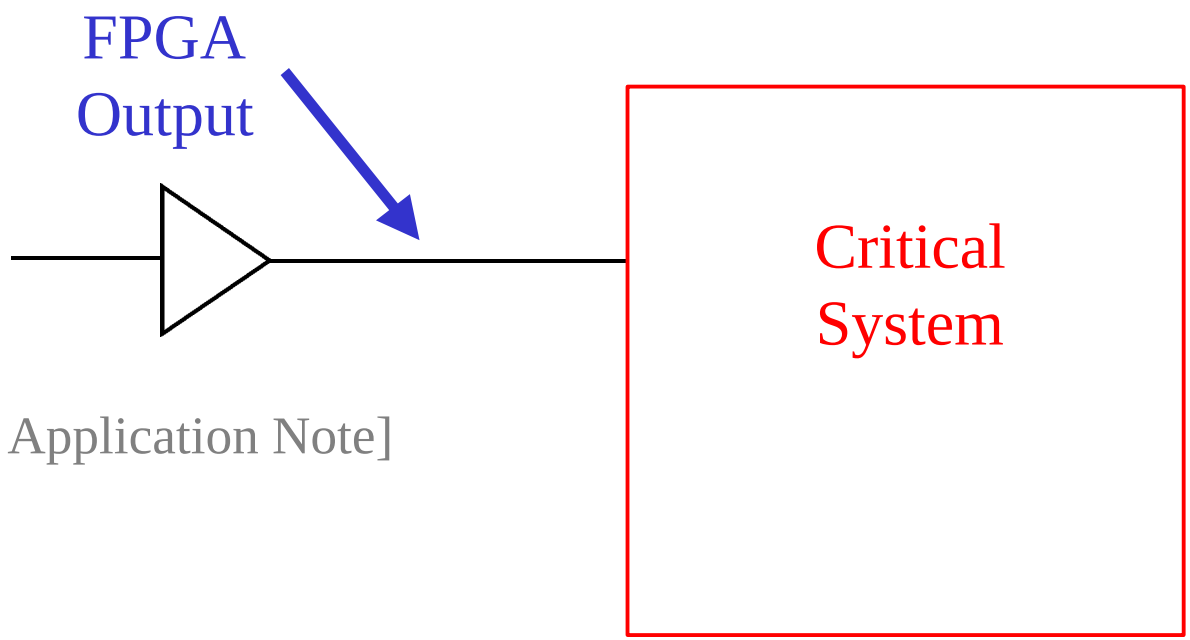
Startup Transients

Start up Transient - Outputs

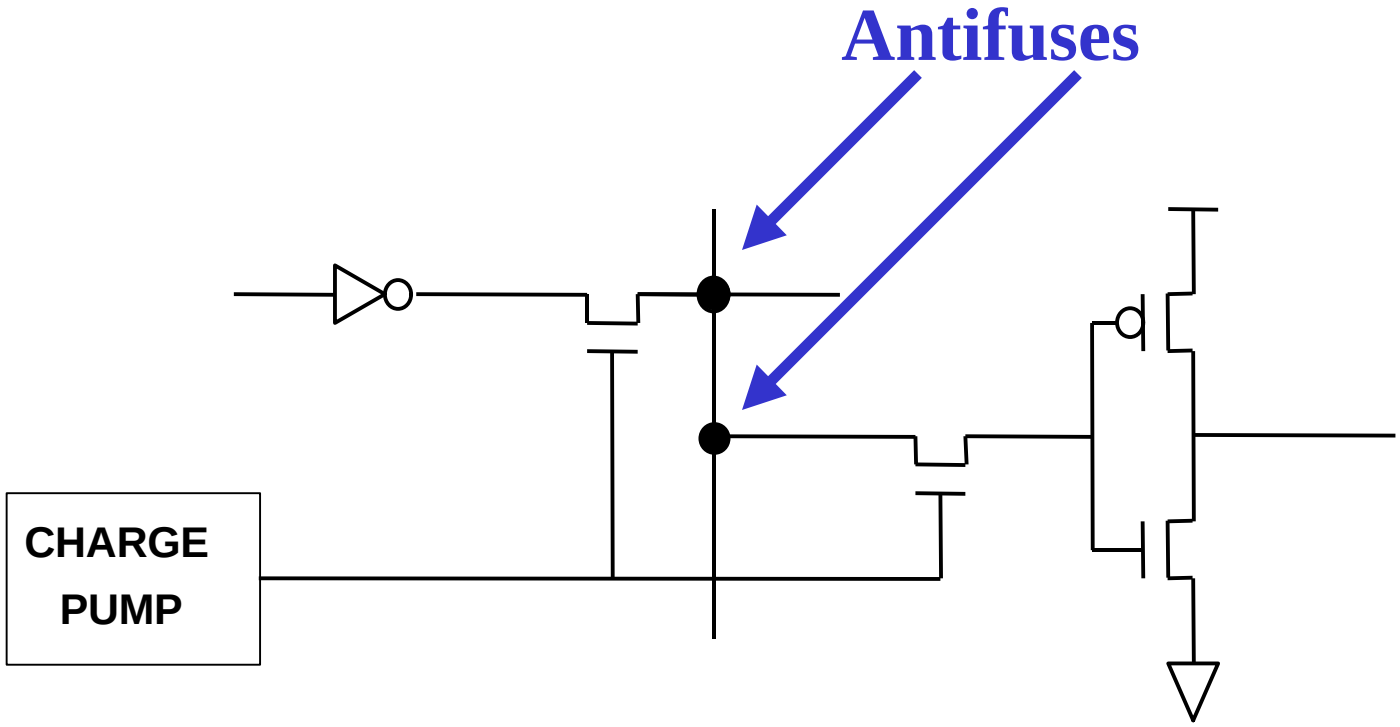


[from Actel Application Note]

<u>Power Up</u>

Actel FPGAs are nonvolatile and therefore require no external configuration circuitry on power up. However, at power up it does take a finite amount of time for the device to become stable and operate normally. For a V_{CC} slew rate of ~30 ns/V, it takes approximately 250 ms for the device to become fully operational. Power up time varies with temperature, where cold is worst case. At power up, the state of all flip-flops is undefined. Some new designs will be power up safe.

Start up Transient
Charge Pump and Isolation

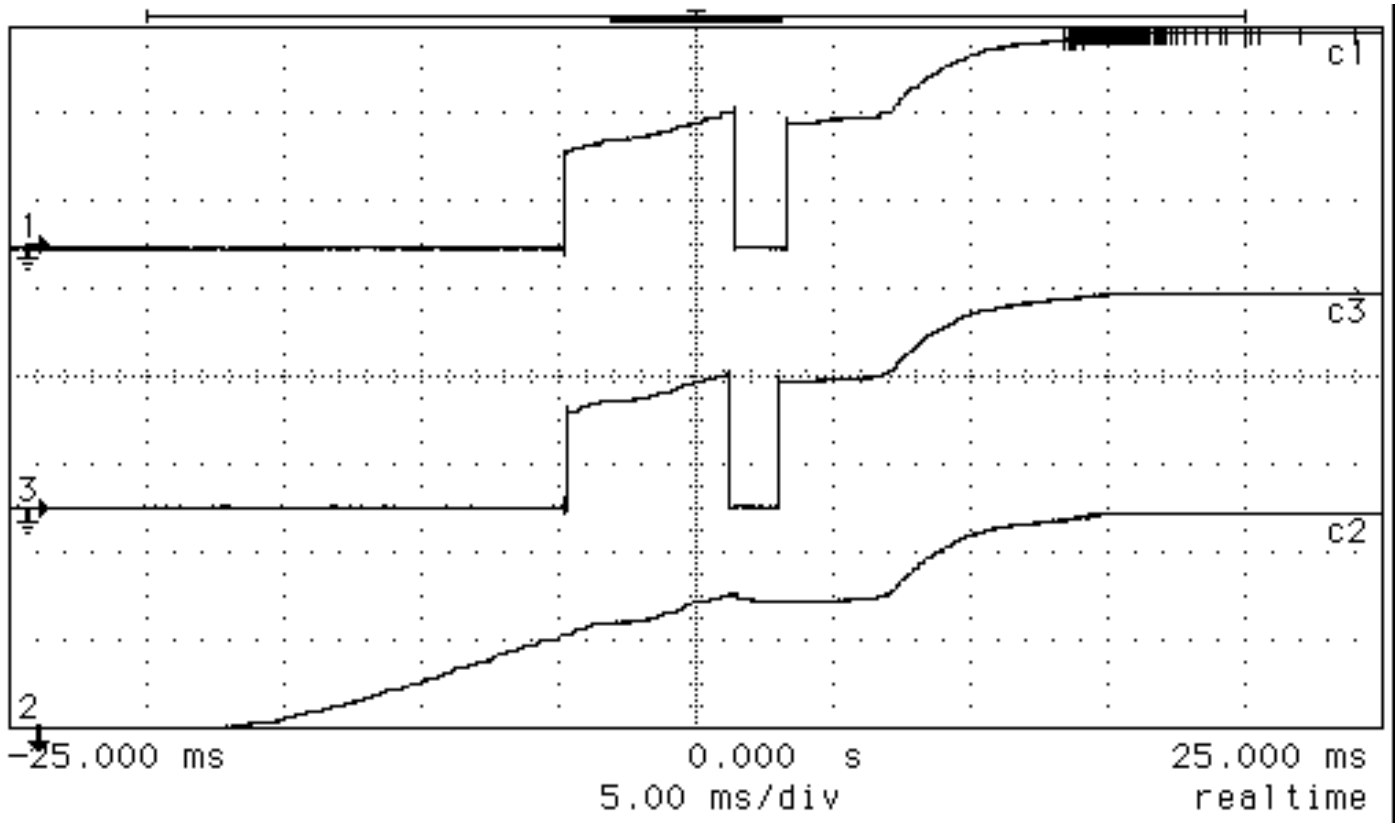


Start up Transient - Outputs

Fire Cover

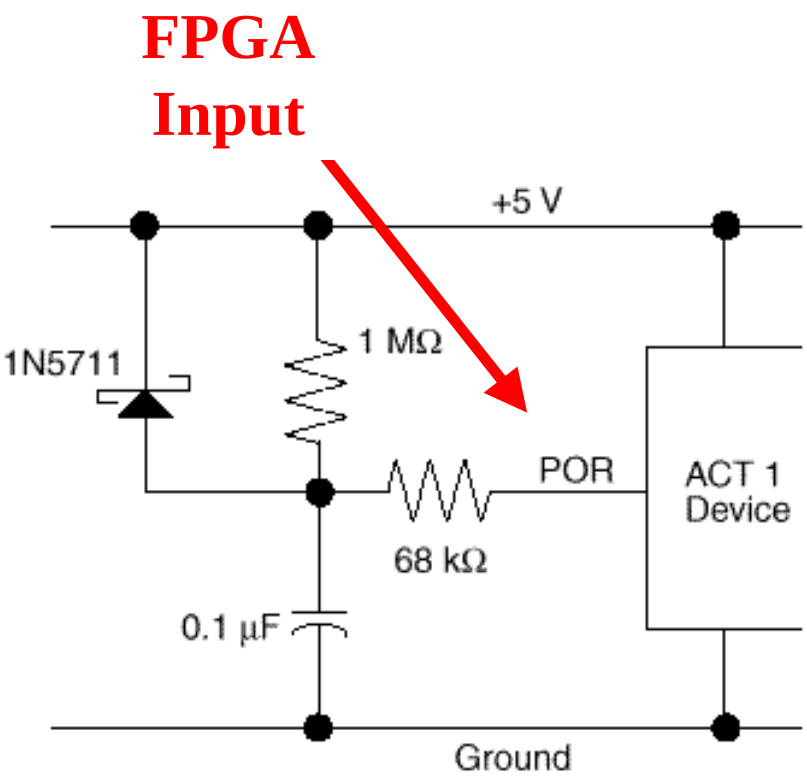
Arm

V_{CC}



Hor: 5 ms/Division; Ver: 2 volts/Div

Start up Transient - Inputs

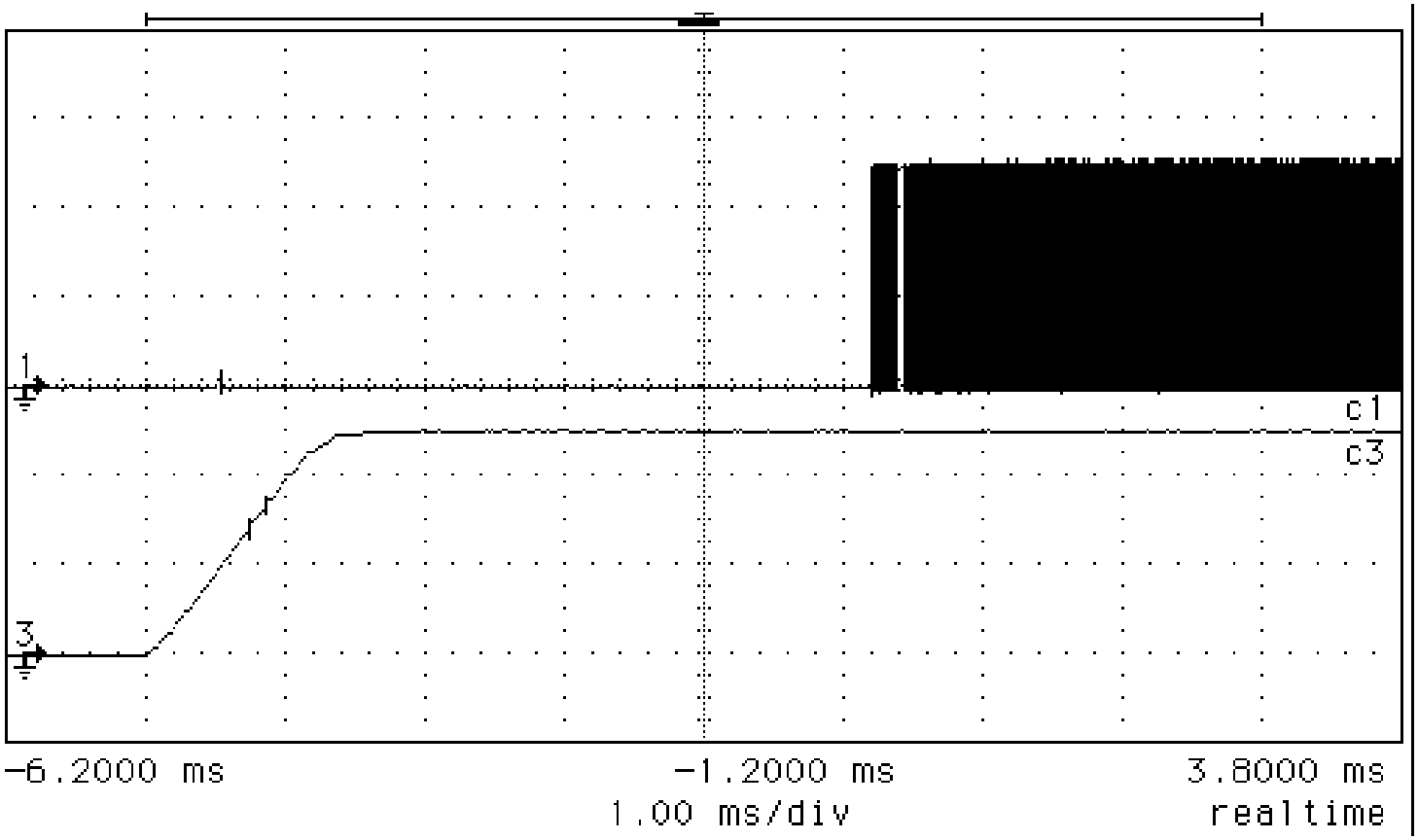


During the start up time with many FPGA models, an input may source current. In this application, a buffer with Schmidt trigger inputs is recommended.

Flight Oscillator Start Time

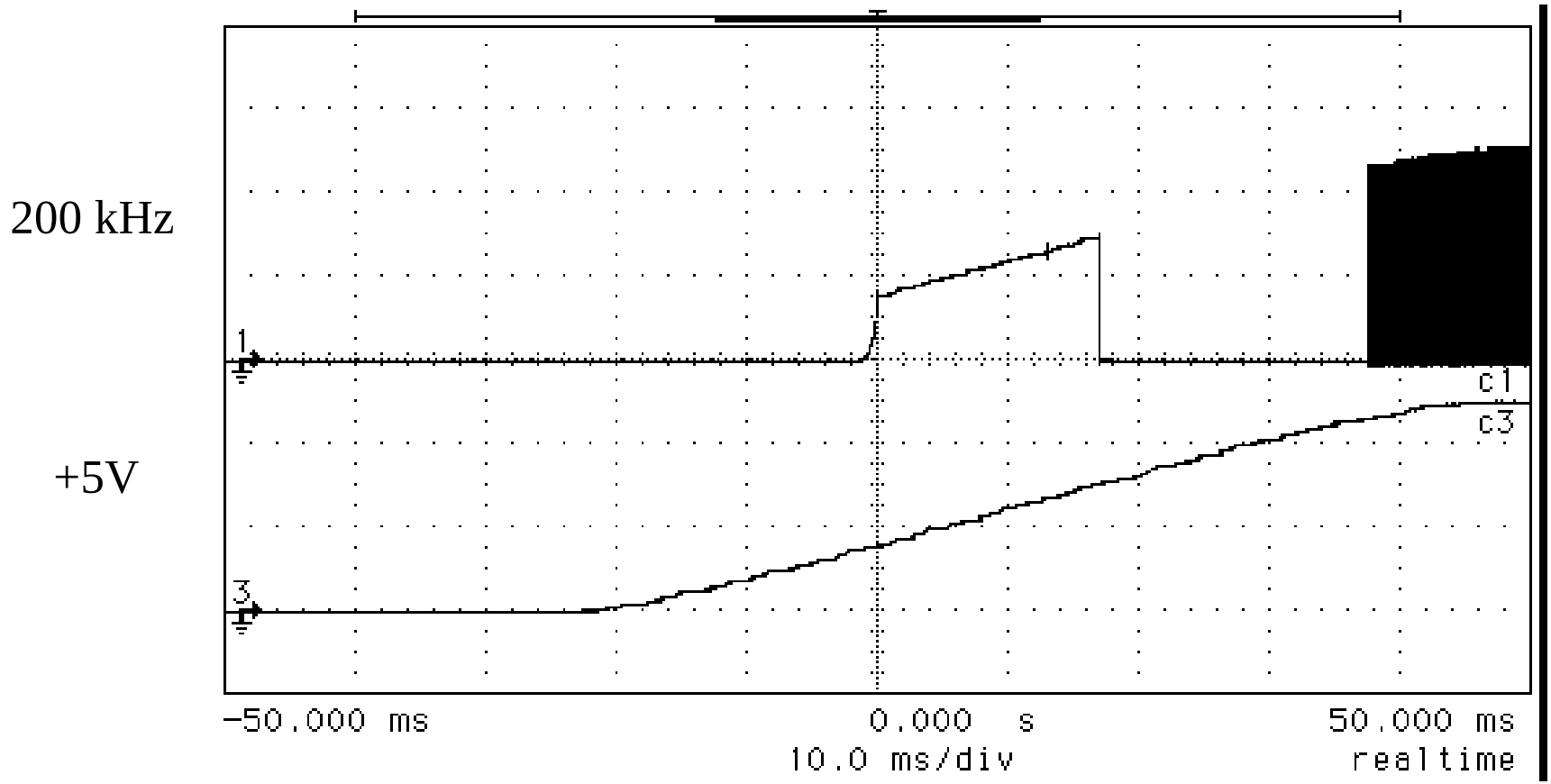
200 kHz

+5V



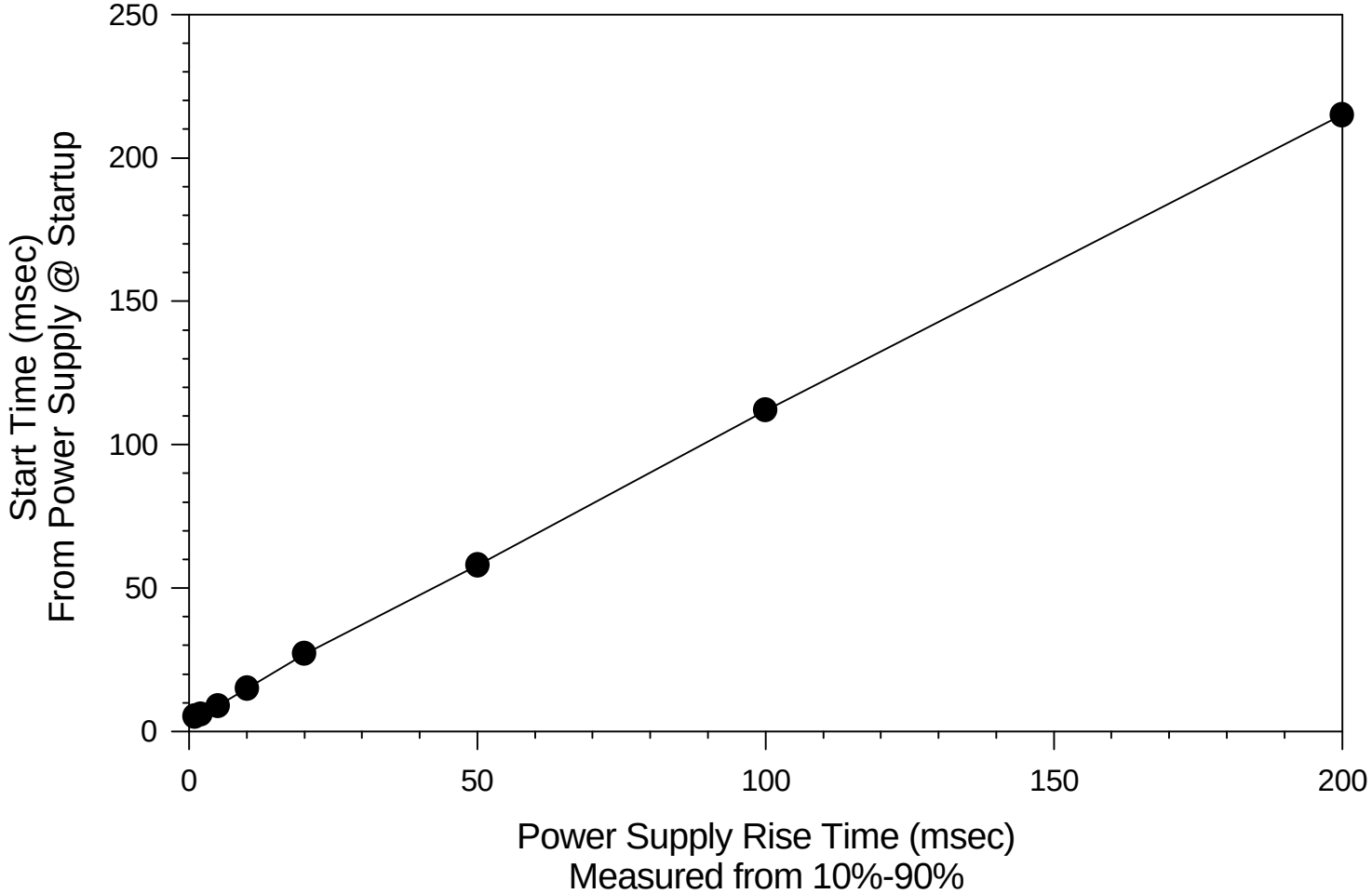
1 ms/div; t_{RISE} = 1 ms

Flight Oscillator Start Time

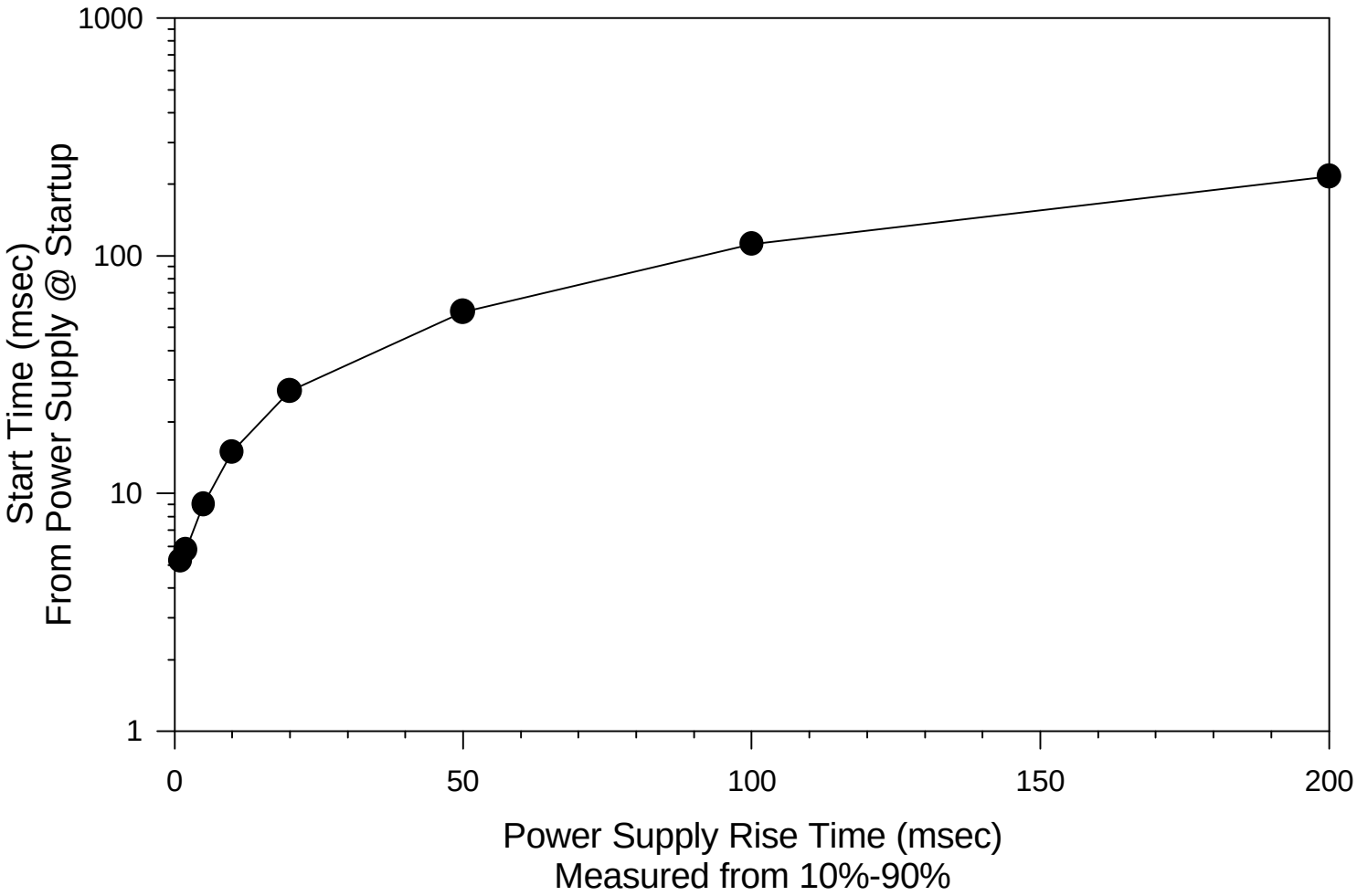


10 ms/div; t_{RISE} = 50 ms

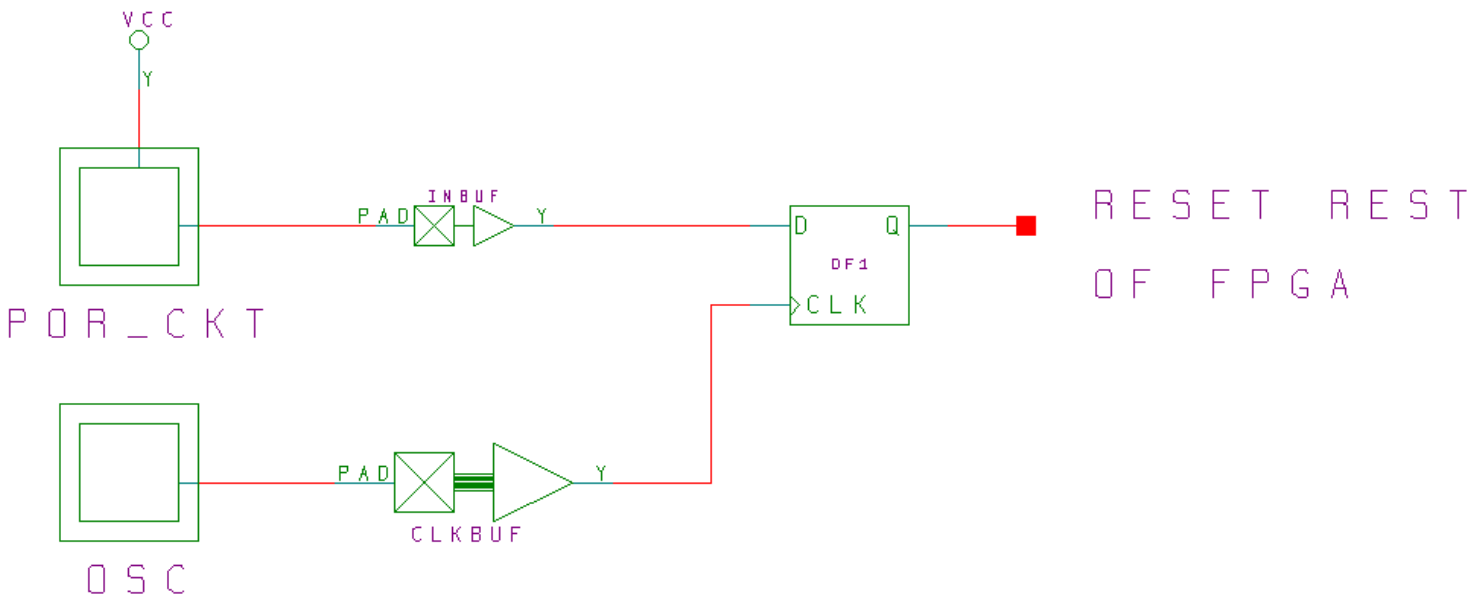
Flight Oscillator Start Time Summary



Flight Oscillator Start Time Summary



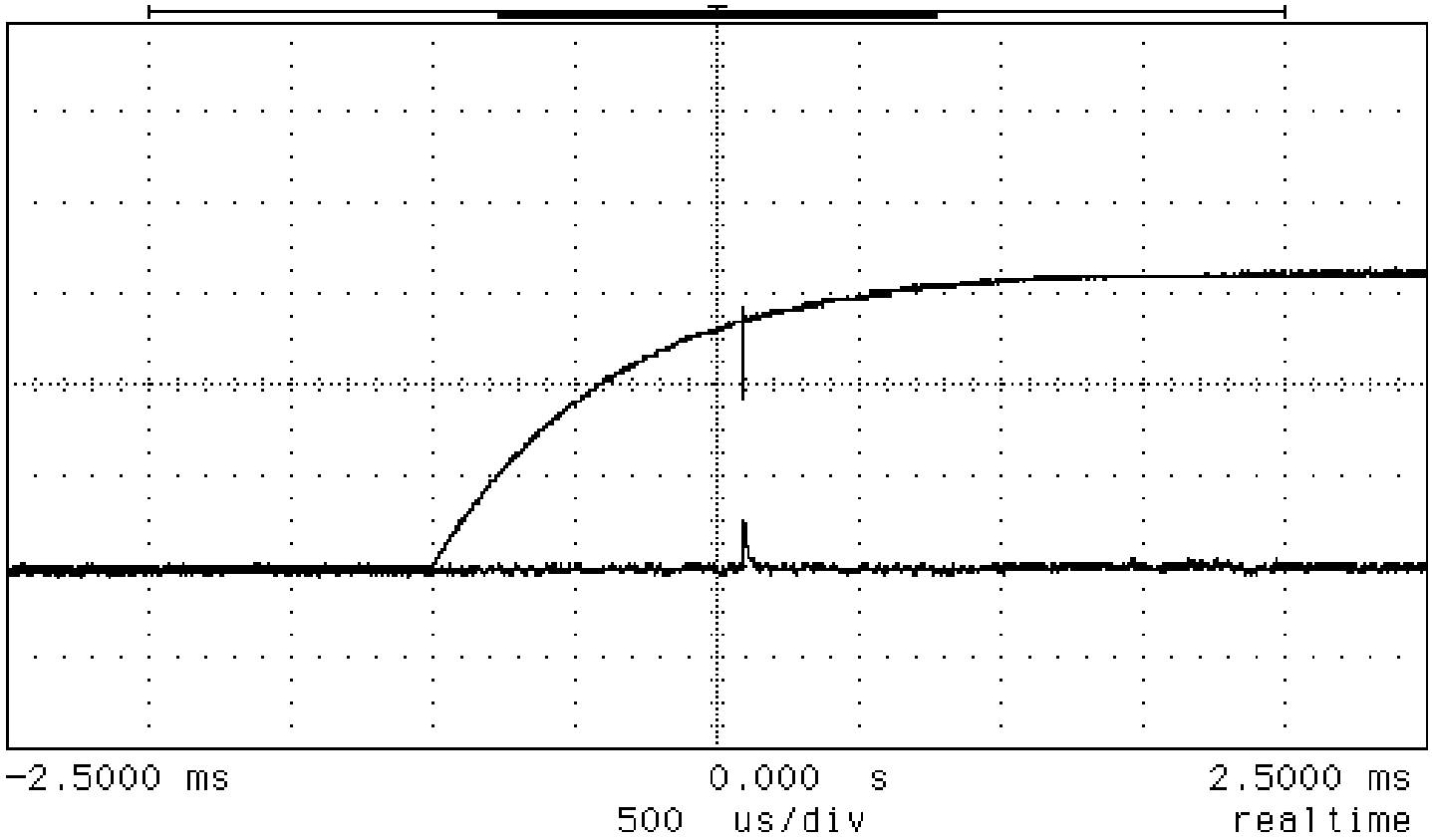
Synchronous Reset



- FPGA may not be functional during power-on transient
- Crystal oscillator start time

Startup Current Transient

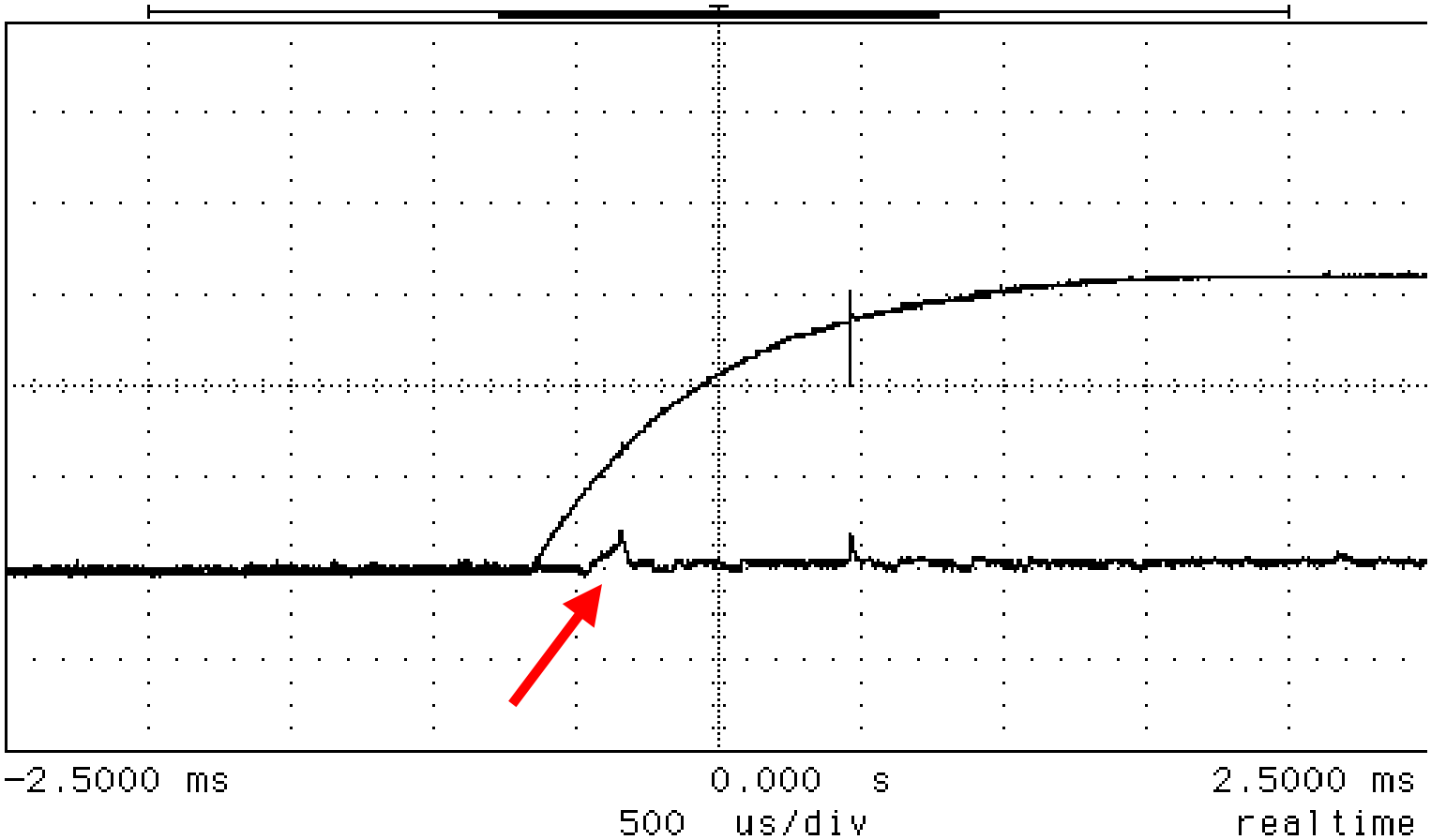
Case Study: RT54SX32 Pre-Irradiation



Startup current transient (3.3V supply) of an RT54SX32 pre-irradiation. Voltage at 1V/Div and current at 100mA/Div.

Startup Current Transient

Case Study: RT54SX32 Post-Irradiation



Startup current transient (3.3V supply) of an RT54SX32 after 98 krad (Si). Voltage at 1V/Div and current at 100 mA/Div.

Startup Current Transient
Xilinx Technology

- Two sets of requirements for the power-on transient for Xilinx XQR4000XL and Virtex 2.5V FPGAs.
  - Rise time
  - Current capability of the power supply.
- Noted that unlike Actel FPGAs where slower power supply rise times result in higher current values, in Xilinx devices, *faster* rise times result in higher current values.

Startup Current Transient
Xilinx XQR4000XL

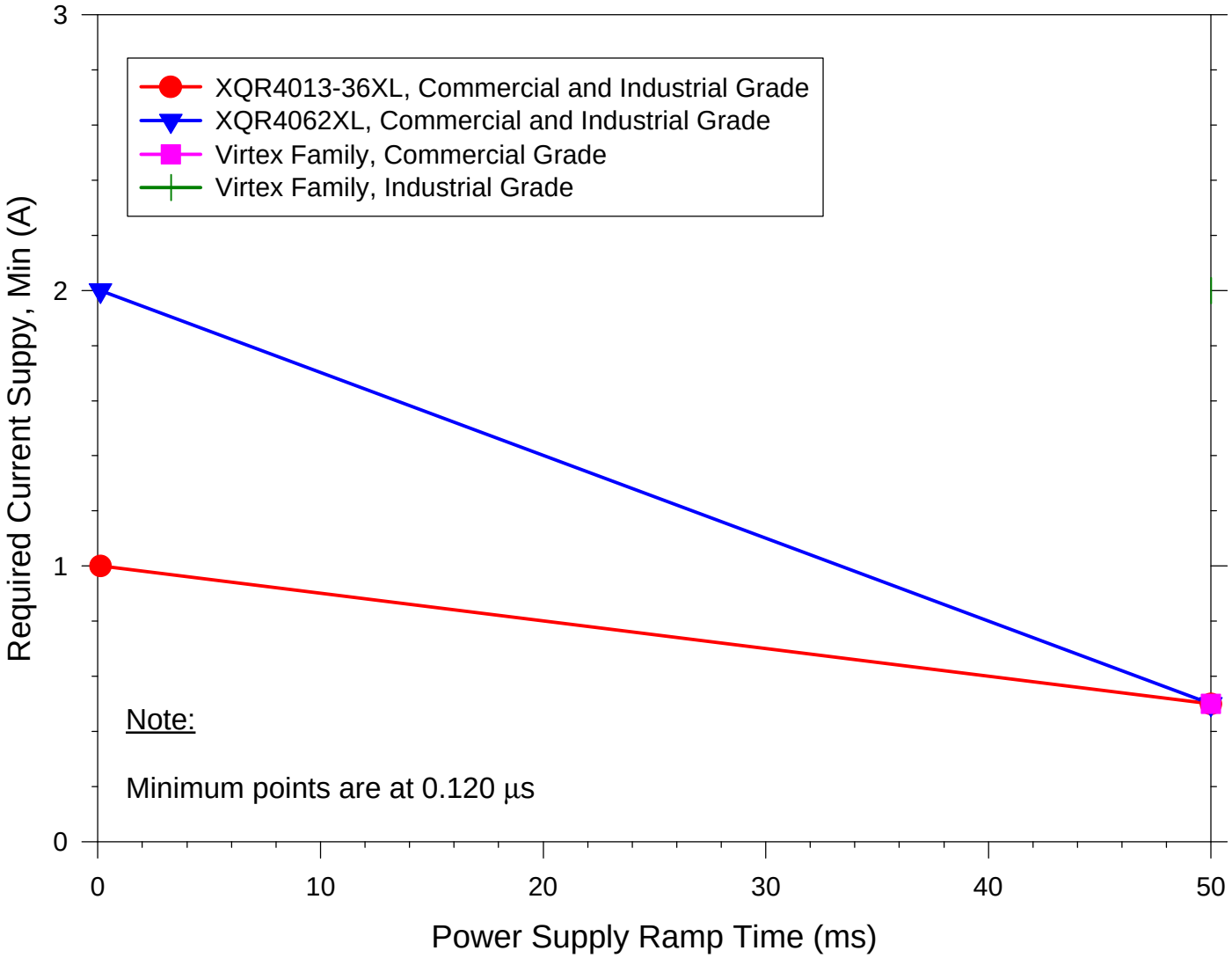
- Rise Time
  - Slowest power supply rise time is 50 ms. Many power supplies can meet this specification easily
  - Some spaceborne power supplies may have longer rise times.
- Current Levels
  - The minimum current is broken into two groups: XQR4013-36XL and the XQR4062XL. Note that according to the specification, the values refer to commercial and industrial grade products only, with the transition measured from 0 VDC to 3.6 VDC. *Actual* currents may be higher than the minimums specified.
  - Note 3 in the specification states that the duration of the peak current level will be less than 3 ms.

Startup Current Transient
Xilinx Virtex

- Complete power supply requirements are not yet specified in the radiation hard data sheet. Some of the information is taken from the commercial data sheet.
- Rise Time
  - Slowest power supply rise time for this series of parts is 50 ms.
  - The fastest suggested ramp rate is 2 ms.
    - May be slow for some power supplies. The parameter measurement criteria on the radiation hard data sheet is from 1 VDC to 2.375 VDC.
- Current Levels
  - The data sheet only specifies a minimum required current supply for Virtex devices at a power supply rise time of 50 ms.
  - According to the non-military specification, it is 500 mA for commercial grade devices and 2 A for industrial grade parts.
  - Additionally, shorter power supply rise times will result in higher currents.
  - The duration of peak currents will be less than 3 ms.

Startup Current Transient

Summary: Xilinx Technology



I_{CC} Start-Up Transient Study in the RT1280A

An examination of the effects of radiation, a detailed look at the response of the part, annealing, and impacts to the board-level and system designs.

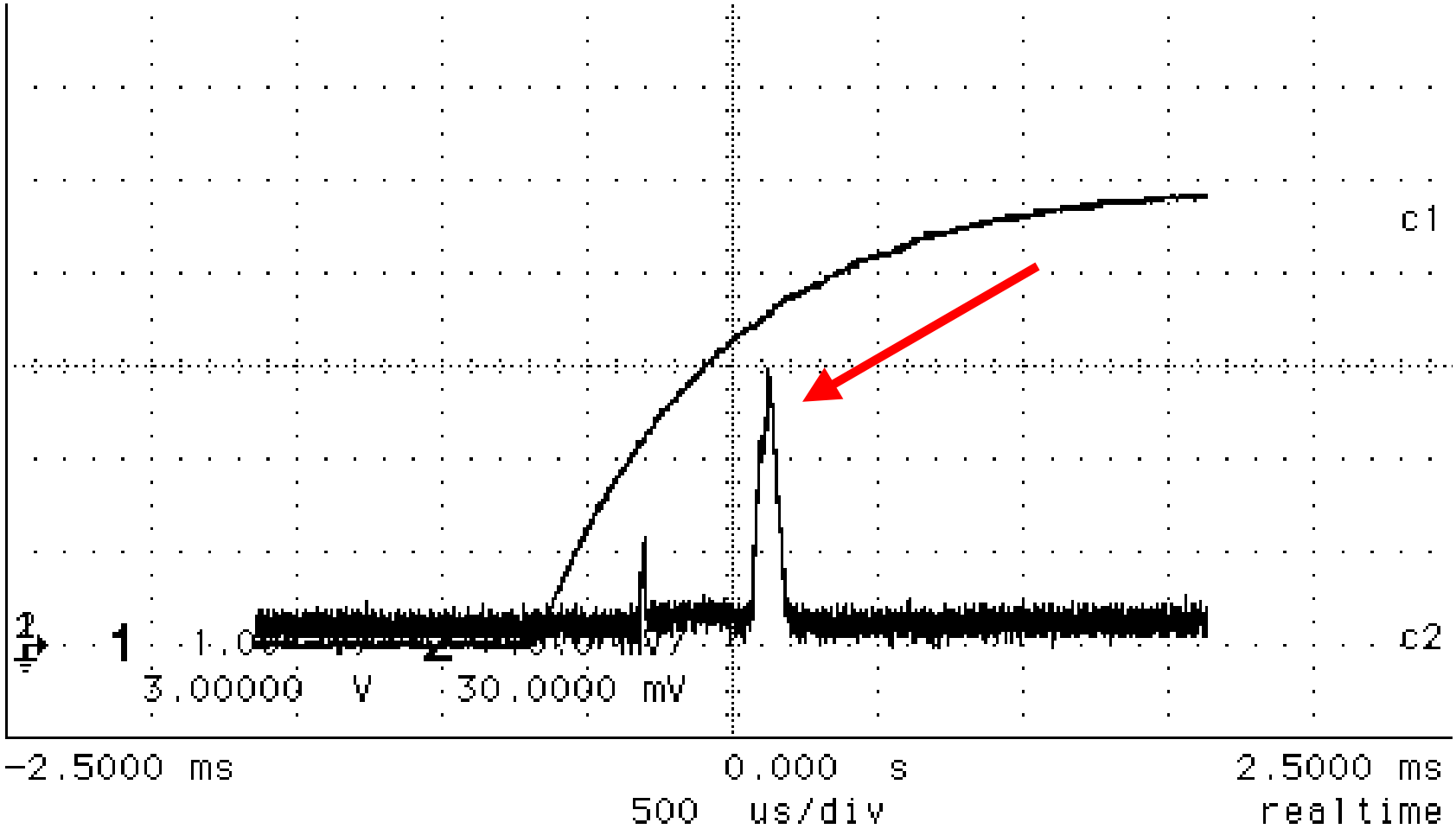
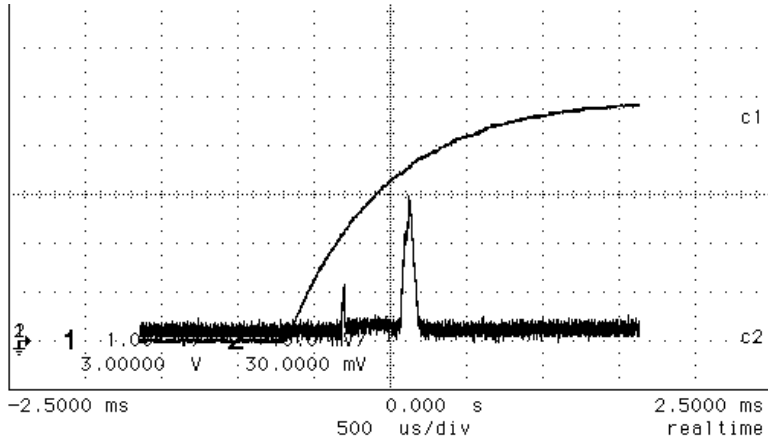


Figure 1. Startup transient after 4 krad (Si) exposure at 1 krad (Si)/day. The left current peak is unchanged from the pre-irradiation measurement and remained unchanged over the course of this experiment. Analysis on next slide.



- Startup transient after 4 krad (Si) exposure at 1 krad (Si)/day.
- Left current peak is unchanged from the pre-irradiation measurement and remained unchanged over the course of this experiment.
  - This current peak is expected as the NMOSFET isolate transistors are not fully conducting, resulting in totem pole currents in the input circuit of the logic modules.
- This current level or width is not specified in either the commercial or military specifications.
- The 350 mA current peak on the right appears when V_{CC} reaches 3.5 VDC.
- The power supply used for these tests had a rise time of < 2 msec.
- Voltage is at 1V/div; current is at 100 mA/div.

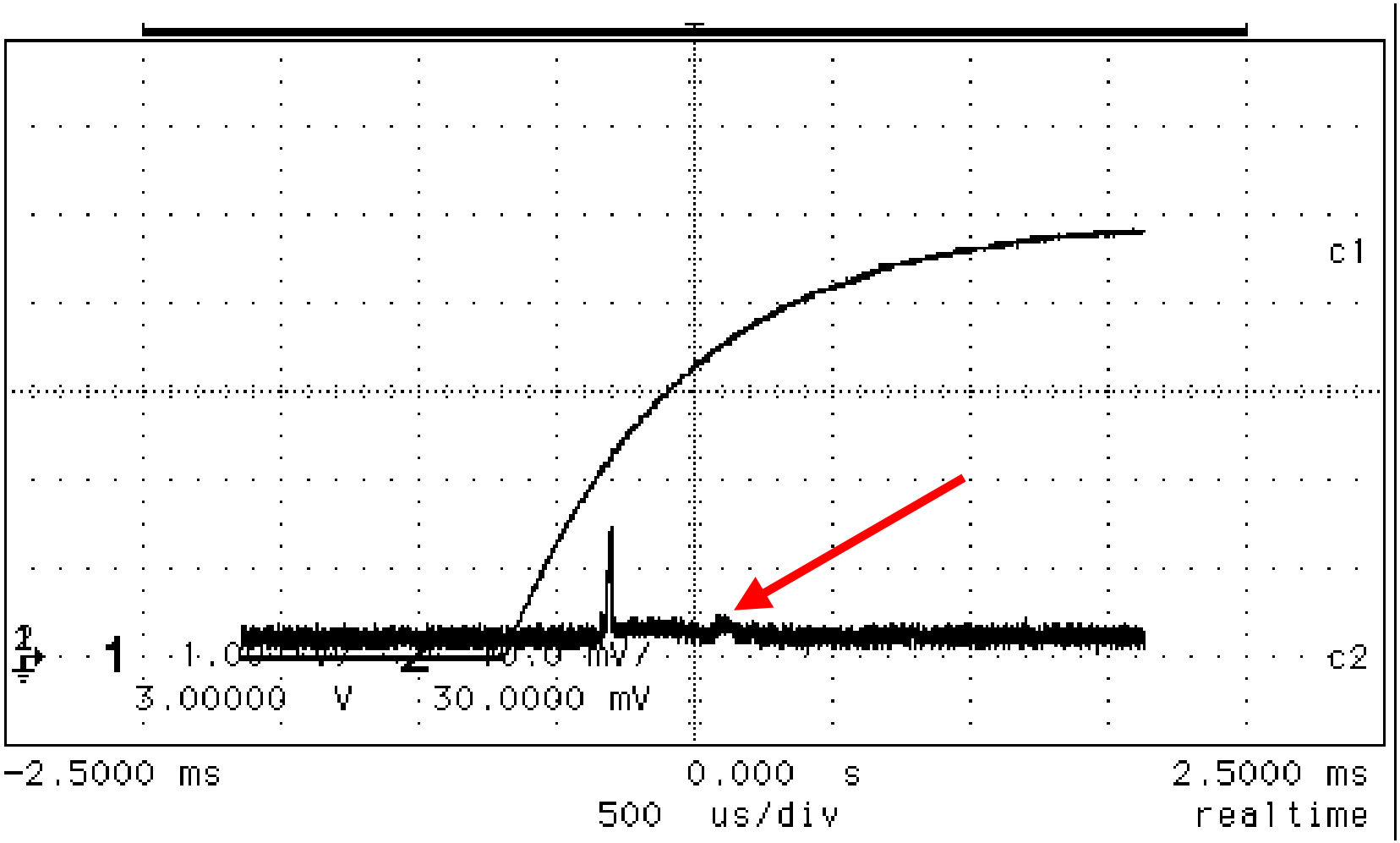


Figure 2. Startup transient after 5 days of room temperature, biased anneal, following the 4 krad (Si) irradiaton. The radiation-induced current peak is essentially gone. Voltage is at 1V/div; current is at 100 mA/div.

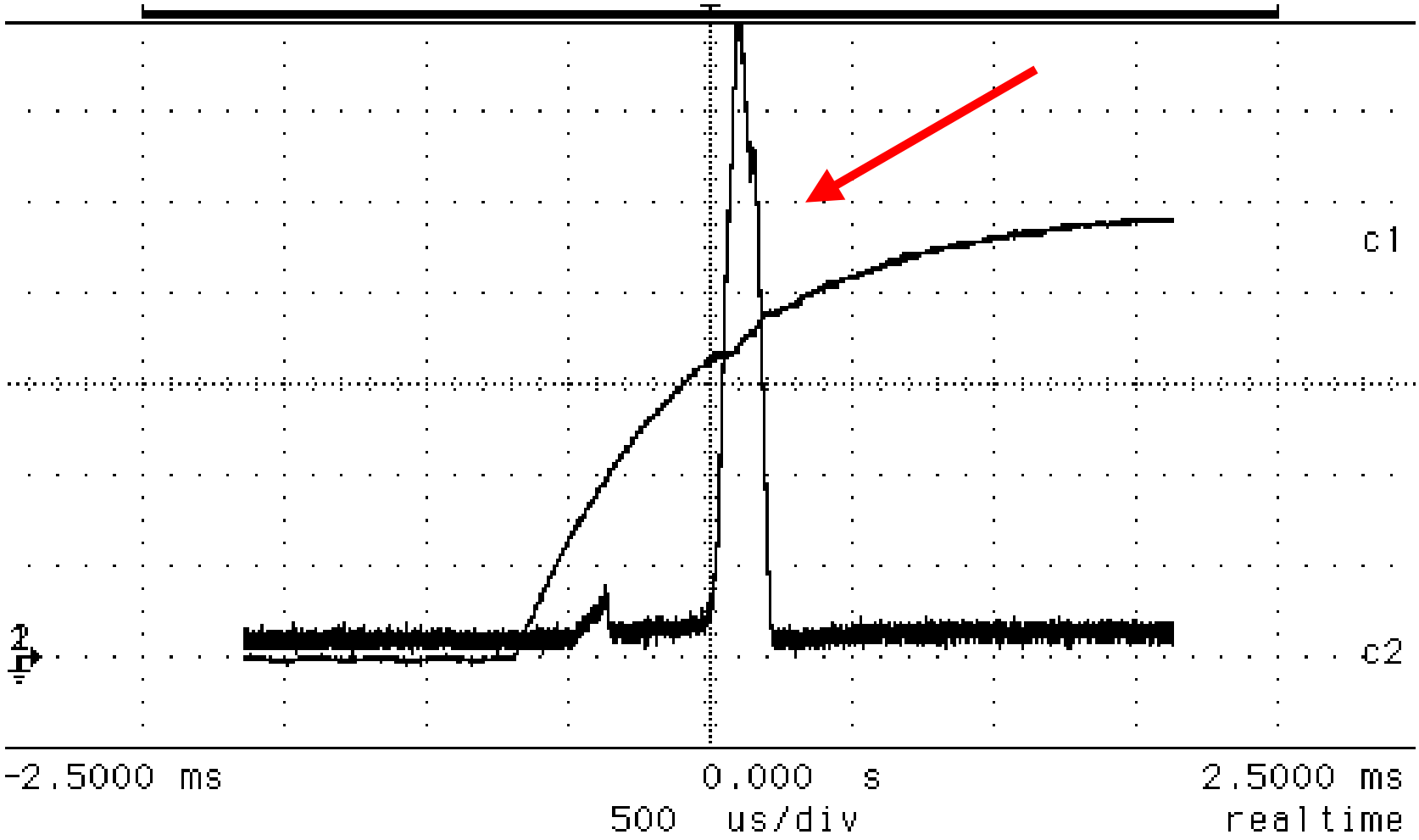
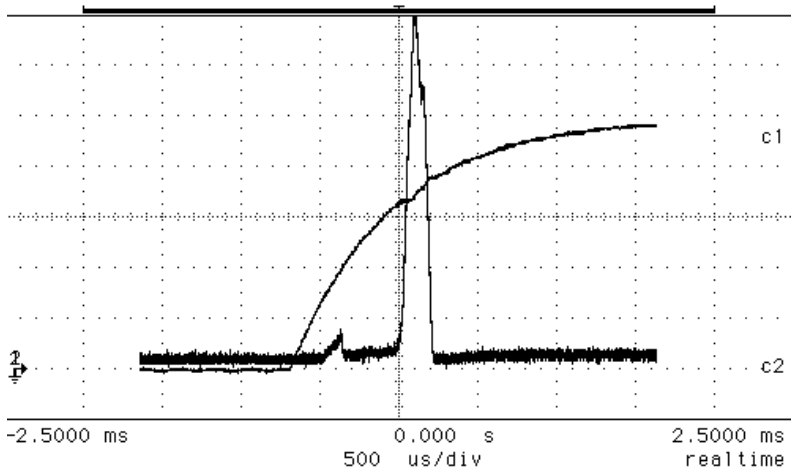
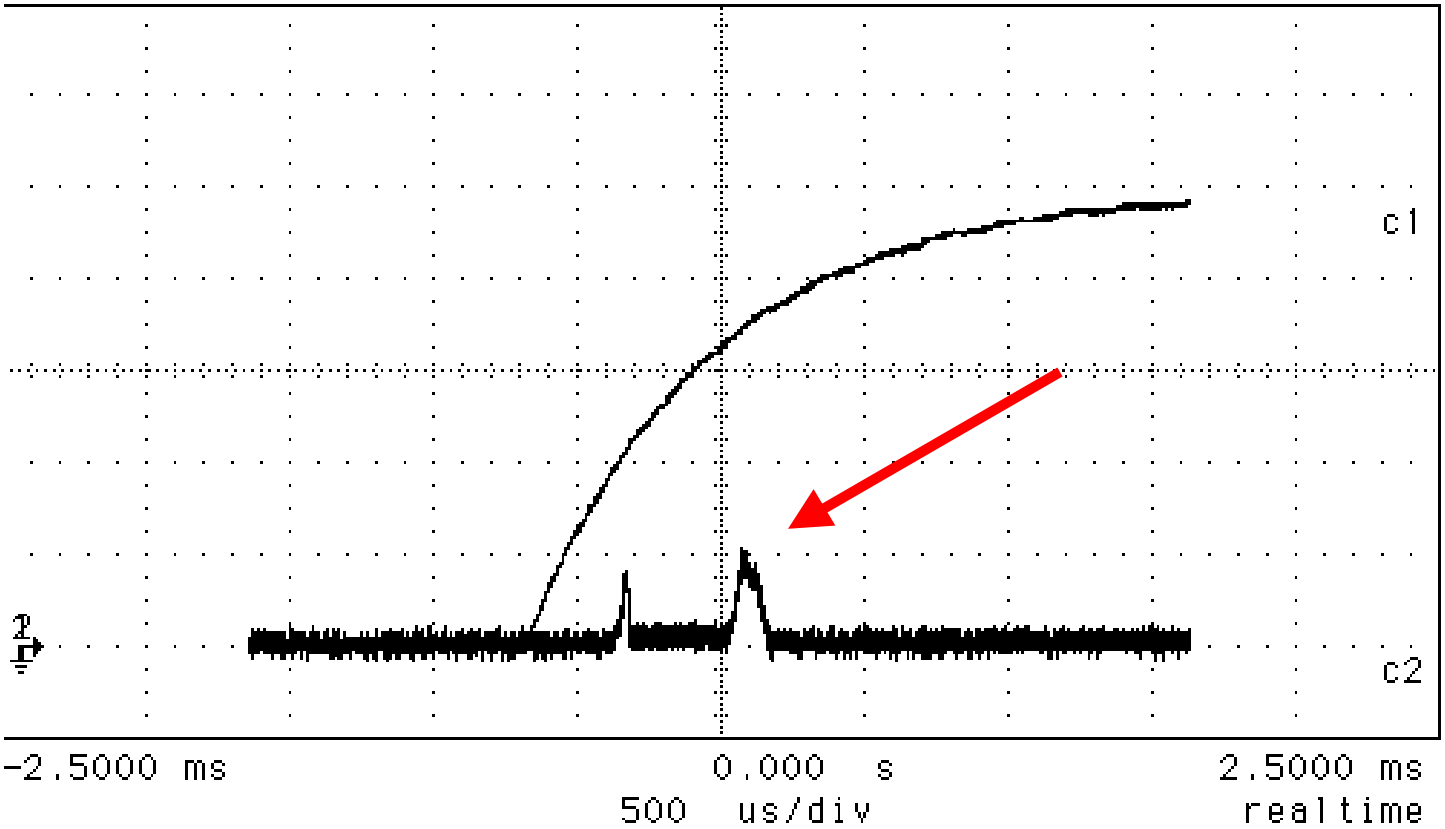


Figure 3. Startup transient after an additional 2 krad (Si) exposure at 1 krad (Si)/day for a total of 6 krads (Si). The radiation-induced current peak is now about 700 mA. Analysis on next slide.



- Startup transient after an additional 2 krad (Si) exposure at 1 krad (Si)/day for a total of 6 krads (Si).
- The radiation-induced current peak is now about 700 mA.
- The current draw still appears when V_{CC} reaches 3.5 VDC, unchanged from the 4 krad (Si) radiation step.
- At V_{CC}=3.5VDC, bulk capacitors on the board will have charge Q = 3.5V x C, which will provide charge in addition to that available from the power supply and helping to support the voltage rail. An 18 µF bulk capacitor will store 630 µC.
  - The current draw for this transient is approximately 100 µC.
- Voltage is at 1V/div; current is at 100 mA/div.



- Effects of 28-day, biased, room temperature anneal after the 6 krads (Si) irradiation step.
- The radiation-induced current peak is now reduced to about 100 mA.
- The current draw for this transient is approximately 12 µC, reduced from approximately 100 µC immediately after the 6 krads (Si) exposure.
- Voltage is at 1V/div; current is at 100 mA/div.

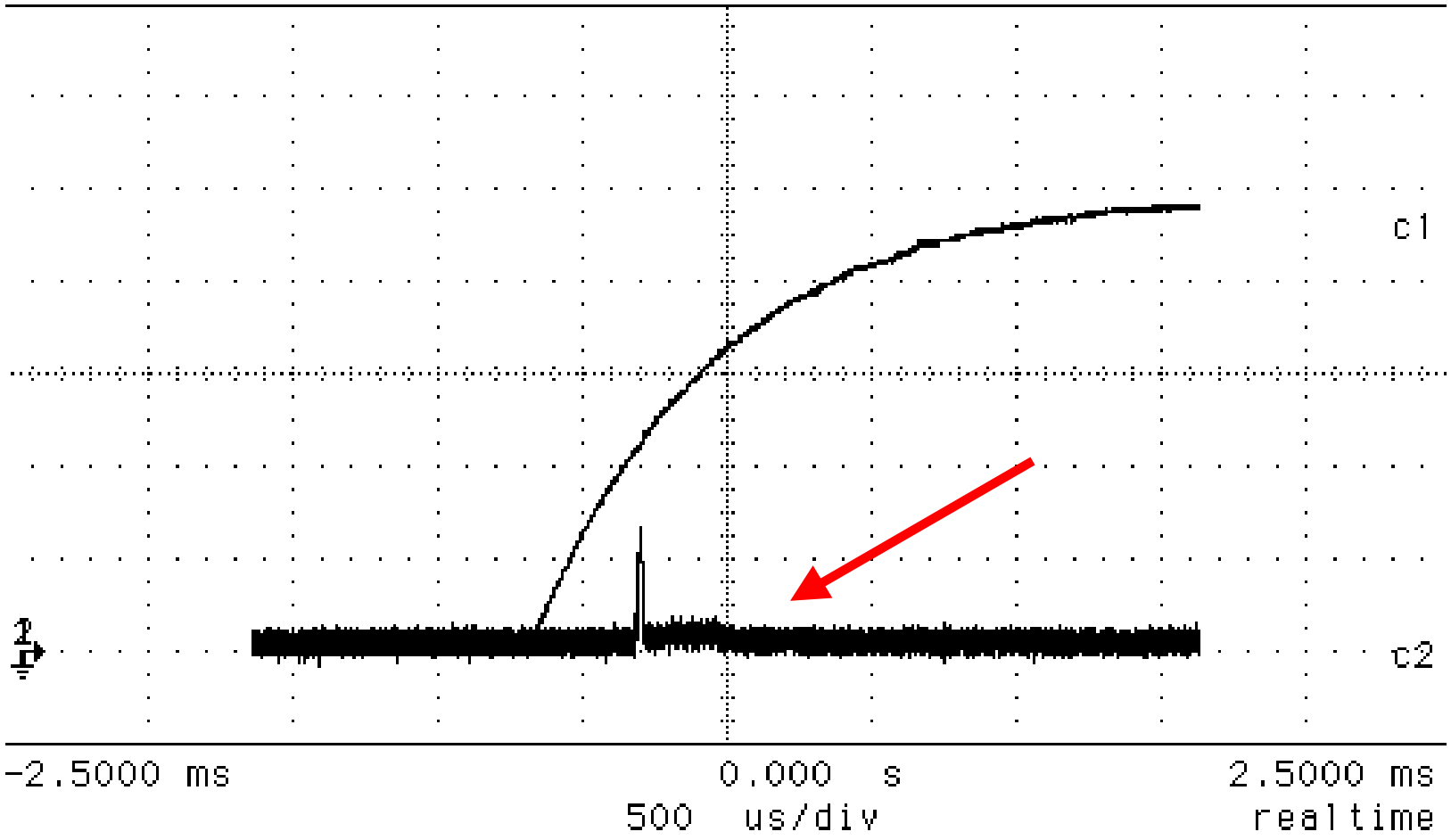
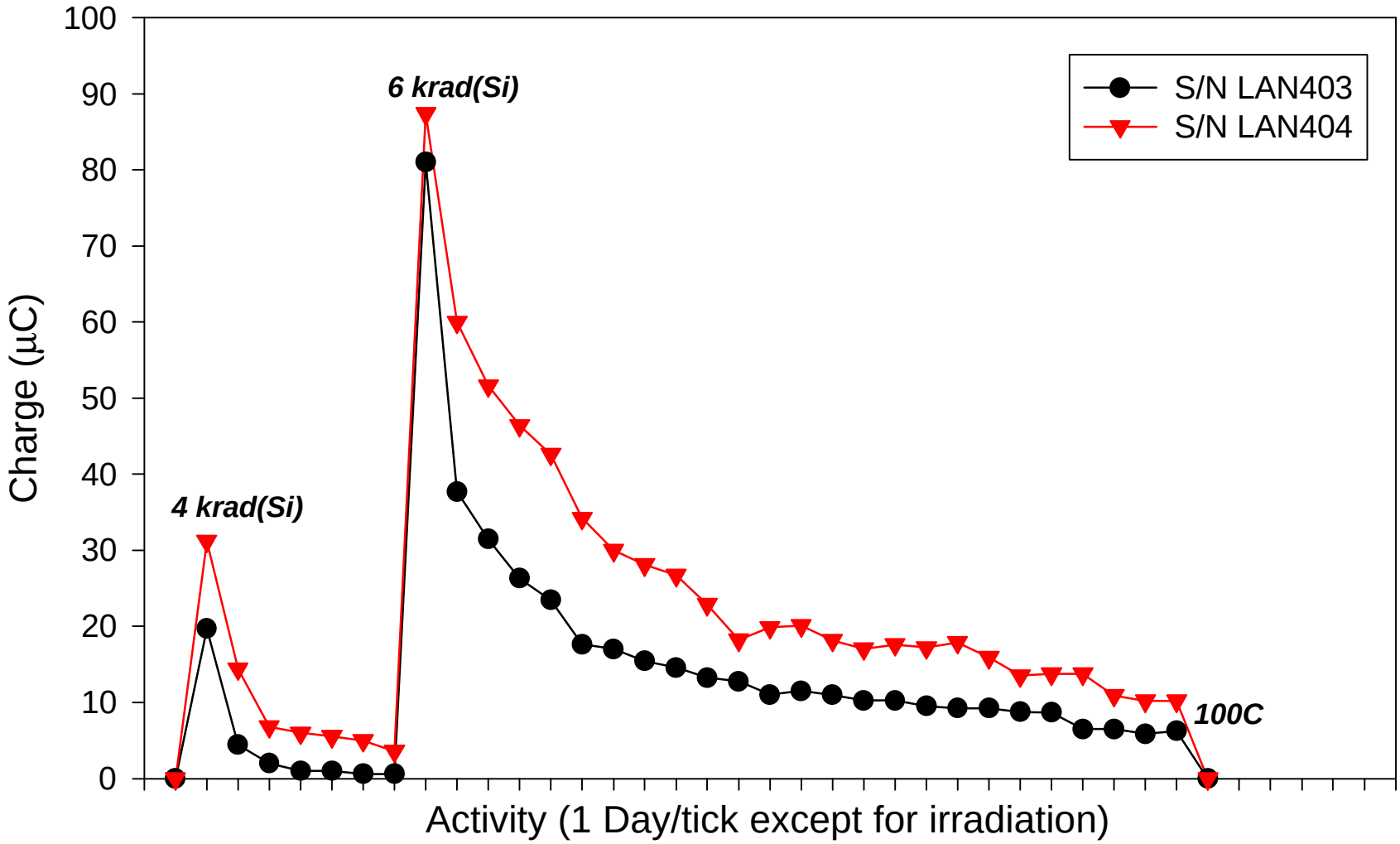


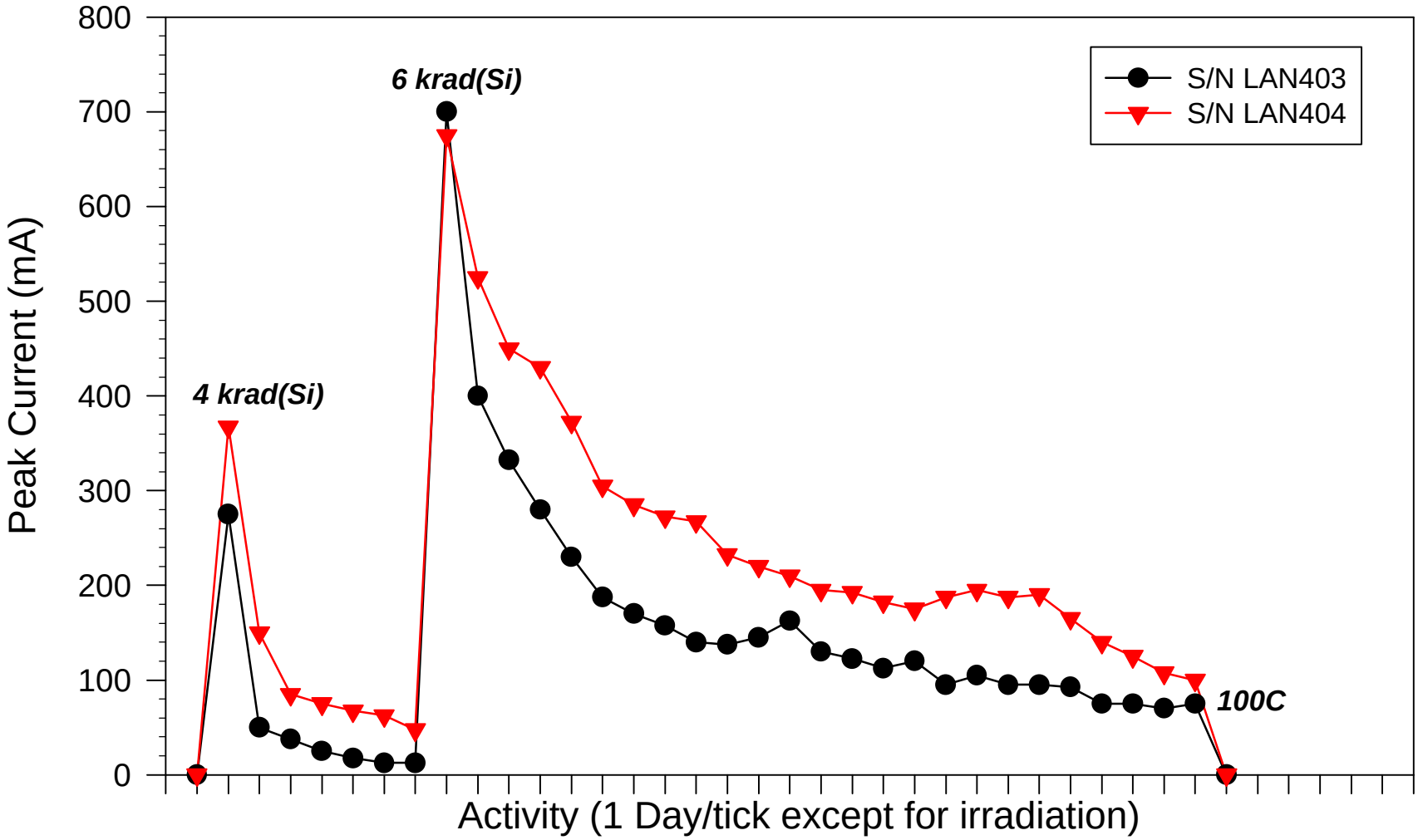
Figure 5. Effects of 100 °C, biased anneal after the 6 krads (Si) irradiation step and room temperature annealing. The radiation-induced startup current is now virtually eliminated, showing that annealing is effective. Voltage is at 1V/div; current is at 100 mA/div.

I_{CC} Startup Transient
RT1280A: Charge

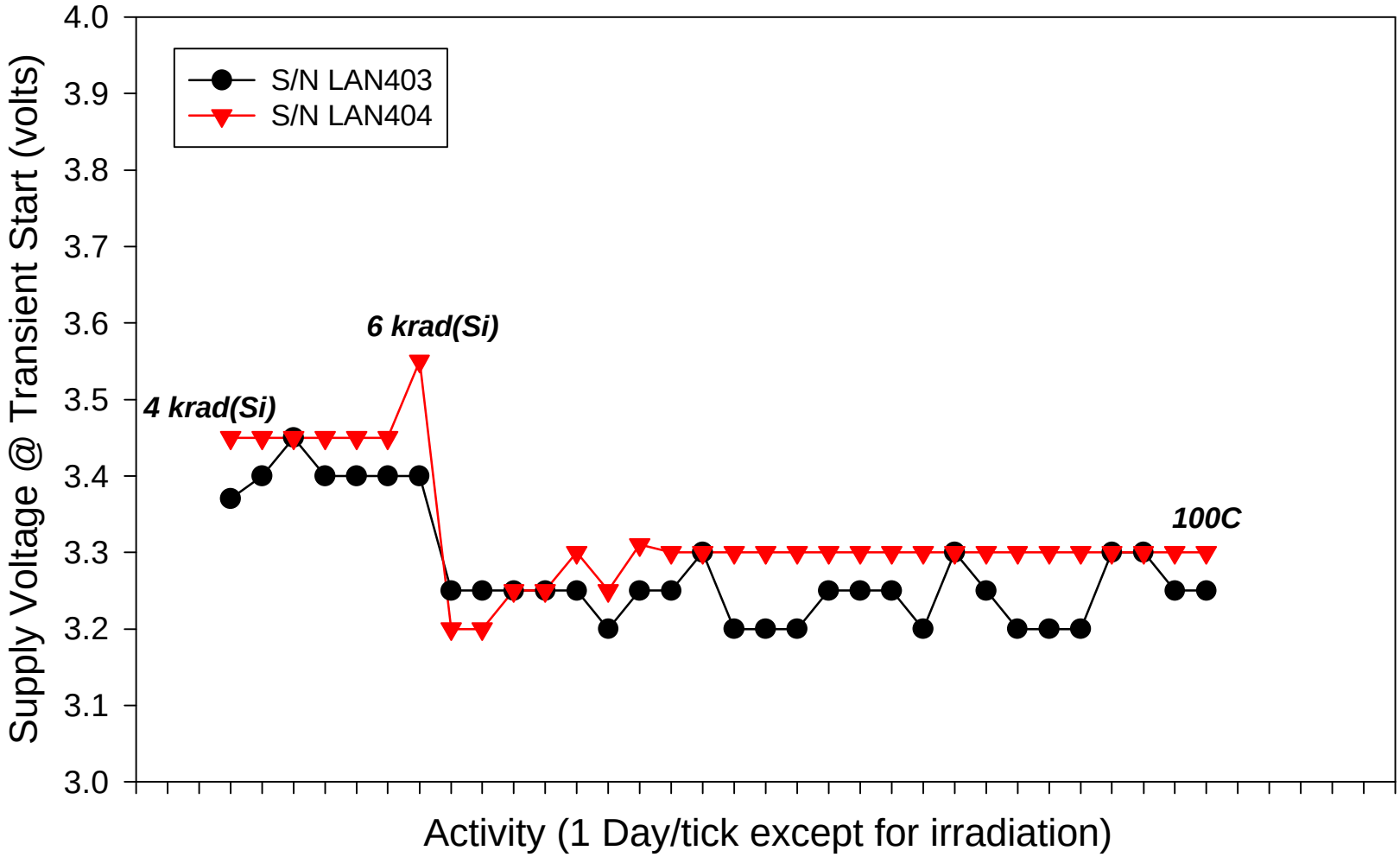


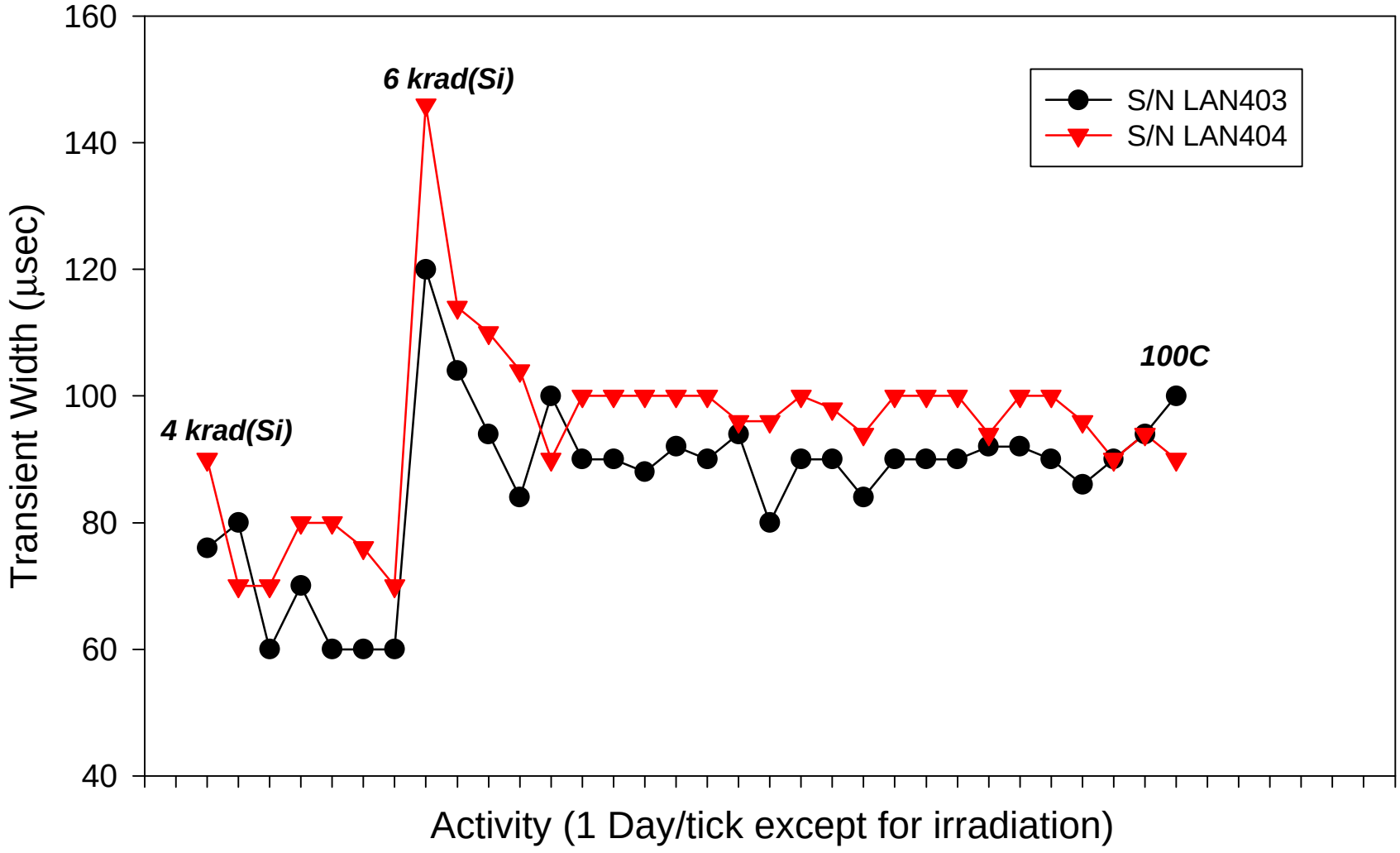
I_{CC} Startup Transient

RT1280A: Peak Current



I_{CC} Startup Transient
RT1280A: Trip Voltage



I_{CC} Startup Transient

RT1280A: Transient Pulse Width