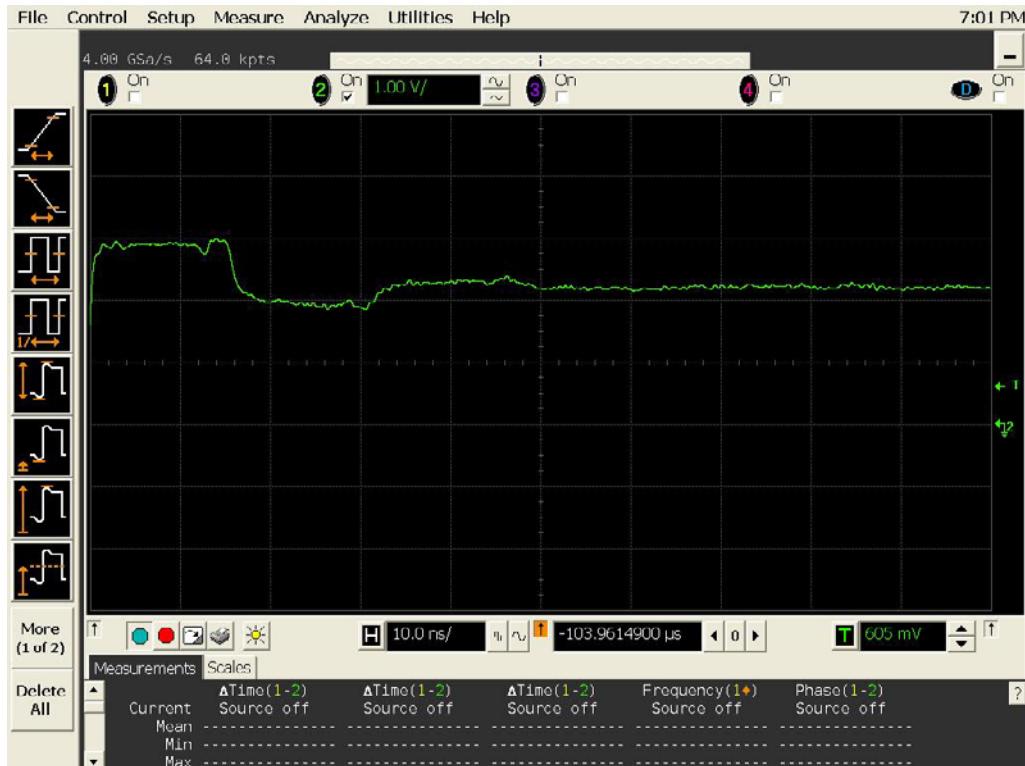


Figure 11b DUT 7926 Post-Annealing Rising Edge,  
abscissa scale is 1 V/div and ordinate scale is 10 ns/div.

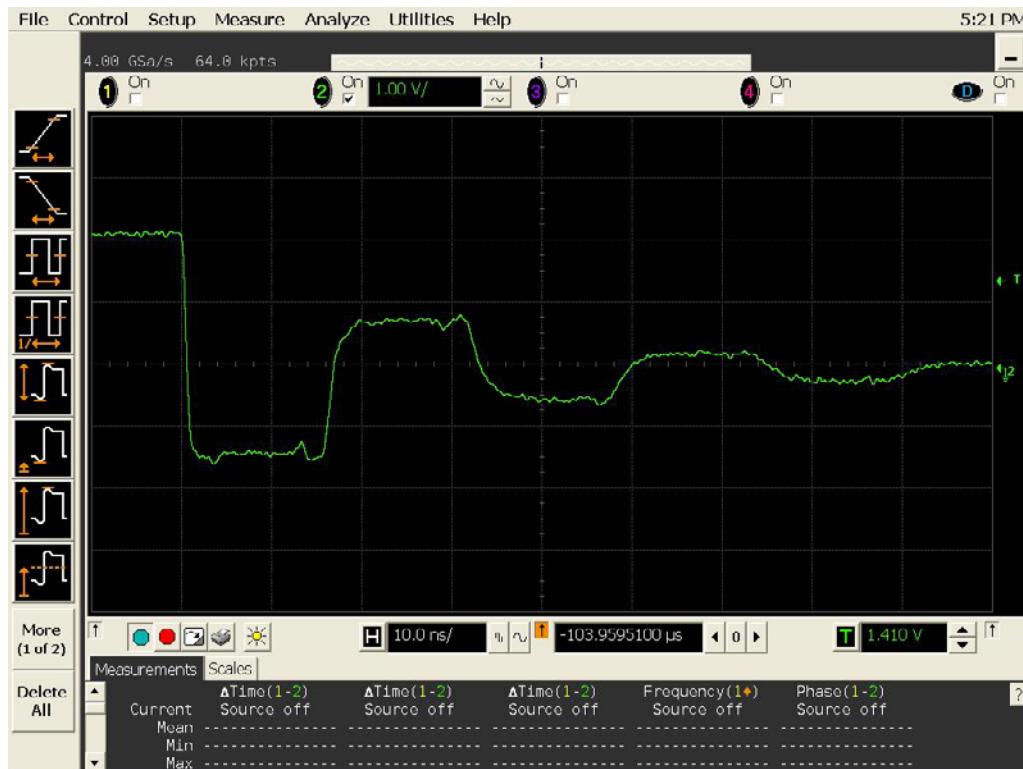


Figure 12a DUT 7943 Pre-Irradiation Falling Edge,  
abscissa scale is 1 V/div and ordinate scale is 10 ns/div.

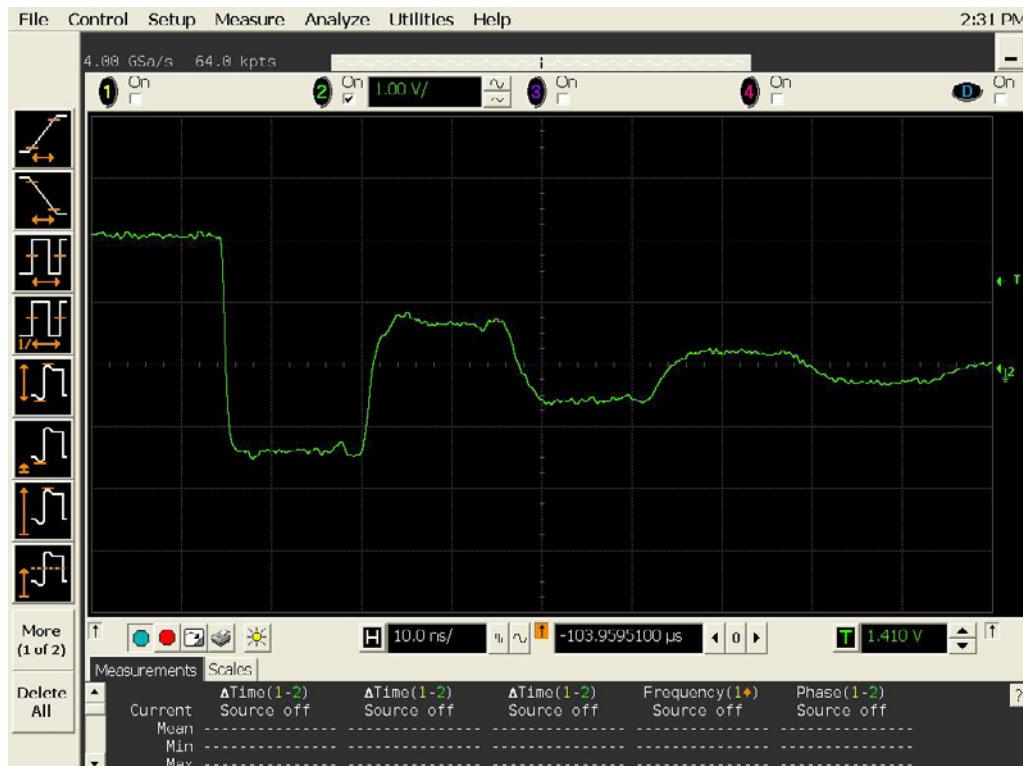


Figure 12b DUT 7943 Post-Annealing Falling Edge,  
abscissa scale is 1 V/div and ordinate scale is 10 ns/div.

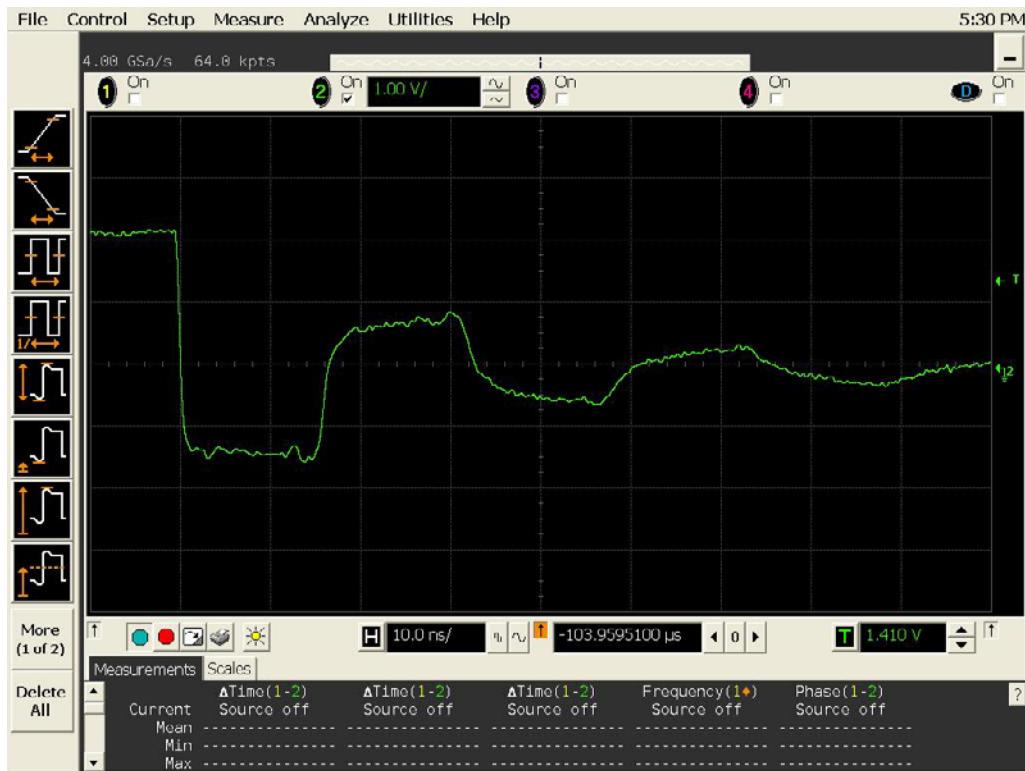


Figure 13a DUT 7973 Pre-Irradiation Falling Edge,  
abscissa scale is 1 V/div and ordinate scale is 10 ns/div.

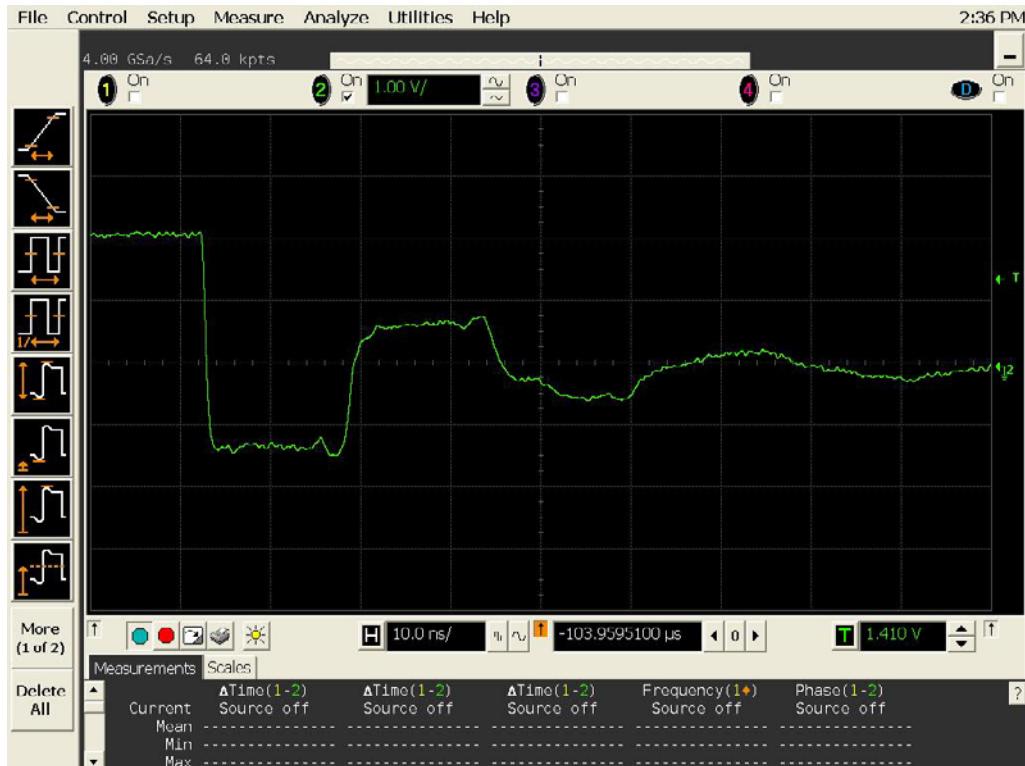


Figure 13b DUT 7973 Post-Annealing Falling Edge,  
abscissa scale is 1 V/div and ordinate scale is 10 ns/div.

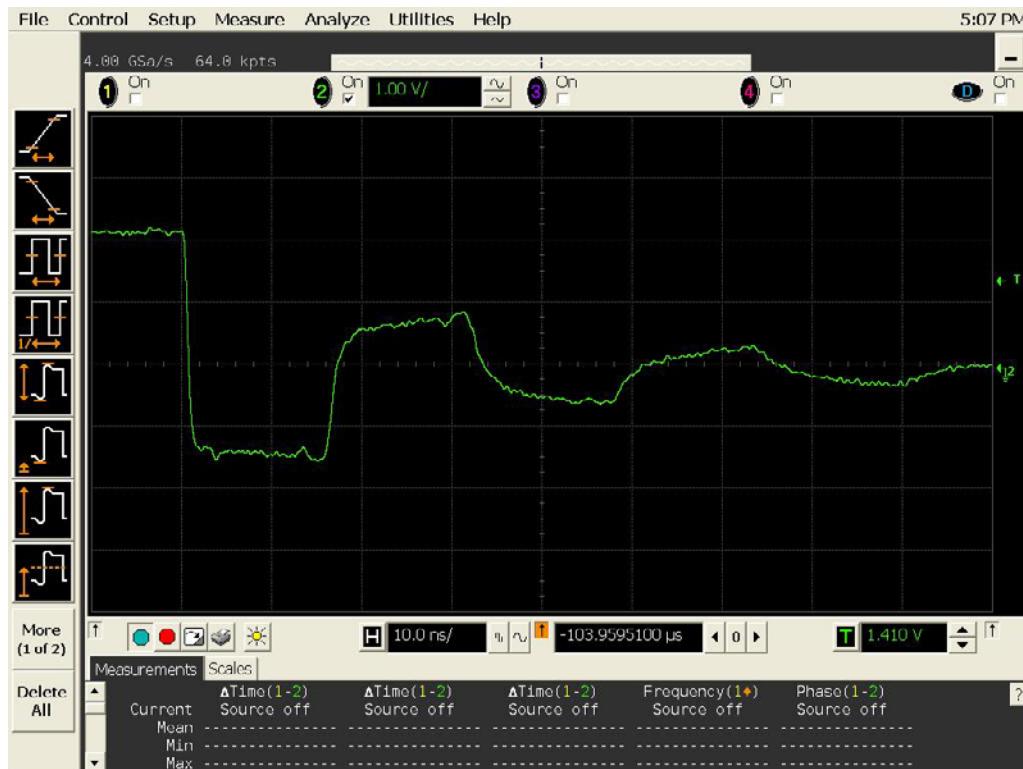


Figure 14a DUT 7992 Pre-Irradiation Falling Edge,  
abscissa scale is 1 V/div and ordinate scale is 10 ns/div.

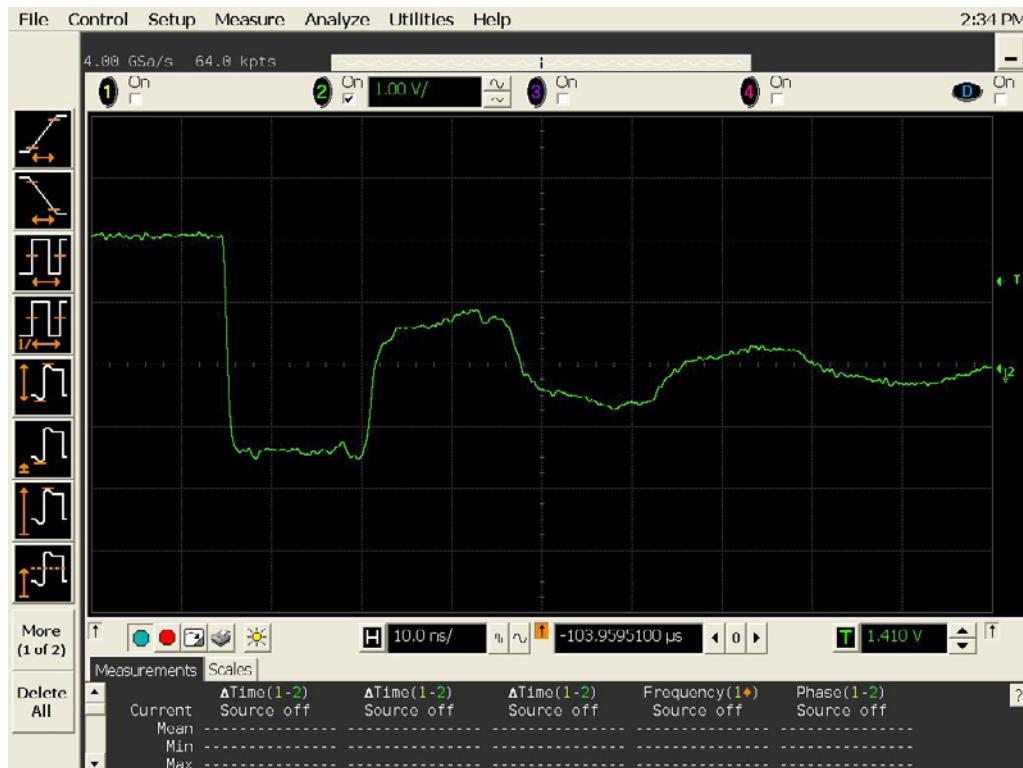


Figure 14b DUT 7992 Post-Annealing Falling Edge,  
abscissa scale is 1 V/div and ordinate scale is 10 ns/div.

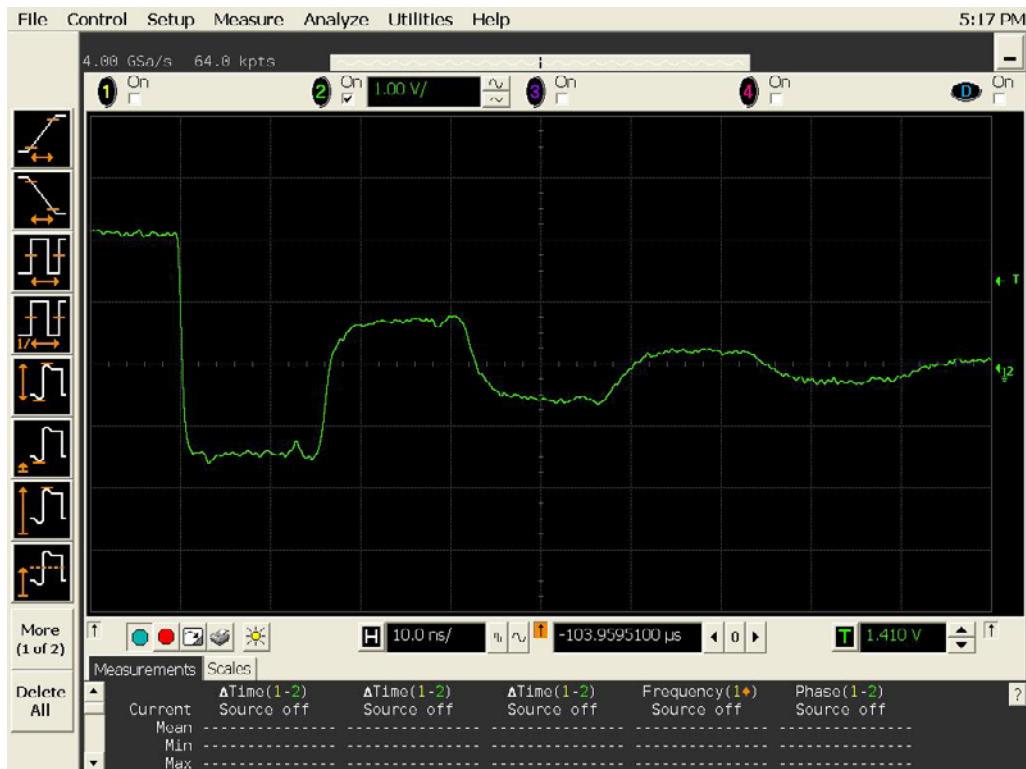


Figure 15a DUT 7942 Pre-Irradiation Falling Edge,  
abscissa scale is 1 V/div and ordinate scale is 10 ns/div.

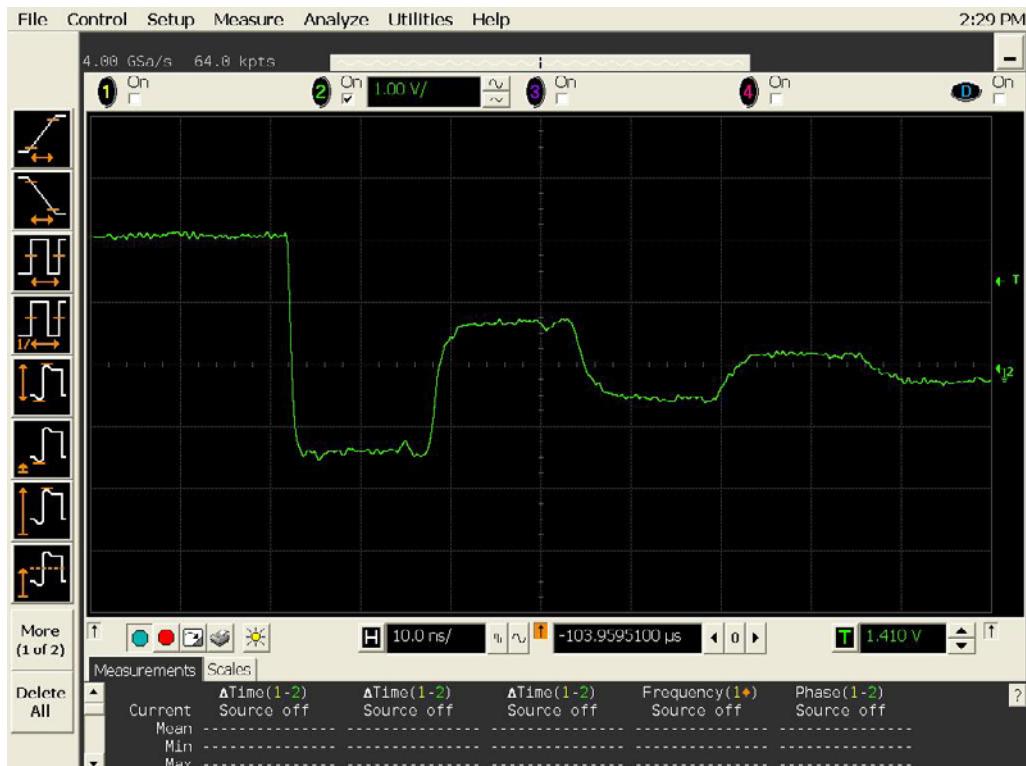


Figure 15b DUT 7942 Post-Annealing Falling Edge,  
abscissa scale is 1 V/div and ordinate scale is 10 ns/div.

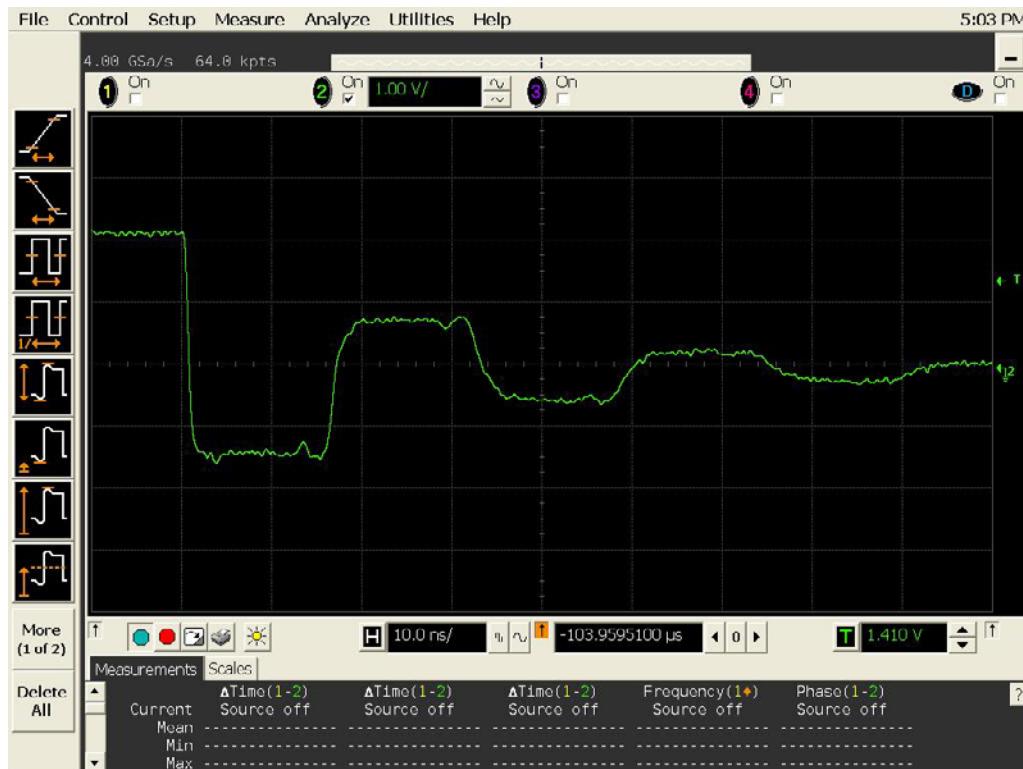


Figure 16a DUT 7956 Pre-Irradiation Falling Edge,  
abscissa scale is 1 V/div and ordinate scale is 10 ns/div.



Figure 16b DUT 7956 Post-Annealing Falling Edge,  
abscissa scale is 1 V/div and ordinate scale is 10 ns/div.



Figure 17a DUT 7972 Pre-Irradiation Falling Edge,  
abscissa scale is 1 V/div and ordinate scale is 10 ns/div.



Figure 17b DUT 7972 Post-Annealing Falling Edge,  
abscissa scale is 1 V/div and ordinate scale is 10 ns/div.

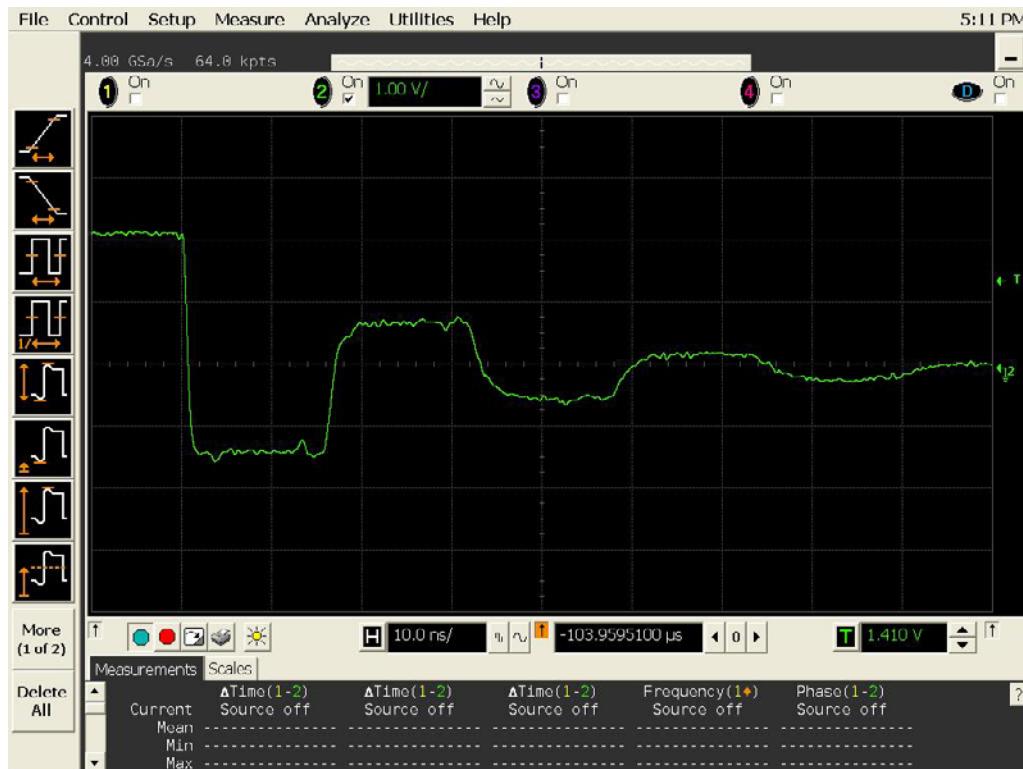


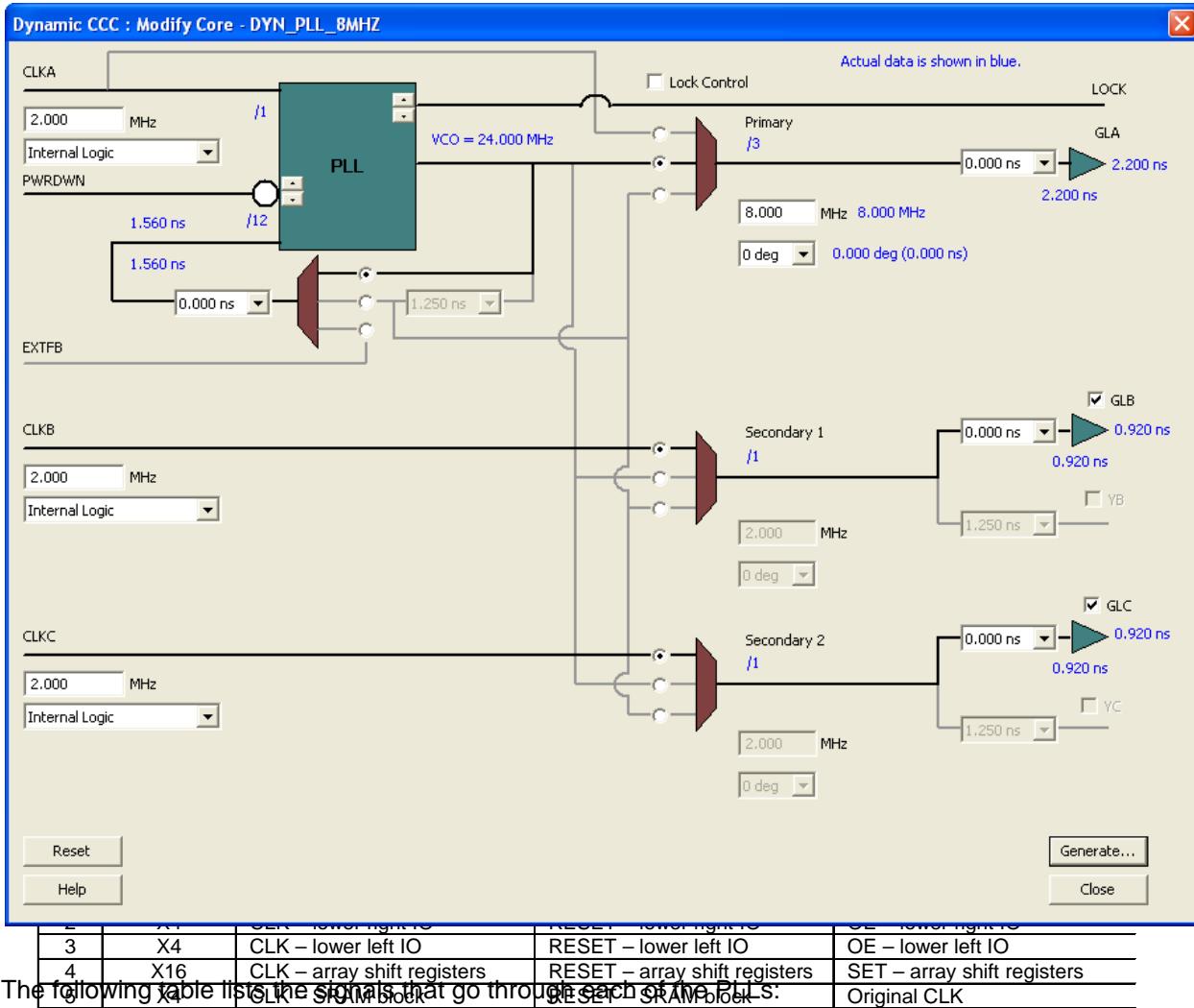
Figure 18a DUT 7926 Pre-Irradiation Falling Edge,  
abscissa scale is 1 V/div and ordinate scale is 10 ns/div.



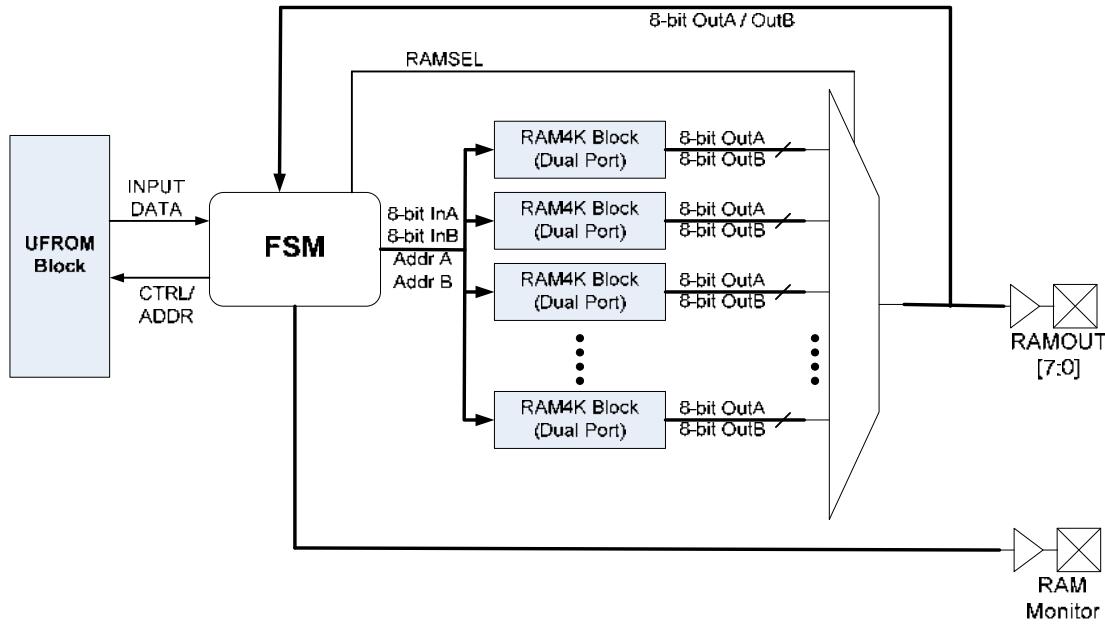
Figure 18b DUT 7926 Post-Annealing Falling Edge,  
abscissa scale is 1 V/div and ordinate scale is 10 ns/div.

## Appendix A: DUT Design Block Diagrams and Schematics

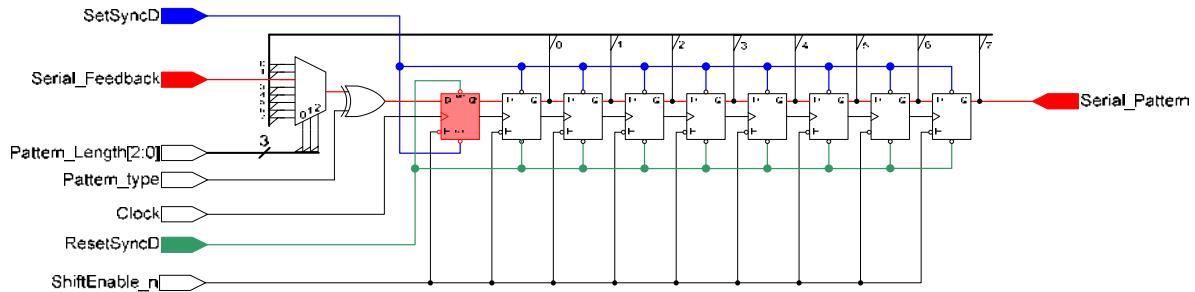
### A. PLL Block



## B. UFROM/SRAM Block

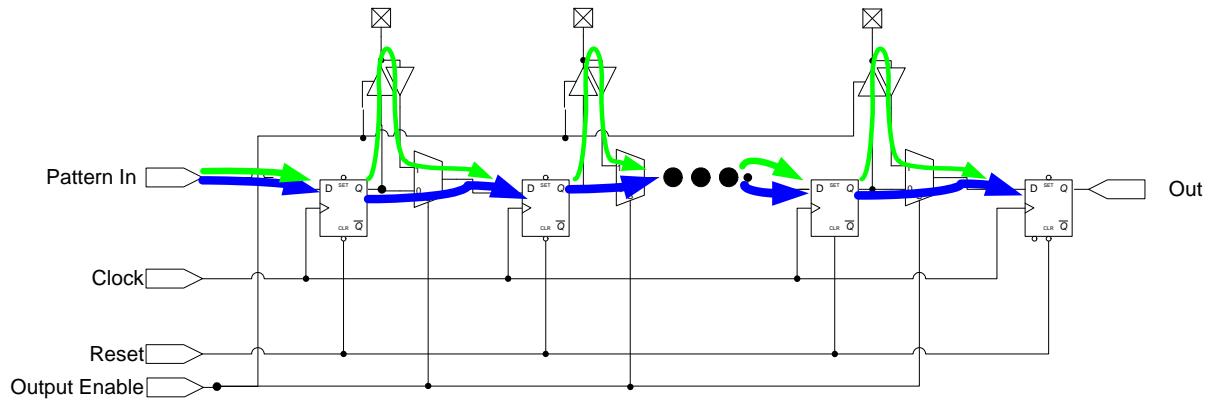


## C. Pattern Generators Block

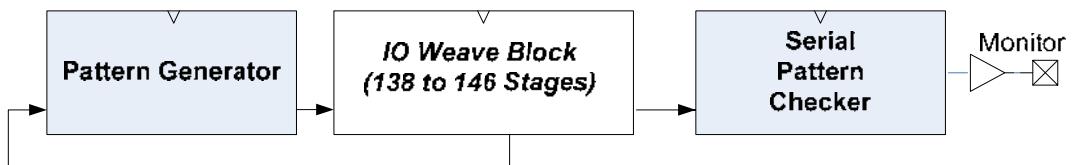


Type	Patter n	Patter n	Code Length	$\Delta$ Bits	Switching Rate
0	000	1 0 $\Rightarrow$ 0 1 $\nwarrow$	2	2	100.00%
0	001	1 0 0 $\Rightarrow$ 0 1 0 $\Rightarrow$ 0 0 1 $\nwarrow$	3	2	66.67%
0	010	One hot I/O at a time switching in entire I/O ring	#Bits+9	2	N/A
0	011	1 0 0 0 0 0 $\Rightarrow$ 0 1 0 0 0 0 $\Rightarrow$ 0 0 1 0 0 0 $\Rightarrow$ 0 0 0 1 0 0 $\Rightarrow$ 0 0 0 0 1 0 $\Rightarrow$ 0 0 0 0 0 1 $\nwarrow$	5	2	40.00%
0	100	1 0 0 0 0 0 0 $\Rightarrow$ 0 1 0 0 0 0 0 $\Rightarrow$ 0 0 1 0 0 0 0 $\Rightarrow$ 0 0 0 1 0 0 0 $\Rightarrow$ 0 0 0 0 1 0 0 $\Rightarrow$ 0 0 0 0 0 1 0 $\nwarrow$	6	2	33.33%
0	101	1 0 0 0 0 0 0 0 $\Rightarrow$ 0 1 0 0 0 0 0 0 $\Rightarrow$ 0 0 1 0 0 0 0 0 $\Rightarrow$ 0 0 0 1 0 0 0 0 $\Rightarrow$ 0 0 0 0 1 0 0 0 $\Rightarrow$ 0 0 0 0 0 1 0 $\nwarrow$	7	2	28.57%
0	110	1 0 0 0 0 0 0 0 0 $\Rightarrow$ 0 1 0 0 0 0 0 0 0 $\Rightarrow$ 0 0 1 0 0 0 0 0 0 $\Rightarrow$ 0 0 0 1 0 0 0 0 0 $\Rightarrow$ 0 0 0 0 1 0 0 0 $\nwarrow$	8	2	25.00%
0	111	1 0 0 0 0 0 0 0 0 0 $\Rightarrow$ 0 1 0 0 0 0 0 0 0 0 $\Rightarrow$ 0 0 1 0 0 0 0 0 0 0 $\Rightarrow$ 0 0 0 1 0 0 0 0 0 0 $\nwarrow$	9	2	22.22%
1	000	1 0 $\Rightarrow$ 1 1 $\Rightarrow$ 0 1 $\Rightarrow$ 0 0 $\nwarrow$	2	1	50.00%
1	001	1 0 0 $\Rightarrow$ 1 1 0 $\Rightarrow$ 1 1 1 $\Rightarrow$ 0 1 1 $\Rightarrow$ 0 0 1 $\Rightarrow$ 0 0 0 $\nwarrow$	3	1	33.33%
1	010	Wave of 0's followed by wave of 1's	#Bits+9	1	N/A
1	011	1 0 0 0 0 $\Rightarrow$ 1 1 0 0 0 $\Rightarrow$ 1 1 1 0 0 $\Rightarrow$ 1 1 1 1 0 $\Rightarrow$ 1 1 1 1 1 $\Rightarrow$ 0 1 1 1 1 $\Rightarrow$ 0 0 1 1 1 $\Rightarrow$ 0 0 0 1 1 $\Rightarrow$ 0 0 0 0 1 $\Rightarrow$ 0 0 0 0 0 $\nwarrow$	5	1	20.00%
1	100	1 0 0 0 0 0 $\Rightarrow$ 1 1 0 0 0 0 $\Rightarrow$ 1 1 1 0 0 0 $\Rightarrow$ 1 1 1 1 0 0 $\Rightarrow$ 1 1 1 1 1 0 $\Rightarrow$ 1 1 1 1 1 1 $\nwarrow$	6	1	16.67%
1	101	1 0 0 0 0 0 0 $\Rightarrow$ 1 1 0 0 0 0 0 $\Rightarrow$ 1 1 1 0 0 0 0 $\Rightarrow$ 1 1 1 1 0 0 0 $\Rightarrow$ 1 1 1 1 1 0 0 $\Rightarrow$ 1 1 1 1 1 1 0 $\nwarrow$	7	1	14.29%
1	110	1 0 0 0 0 0 0 0 $\Rightarrow$ 1 1 0 0 0 0 0 0 $\Rightarrow$ 1 1 1 0 0 0 0 0 $\Rightarrow$ 1 1 1 1 0 0 0 0 $\Rightarrow$ 1 1 1 1 1 0 0 0 $\Rightarrow$ 1 1 1 1 1 1 0 $\nwarrow$	8	1	12.50%
1	111	1 0 0 0 0 0 0 0 0 $\Rightarrow$ 1 1 0 0 0 0 0 0 0 $\Rightarrow$ 1 1 1 0 0 0 0 0 0 $\Rightarrow$ 1 1 1 1 0 0 0 0 0 $\Rightarrow$ 1 1 1 1 1 0 0 0 0 $\nwarrow$	9	1	11.11%

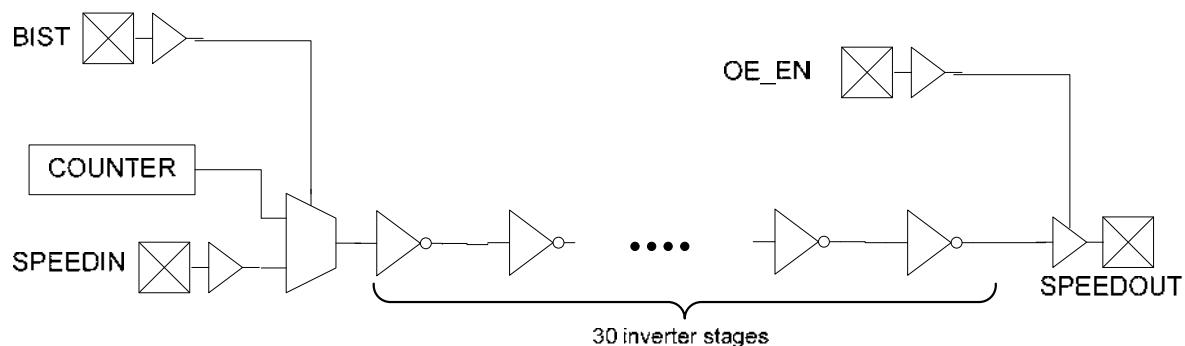
## D. I/O Block



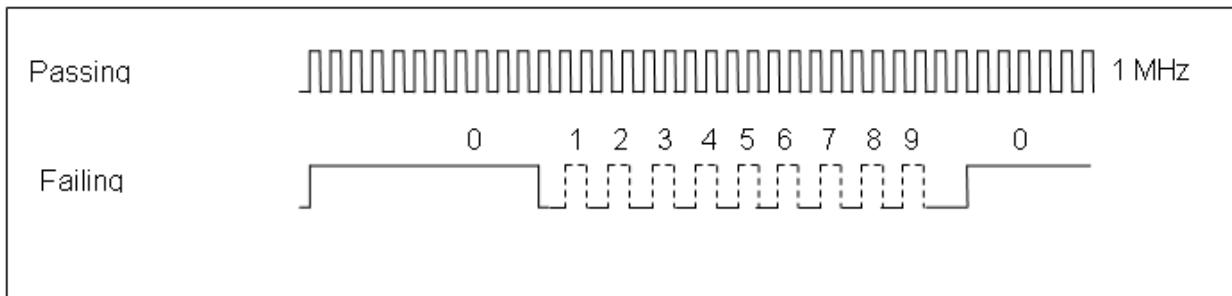
## E. Array Shift Registers Block



## F. Delay Path Block



## G. Monitor Block







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