Initial Dose Rate Testing of the SIRF FX-1

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* AFRL, others Xilinx

Initial Dose Rate Testing of SIRF FX-1

- Testing was conducted at the AFRL Febetron 705 2 Mev Flash X-ray facility at Kirtland AFB on 8-18-2009
- Utilized were a specially socketed V5 AFX prototyping board and ceramic packaged bare SIRF FX-1 die (no heat sink)
- Testing was done up to the maximum dose rate capability of the X-ray facility as was then facilitated
- Calibration of the flash X-ray dose was done in situ with CaF2 total luminescent dosimetry with traceability
- Threshold dose rates were established for logic upset (assumed root cause was lost clock pulses whose number was energy dependent), configuration (programming) latch upset, and dose rate induced latchup (a minimum device performance was established as latchup was not realized)

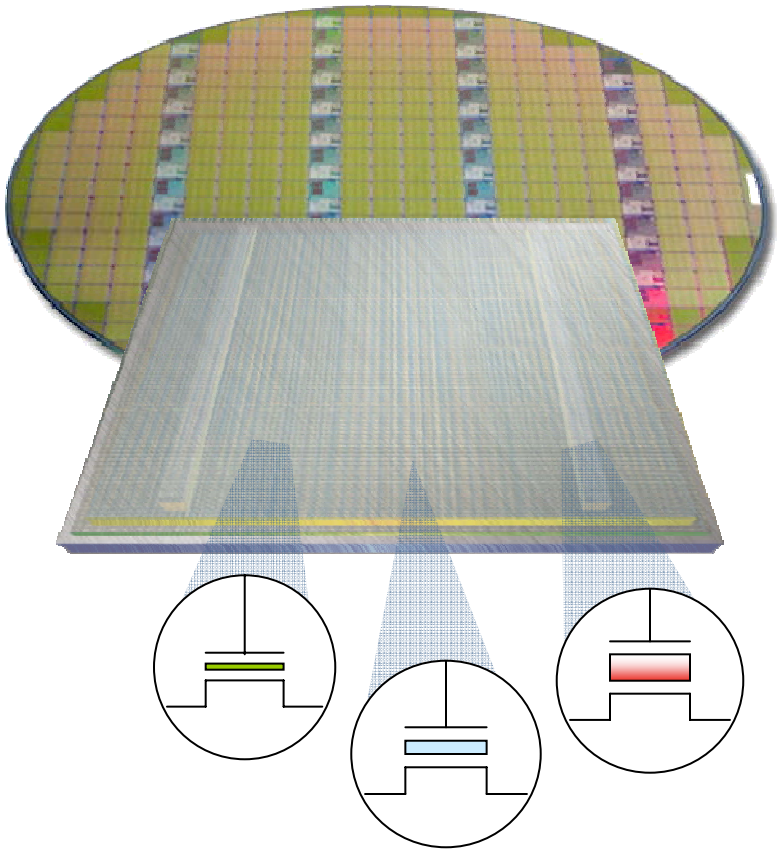
Device Tested

Part Number		XQR5VX130T
Logic Cells		131,072
6-input LUTS, CLB-FFs		81,920
Distributed RAM (kBit)		1,580
BRAM Blocks (36kBit)		288
Total BRAM (kBit)		10,368
Clock Tiles (4 PLL, 2 DCM)		6
DSP48E Slices		320
MGT-GTX Channels		18
PCI Express Blocks		3
Ethernet MACs		6
User IO		836
Speed Grade Support		-1
Temperature Grade Support		V
Package	**Area (pitch)**	**Max User IO: SelectIO (MGT)**
CF1752	45 x 45mm (1mm)	836 (18)

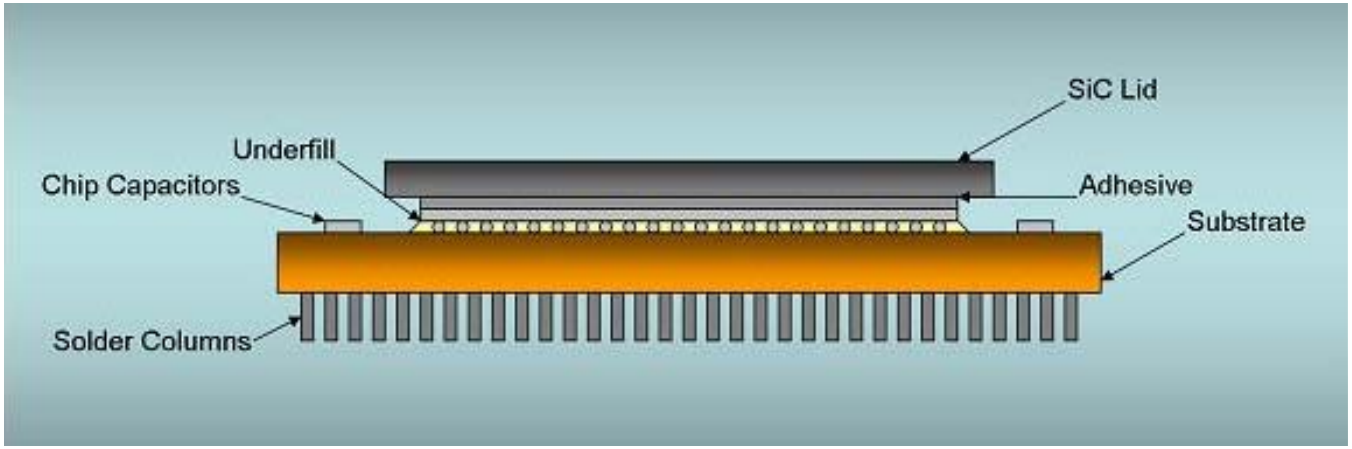
- The ES version of the SIRF FX-1 (XQR5VX130T) was tested for dose rate response
- Dual 64 Mb shift Registers were instantiated into the device with tap points at 25-50-75-100%
- Logical and programming upsets, as well as dose rate induced latchup, were remotely monitored

65nm RHBD Process Generation

- **1.0V, 12-layer Metal, Low-K**
- **Copper via fill**
- **2nd Generation Triple-oxide technology**
  - Low static power (comparable to 90nm)
- **Move from 1.2V to 1V core**
  - 35% lower dynamic power ($P = cv^2f$)
- **Nickel Silicide self-aligned technology**
  - Low resistivity yields high performance
- **Substrate**
  - Fabrication utilizes a thin epitaxial silicon atop a highly doped substrate

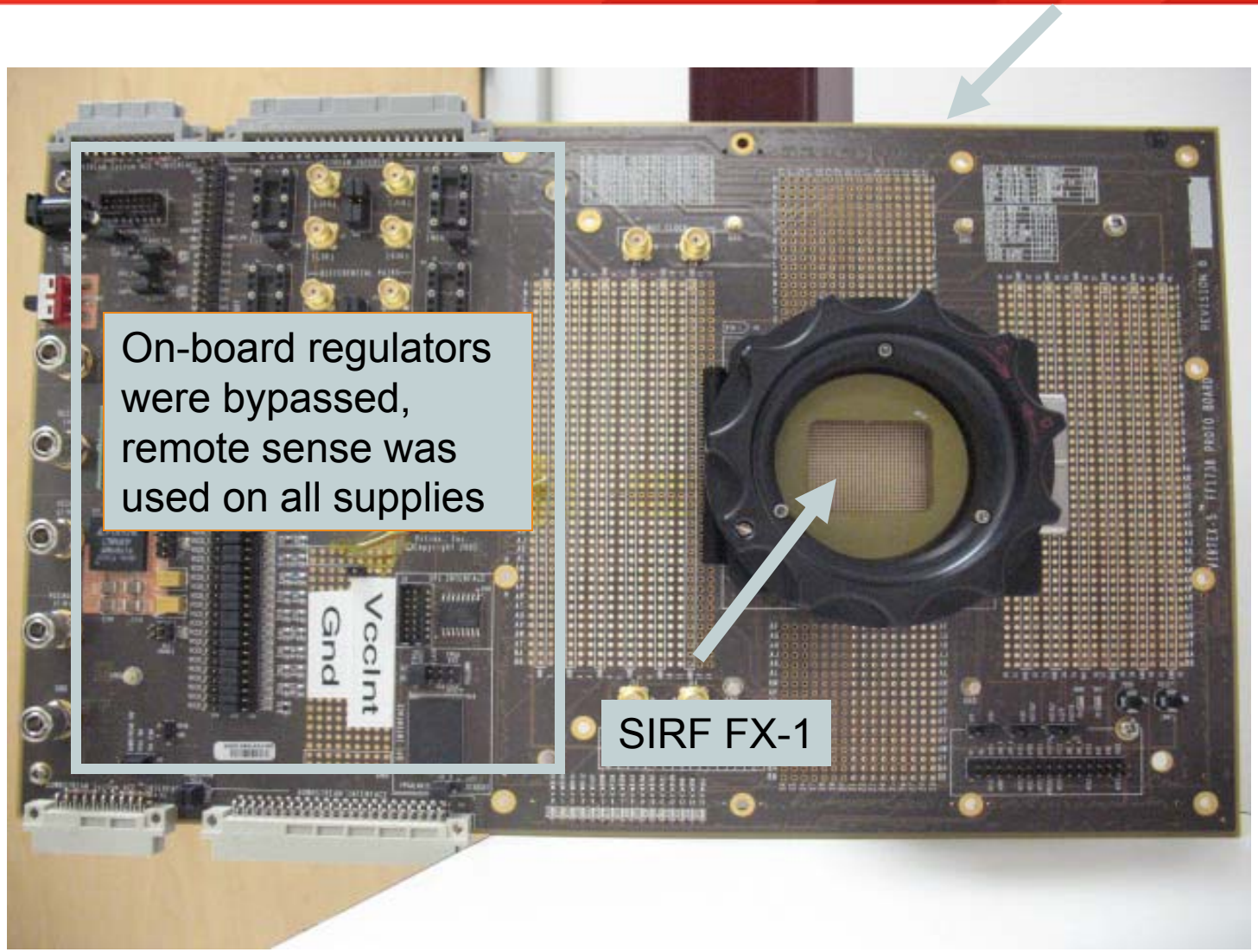


Packaging Considerations

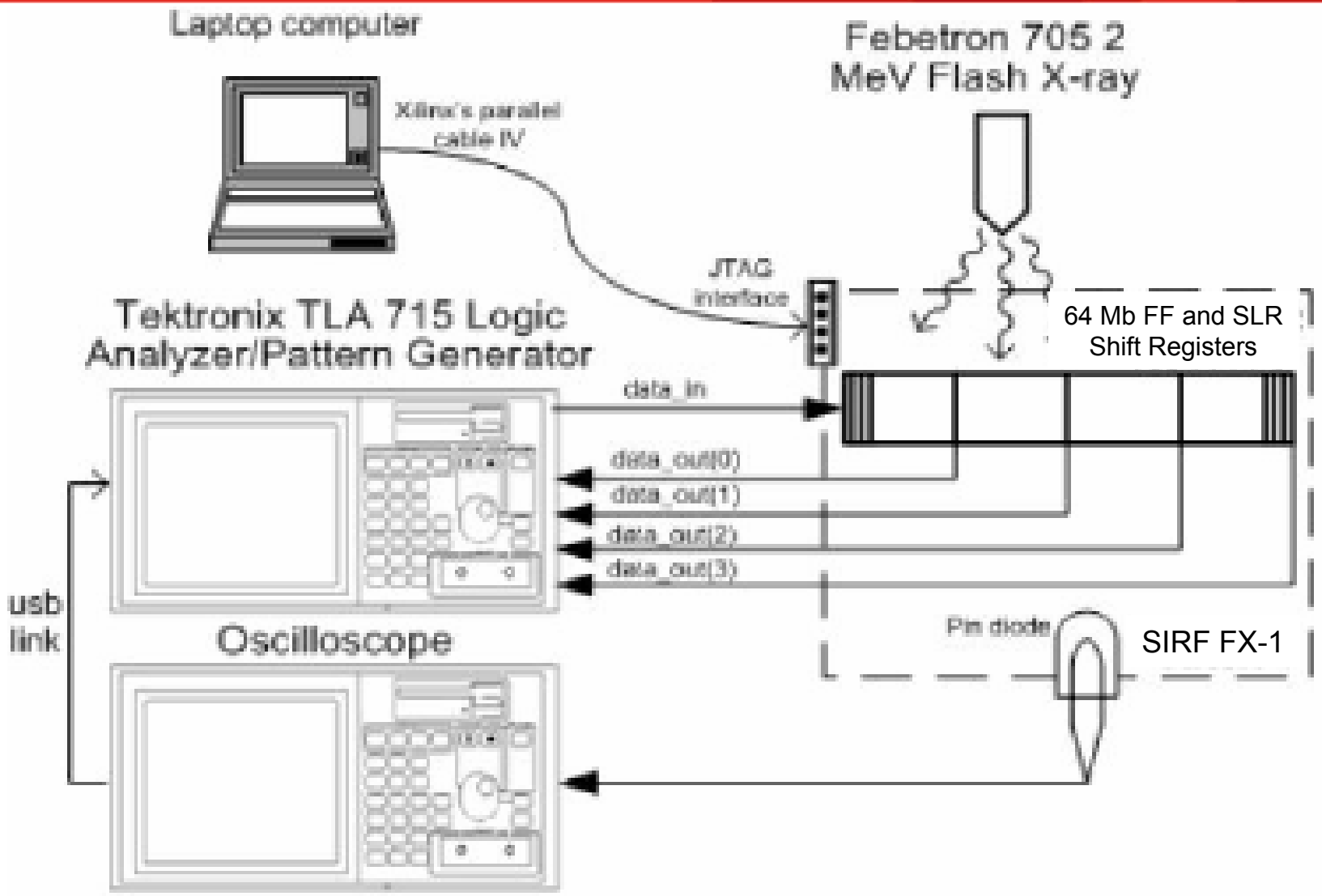


- The SIRF FX-1 is normally packaged in a flip chip ceramic CF1752 package with an attached SiC heat sink
- For this test parts were specially prepared without the normal heat sink (the die was bare & exposed on its back side)
- A PIN diode was placed directly behind the device for pulse rate monitoring and timing during the tests
- CaF2 total luminescent dosimeters were placed directly on top of the die for calibration of the PIN diode response at three dose rate points over the dose rate range tested

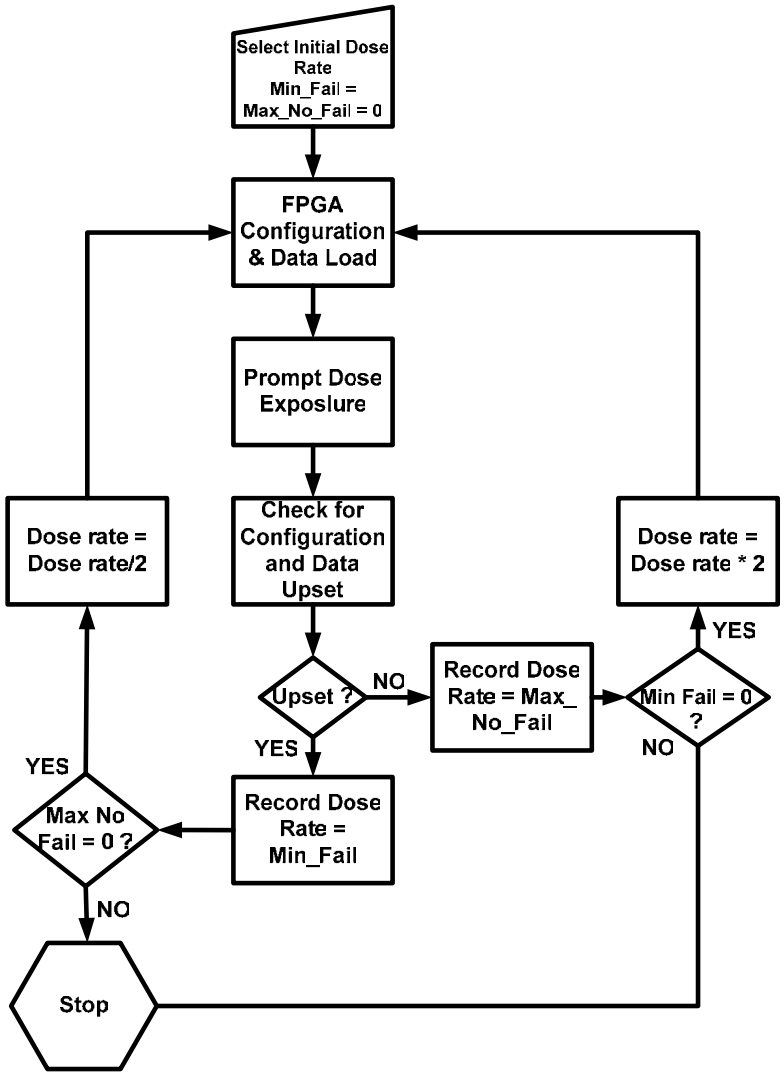
AFX Board with High Speed Socket



Dose Rate Test Facilitation



Test Sequence



- The FPGA was configured through the download cable
- Proper operation of the registers was verified, all currents recorded
- The part was exposed to a prompt dose, currents were again recorded
- The performance of the registers was captured
- The configuration file was read back and captured utilizing custom software
- The dose rate was incremented to a new level

Pulse Rate Test on 2 Shift Registers

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Pulse Broadening Logic Threshold

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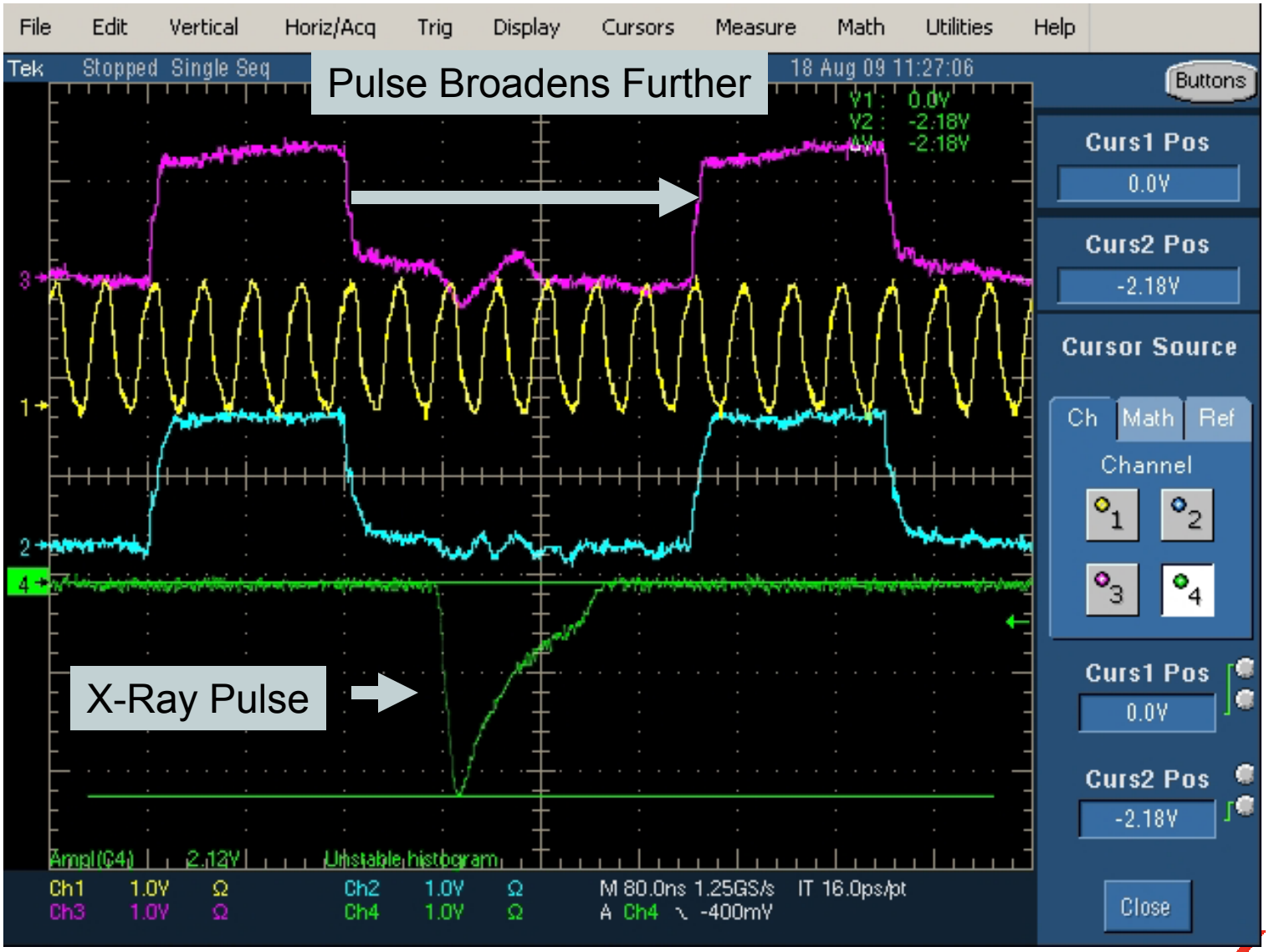
Higher Energy X-Ray Pulse Results



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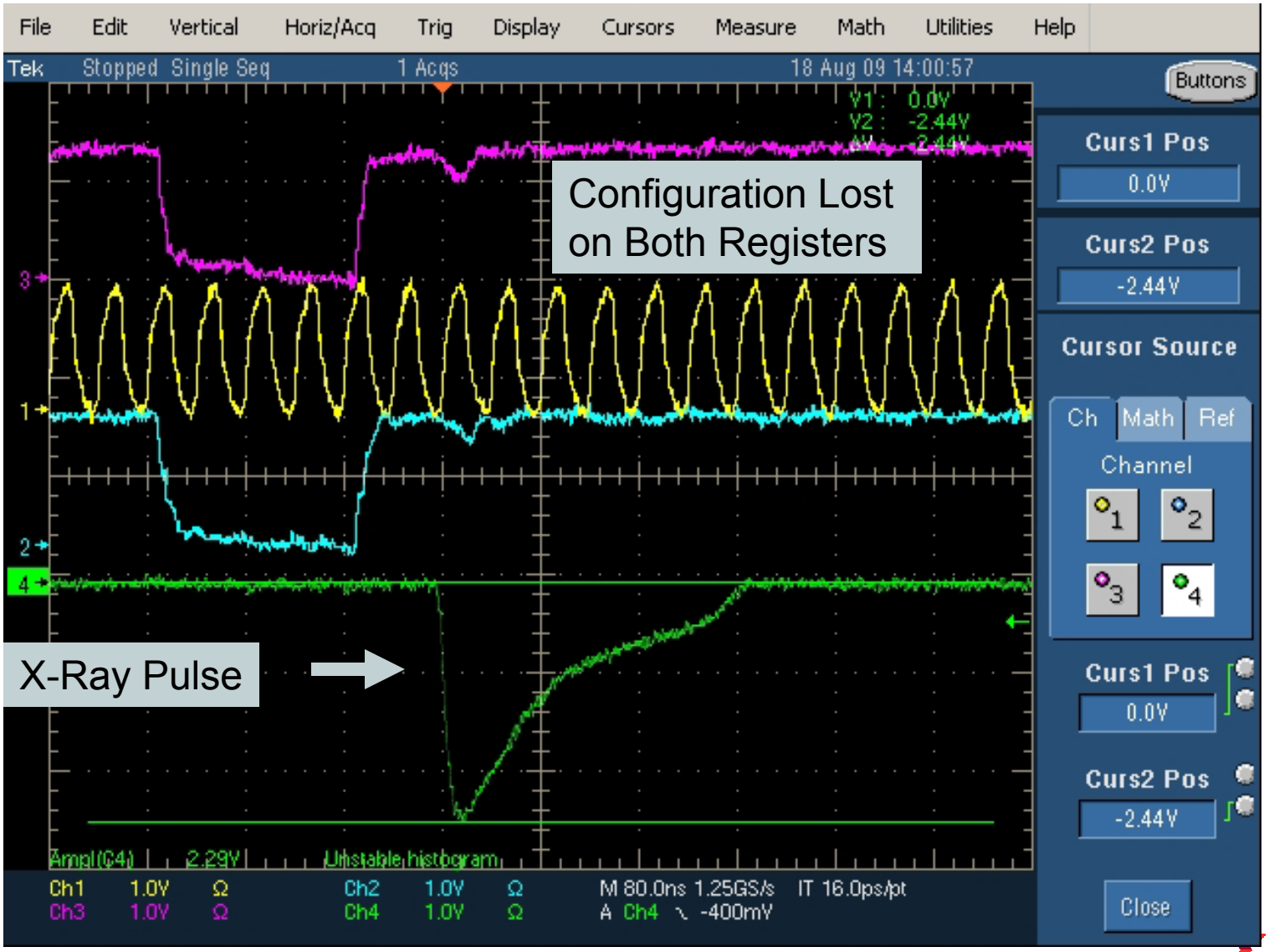
Configuration Upset Threshold



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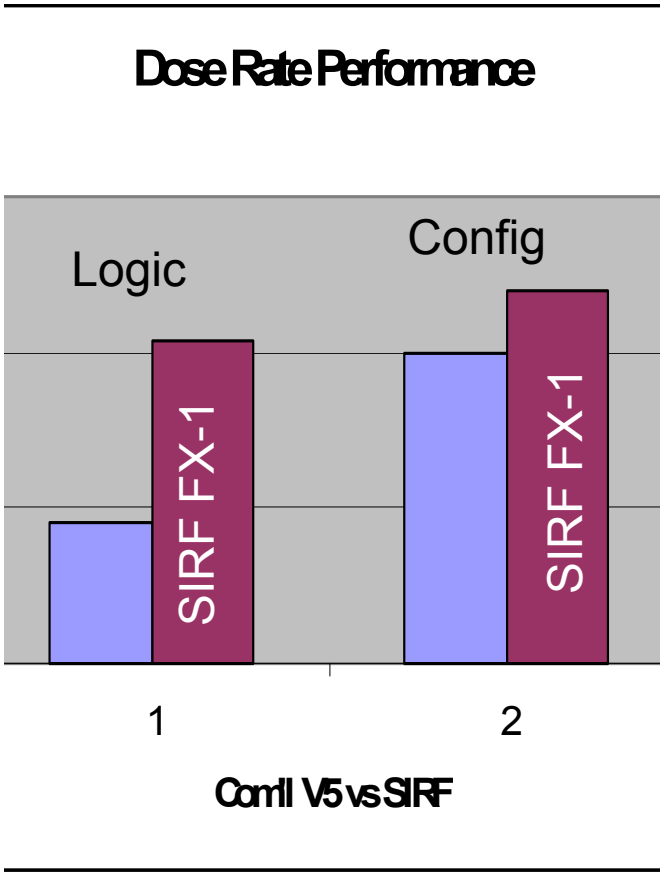
Comparative Performance – FX-1 vs Com'l V5

- **The SIRF FX-1 showed about a one order of magnitude increase in the dose rate upset threshold for instantiated logic compared to the results* on commercially available V5 products**
- **The SIRF FX-1 showed about a 2.5x increase in the dose rate upset threshold for configuration memory over commercial V5 products**



* Coml dose rate results on the XC5VLX50T were previously reported by Vera et. al. at NSREC and in several internal reports by others

Conclusions

- First logic upsets occurred at higher dose rates than the established program goals
- Root cause of logic upset appears to be temporary loss of the clock (length of loss appears to be energy dependent)
- First configuration loss occurred at even higher dose rate than the established program goals
- Destructive latch was not confirmed up to 85% of established program goal for latchup, additional testing is planned at higher dose rate levels