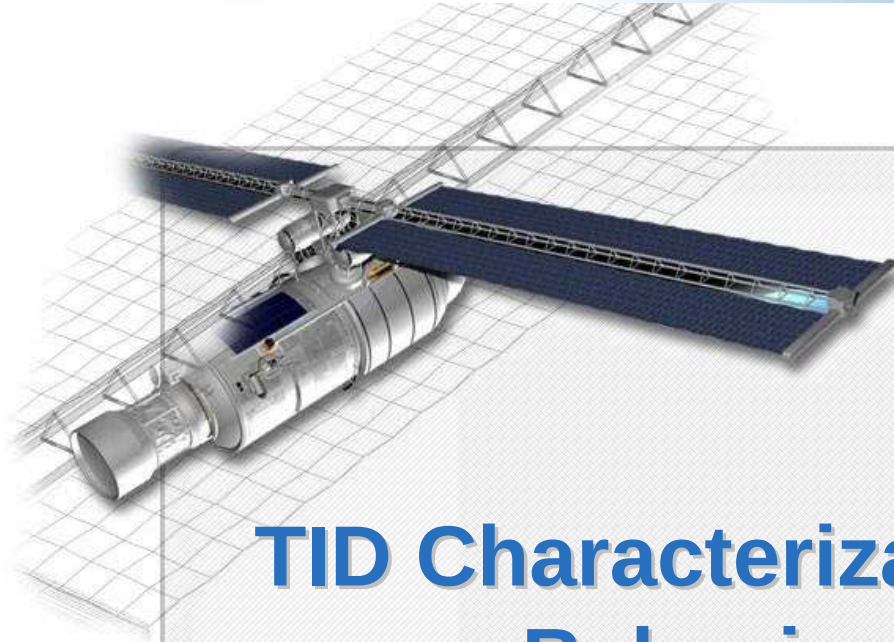
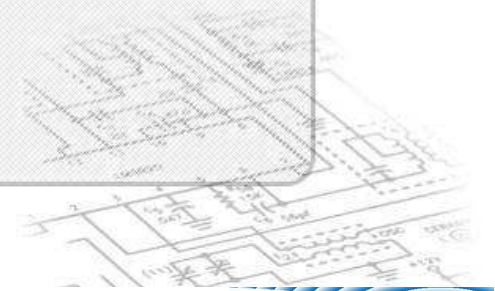




TID Characterization of Power-up Behavior for FPGAs

Presented by Anne Samaras
Realized by Benjamin Vandeveld



A previous study [1] has shown that when submitted to Total Ionizing Dose, high current surges can be observed during power-up of FPGAs.

The aim of this study is to compare the behaviour of various FPGA types during the power-up sequence while submitted to ^{60}Co Total Ionizing Dose irradiation (TID).

[1] ESA_QCA0112T_C : Radiation evaluation of power-up behaviour of XILINX FPGA XQVR300 (Saab Ericsson Space)

Devices under test

PARTS IDENTIFICATION				
Type:	RTAX-1000S	XC4VFX40-10FF672I		
Manufacturer :	 	 	<i>Non-releasable information</i>	
Package :	CQ352	FF672		
Technology:	Antifuse	SRAM		
Quality level :	Prototype	Industrial grade		

Irradiation facility

IRRADIATION FACILITY	
Irradiation source:	^{60}Co
Source location:	U.C.L (Louvain-la-Neuve)
Dose rate:	$36\text{rad}(\text{Si})/\text{h} \leq \text{Dose Rate} \leq 310\text{rad}(\text{Si})/\text{h}$
Irradiation equipment:	GIF

Irradiation conditions

Parts biased in static ON mode	2 RTAX1000S 2 XC4VFX40
Parts in OFF mode (all leads grounded)	1 RTAX1000S 1 XC4VFX40
Control parts (NOT irradiated)	1 XC4VFX40

Irradiation steps

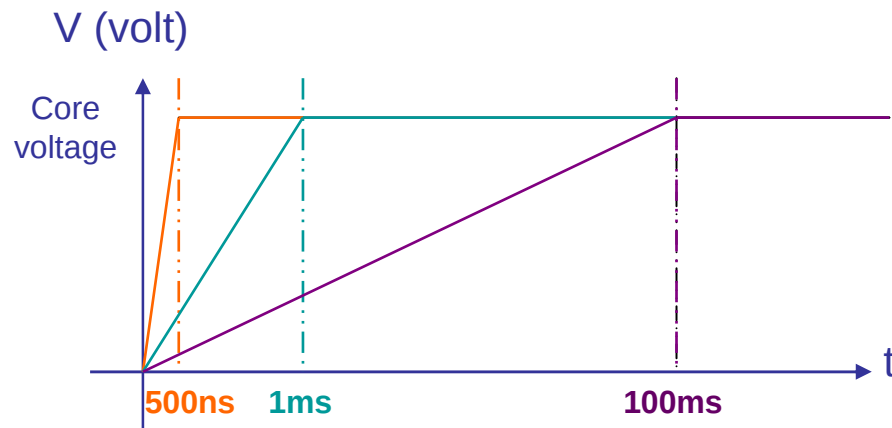
Actel RTAX1000S	
Krad(Si)	Dose Rate (krad(Si)/h)
0	210
20	210
40	210
60	310
80	310
102	310
117	310
140	310
149	36
153	
24h @ 25°C	
168h @ 100°C	

Xilinx XC4VFX40	
Krad(Si)	Dose Rate (krad(Si)/h)
0	210
5	210
10	210
15	310
20	310
41	310
56	210
80	310
102	310
123	210
132	210
149	210
225	
24h @ 25°C	
168h @ 100°C	

*Non-releasable
Information table*

Power-up profiles

Three power-up profiles were applied on the four devices under test (DUT).
Hard switch, fast ramp, and soft ramp

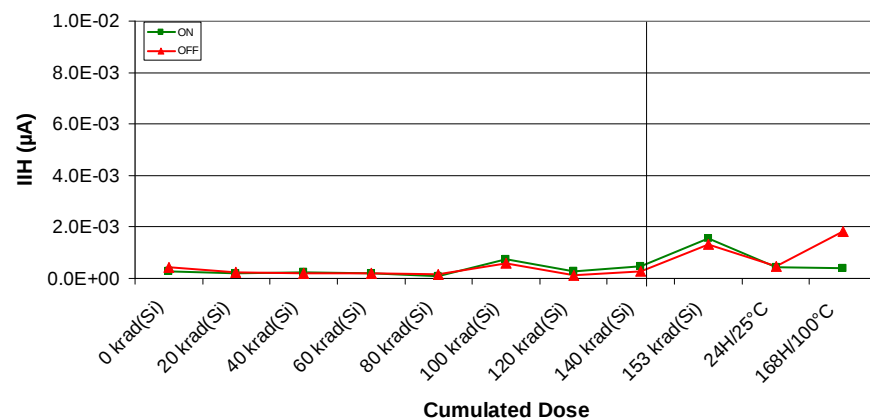


Power-up profiles

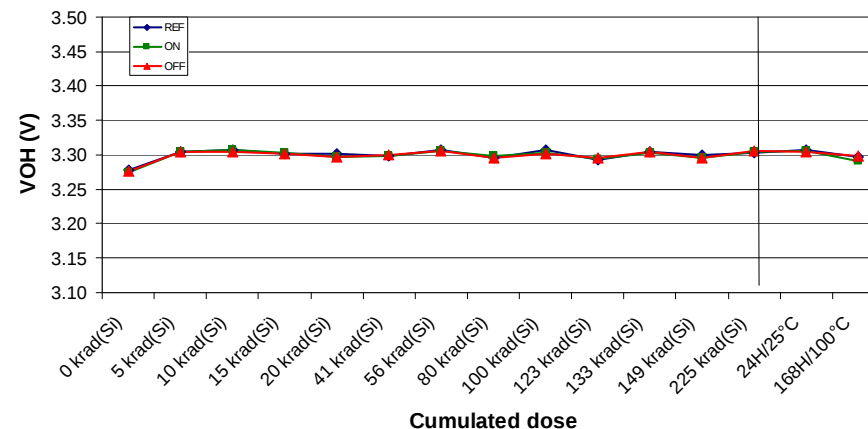
Ramp Type	Timing (0V to core voltage)
Hard	500 ns
Fast	1 ms
Soft	100 ms

Test Results – Parametric test

RTAX1000S



XC4FVX40



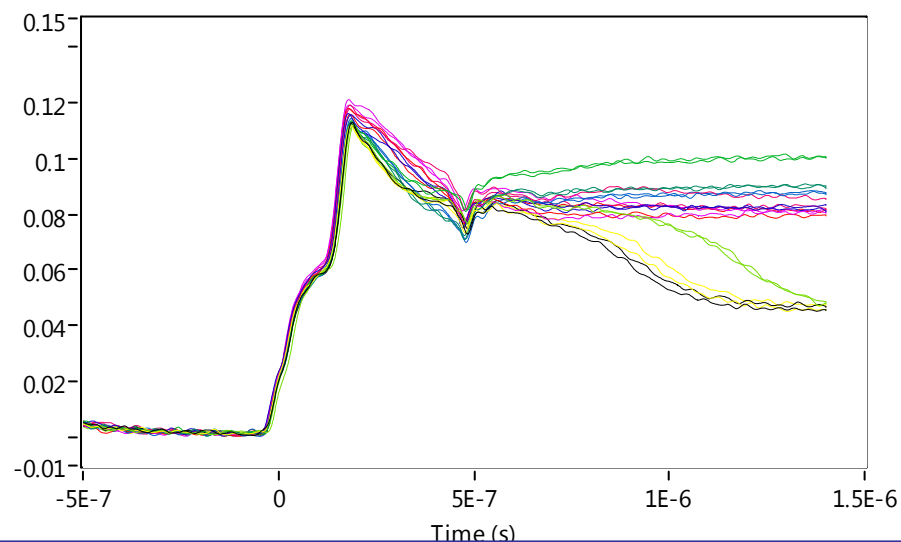
Non-releasable information graphs

- ⇒ No significant drift parameter up to the total ionizing dose
- ⇒ Devices remain functional up to the total ionizing dose

Test Results

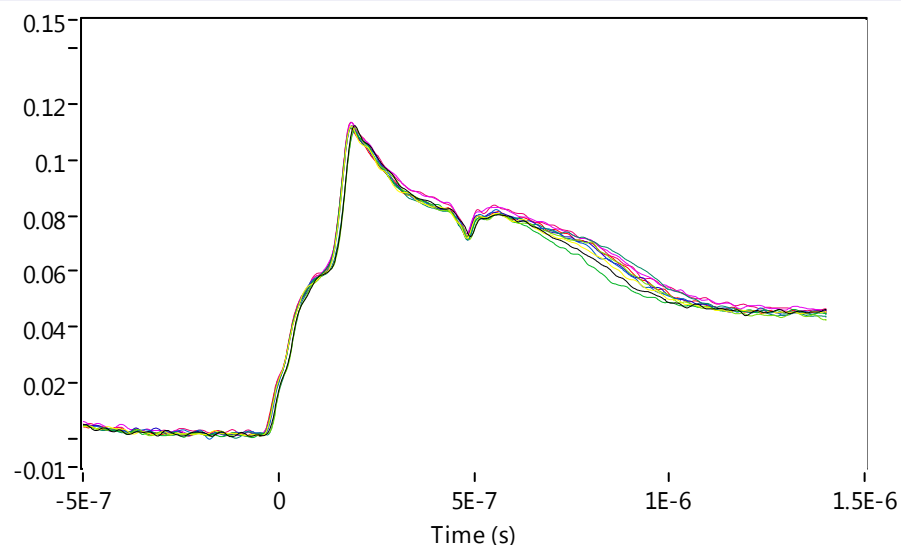
RTAX1000S / Hard Switch

ON



0 krad(Si)	
20 krad(Si)	
60 krad(Si)	
80 krad(Si)	
100 krad(Si)	
120 krad(Si)	
140 krad(Si)	
155 krad(Si)	
24h at 25°C	
168h at 100°C	

OFF

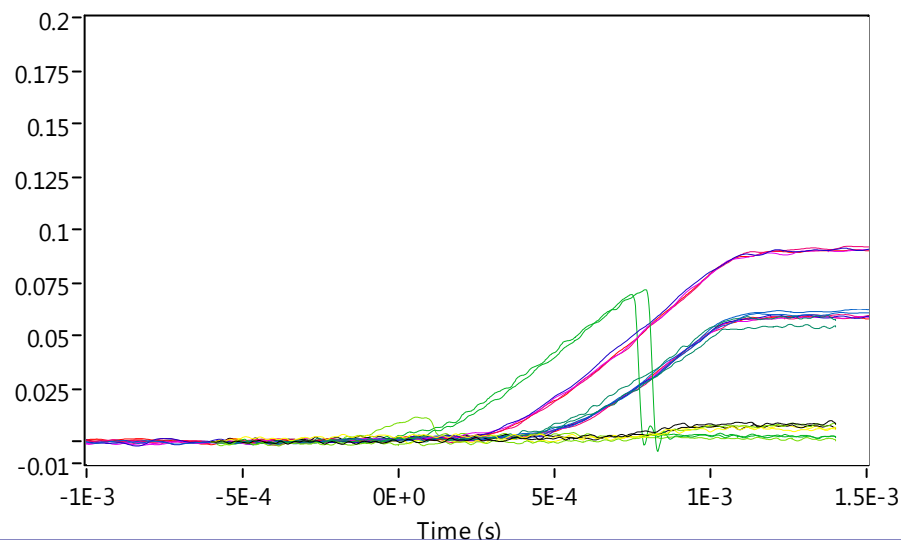


Ramp Type	Timing (0V to core voltage)
Hard	500 ns
Fast	1 ms
Soft	100 ms

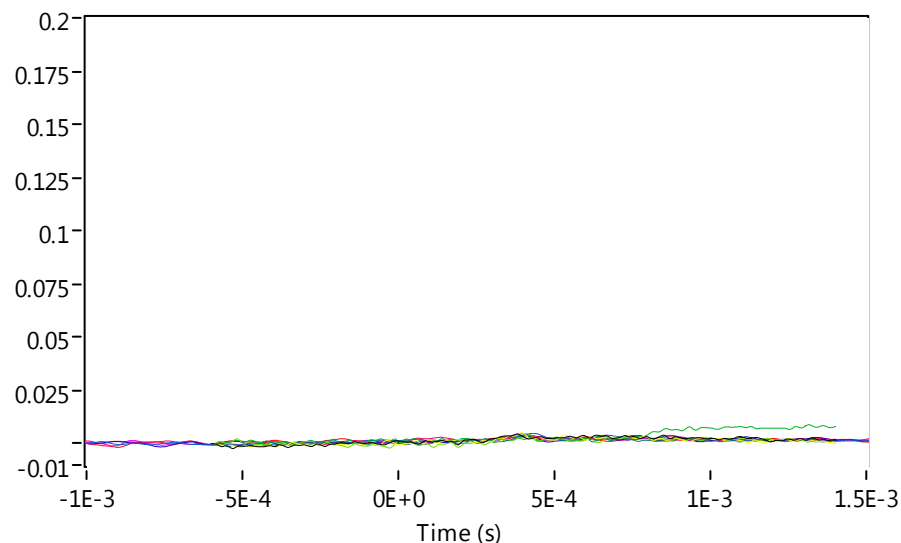
Test Results

RTAX1000S / FAST RAMP

ON



OFF



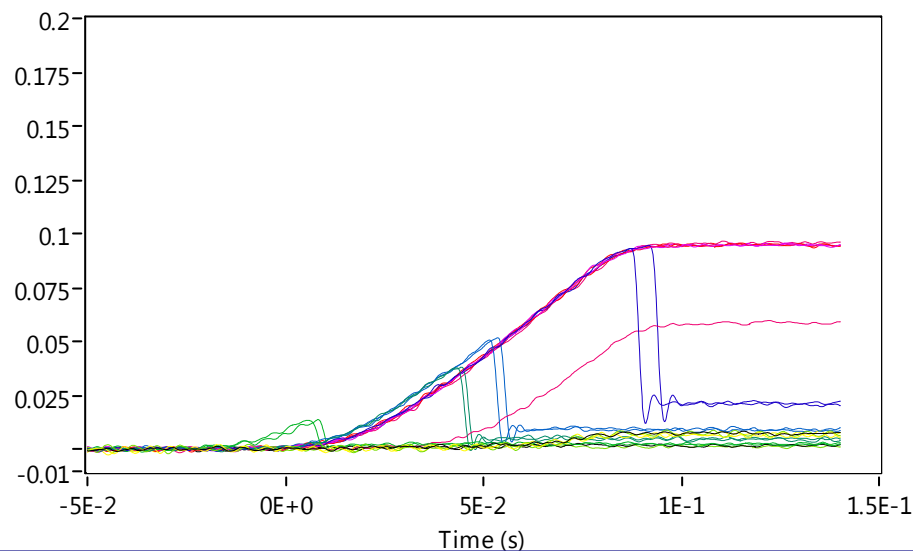
0 krad(Si)	
20 krad(Si)	
60 krad(Si)	
80 krad(Si)	
100 krad(Si)	
120 krad(Si)	
140 krad(Si)	
155 krad(Si)	
24h at 25°C	
168h at 100°C	

Ramp Type	Timing (0V to core voltage)
Hard	500 ns
Fast	1 ms
Soft	100 ms

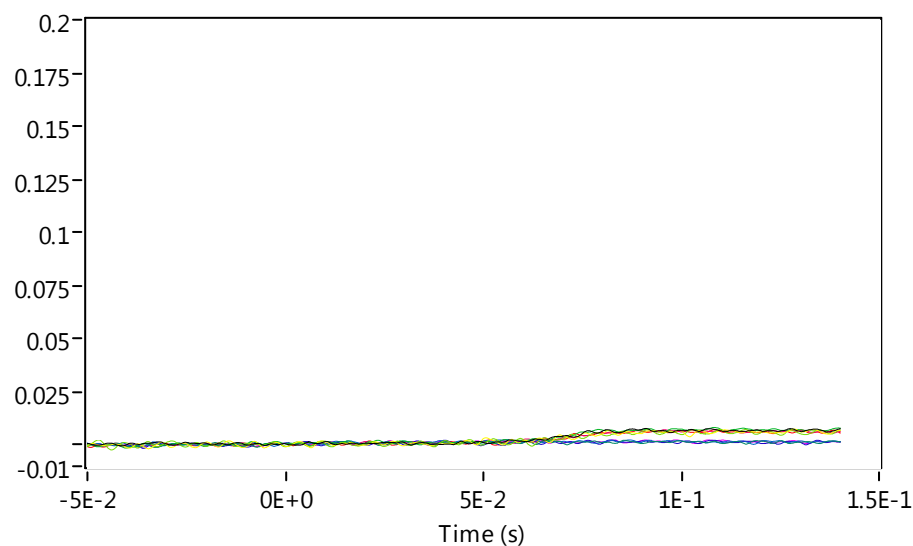
Test Results

RTAX1000S / Soft RAMP

ON



OFF



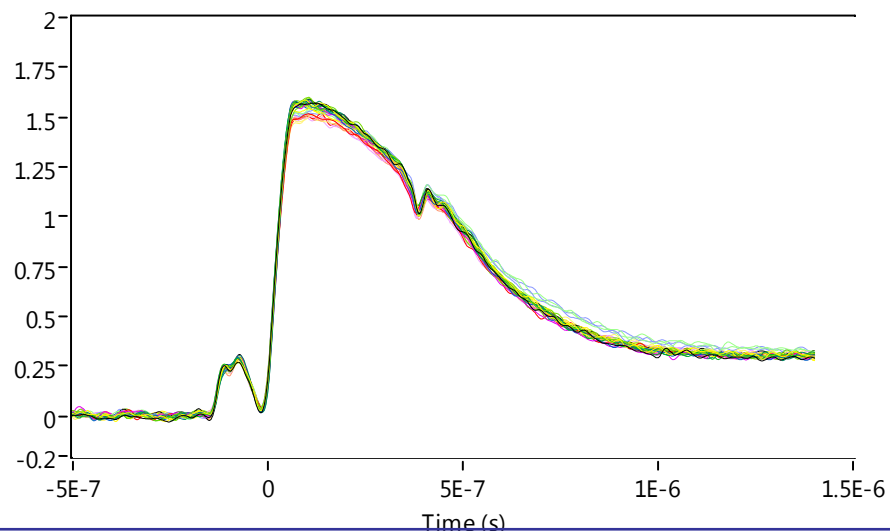
0 krad(Si)	
20 krad(Si)	
60 krad(Si)	
80 krad(Si)	
100 krad(Si)	
120 krad(Si)	
140 krad(Si)	
155 krad(Si)	
24h at 25°C	
168h at 100°C	

Ramp Type	Timing (0V to core voltage)
Hard	500 ns
Fast	1 ms
Soft	100 ms

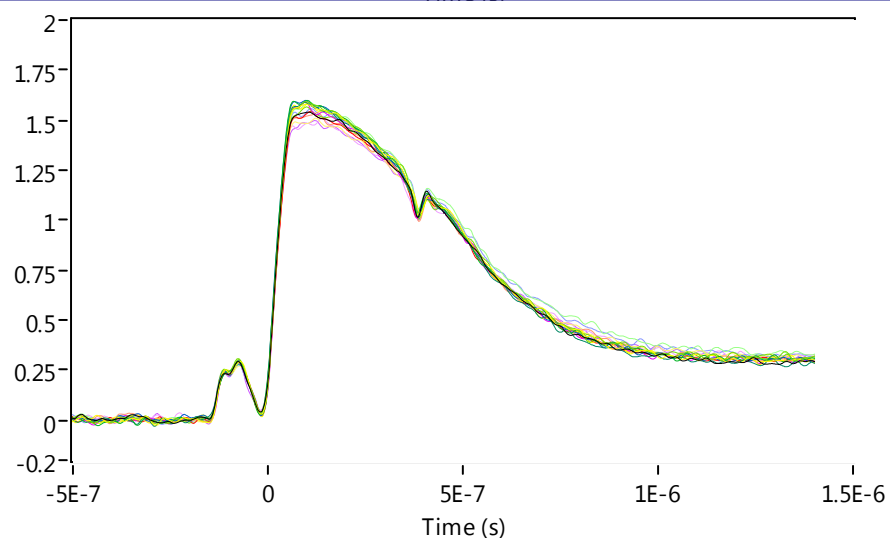
Test Results

XC4VFX40 / Hard Switch

ON



OFF



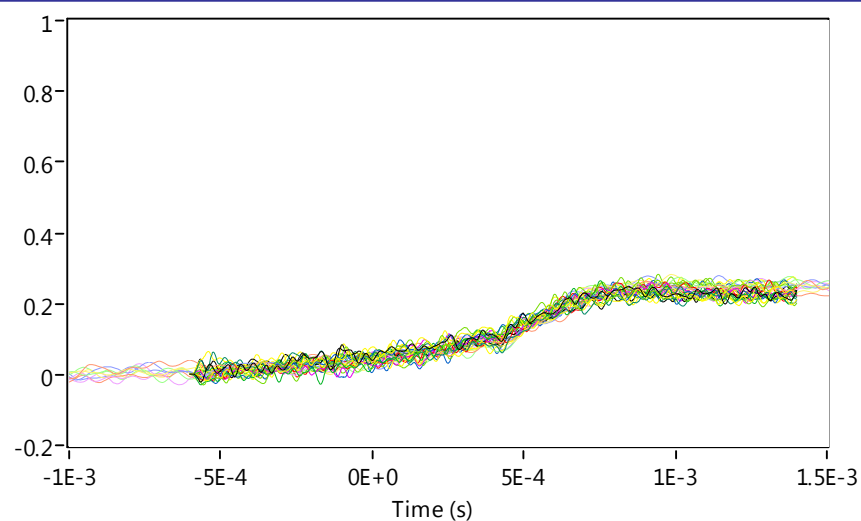
0 krad(Si)	
5 krad(Si)	
10 krad(Si)	
15 krad(Si)	
20 krad(Si)	
41 krad(Si)	
56 krad(Si)	
80 krad(Si)	
100 krad(Si)	
123 krad(Si)	
133 krad(Si)	
149 krad(Si)	
225 krad(Si)	
24h at 25°C	
168h at 100°C	

Ramp Type	Timing (0V to core voltage)
Hard	500 ns
Fast	1 ms
Soft	100 ms

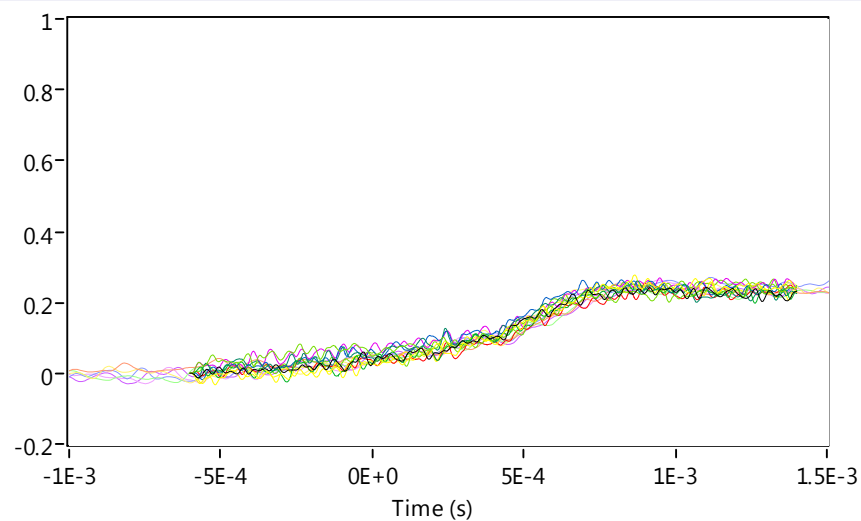
Test Results

XC4VFX40 / Fast Ramp

ON



OFF



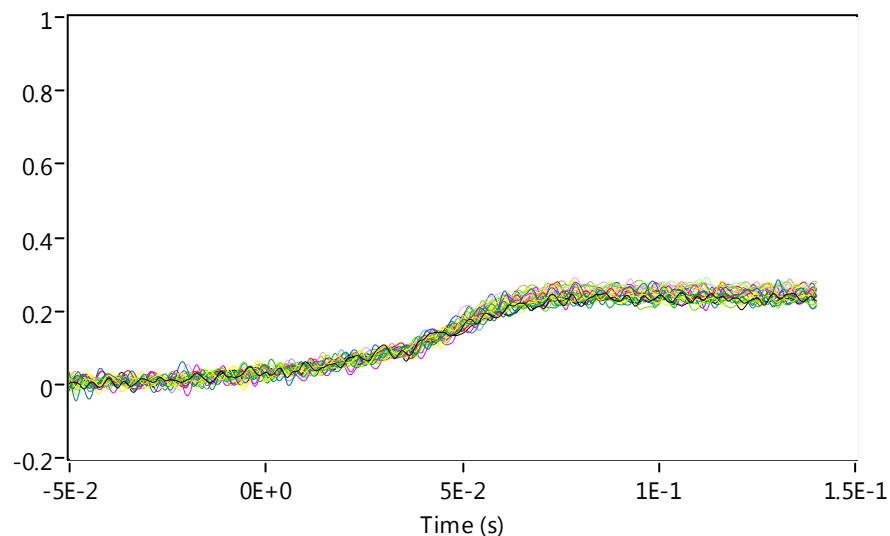
0 krad(Si)	
5 krad(Si)	
10 krad(Si)	
15 krad(Si)	
20 krad(Si)	
41 krad(Si)	
56 krad(Si)	
80 krad(Si)	
100 krad(Si)	
123 krad(Si)	
133 krad(Si)	
149 krad(Si)	
225 krad(Si)	
24h at 25°C	
168h at 100°C	

Ramp Type	Timing (0V to core voltage)
Hard	500 ns
Fast	1 ms
Soft	100 ms

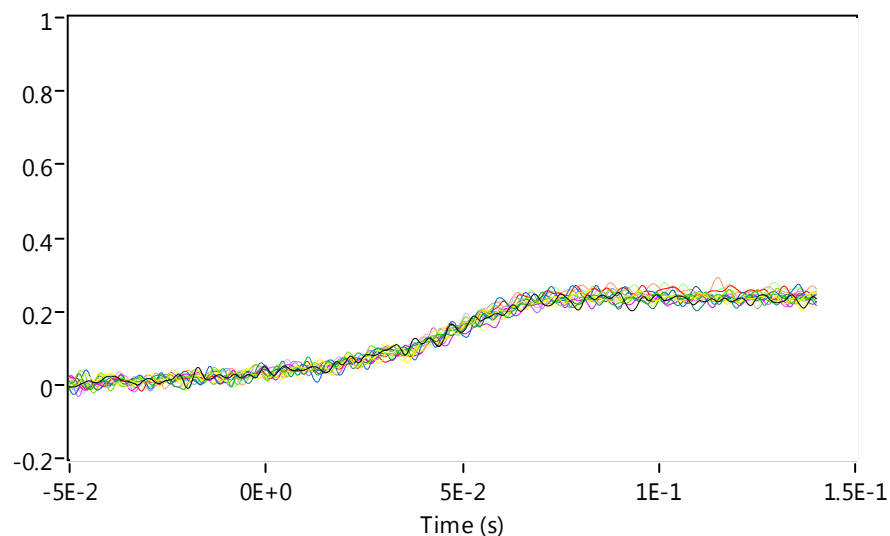
Test Results

XC4VFX40 / Soft Ramp

ON



OFF



0 krad(Si)	
5 krad(Si)	
10 krad(Si)	
15 krad(Si)	
20 krad(Si)	
41 krad(Si)	
56 krad(Si)	
80 krad(Si)	
100 krad(Si)	
123 krad(Si)	
133 krad(Si)	
149 krad(Si)	
225 krad(Si)	
24h at 25°C	
168h at 100°C	

Ramp Type	Timing (0V to core voltage)
Hard	500 ns
Fast	1 ms
Soft	100 ms

Test Results

Results summary

- HARD Switch / parts biased ON

*Non-releasable
information graph*

- Maximum core current according to the cumulated dose

- Best configuration to assure « no drift » under irradiation
- Not recommended by manufacturers
- High surge currents

Test Results

Results summary

- SOFT Ramp / parts biased ON

*Non-releasable
Information graph*

- Maximum core current according to the cumulated dose

- 3 trends

— : XC4VFX40

↗ : RTAX1000S

Non-releasable information

- Surge currents depends on part type: from 0.2 mA to 1.1 A

Test Results

Results summary

- Fast Ramp / parts biased ON

*Non-releasable
Information graph*

- Maximum core current according to the cumulated dose

- 3 trends

— : XC4VFX40

↗ : RTAX1000S

Non-releasable information

- Surge currents depends on part type: from 0.2 mA to 1.1 A

- No critical degradation of the power-up current against TID for each FPGA of this study :
 - Up to 150krad(Si) for RTAX1000S.
 - Up to 225krad(Si) for XC4VFX40.
- No significant differences between fast and soft voltage ramp.
- ACTEL RTAX1000S shows different behaviour depending on bias mode.

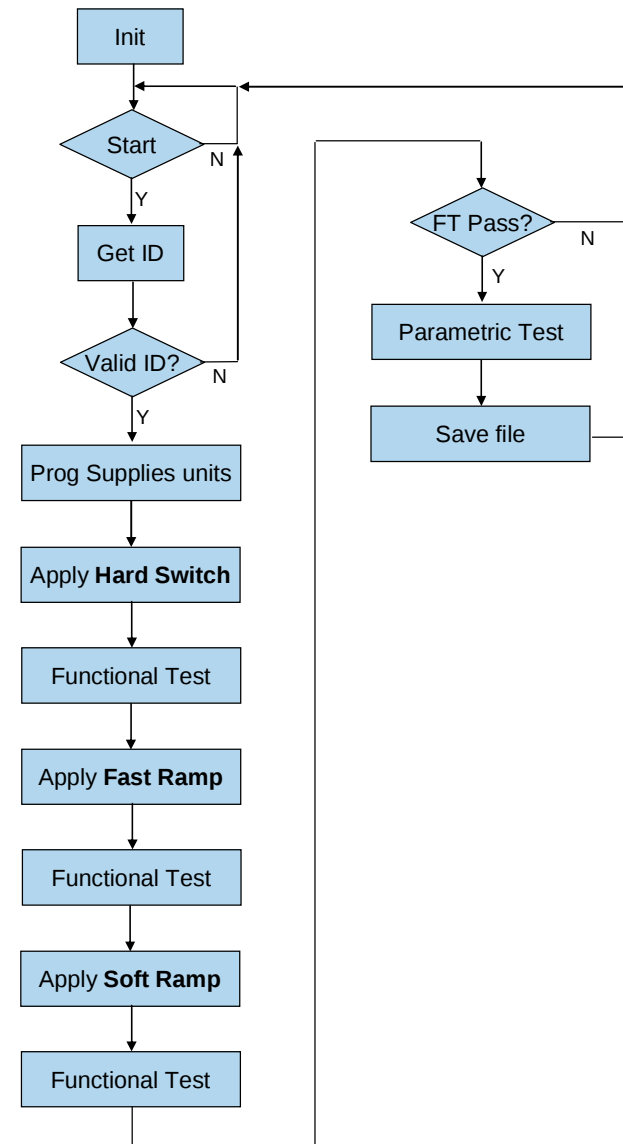
Thank you for your attention

QUESTIONS

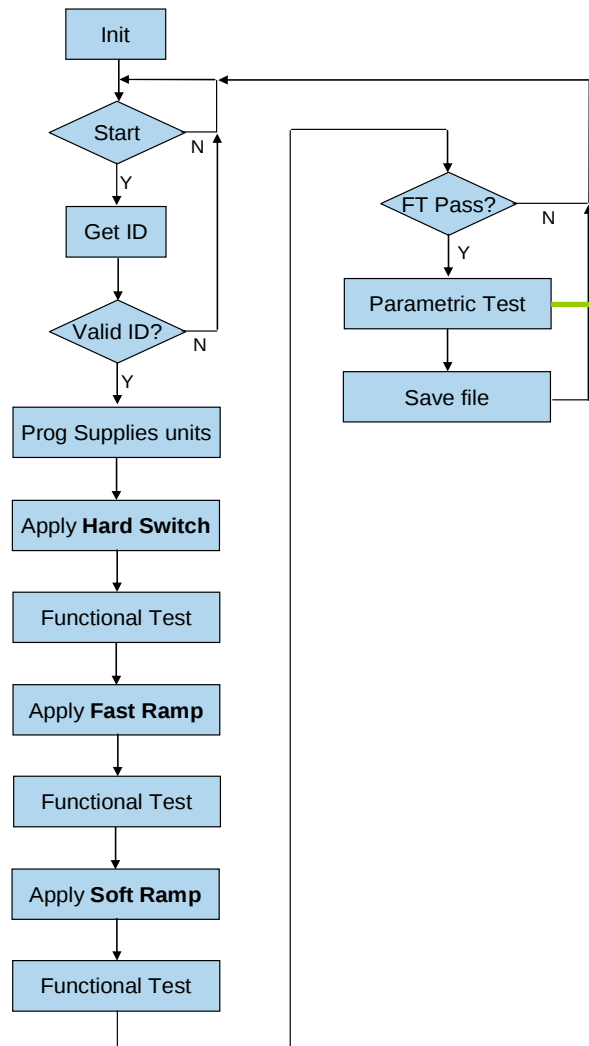


The test bench should :

- Apply the power with different power-up profiles.
- Capture the corresponding current waveform.
- Check the functionality of the device.



Parametric test



Logic levels

VIH	Logic High Input Voltage
VIL	Logic Low Input Voltage
VOH	Logic High Output Voltage
VOL	Logic Low Output Voltage
IIH	Logic High Input Current
IIL	Logic Low Input Current

Functional test : 8 Shift Registers

