SiTime

SiTime Turbo Webinars

SiTime University Turbo Seminar Series

How to Measure Clock Jitter – Part 3

C2C Jitter and Long Term Jitter

May 13, 2013

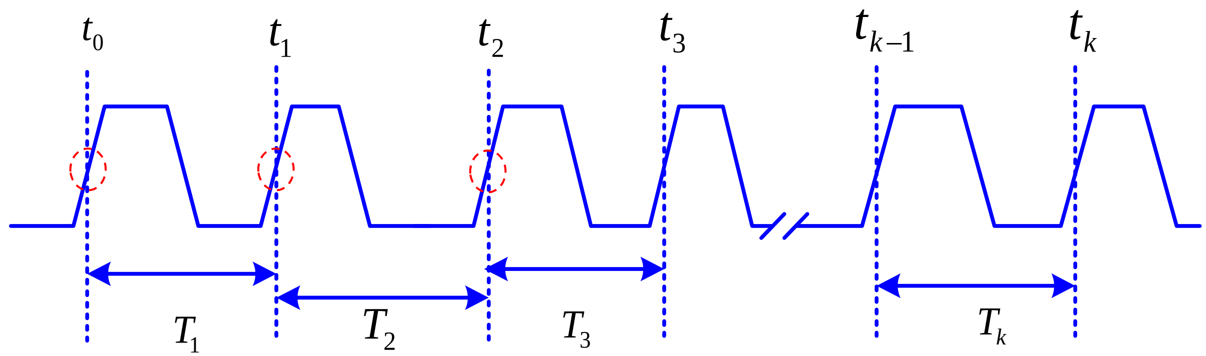
The Smart Timing Choice™

What is Clock Jitter

- Jitter is, "***The deviation of an event timing relative to its ideal value***"
  - Event? - *defined by specific type of jitter*
  - Ideal value? - *event timing on an ideal clock, often estimated from average value of the event*
- Jitter definitions:
  - Period Jitter (Covered in Part 1)
    - Deviation of the clock period from averaged value
  - Timing Interval Error (TIE) Jitter and Phase jitter (Part 2)
    - Error in edge location relative to an ideal clock
  - Cycle-to-Cycle Jitter (Part 3)
    - Deviation of the difference of periods of two consecutive clock cycles
  - Long Term or Multi-Cycle Jitter (Part 3)
    - Deviation of the durations of multiple cycles from the averaged value
    - Also known as long term jitter or accumulated jitter

Jitter Definitions and Terminology

Cycle-to-cycle Jitter (C2C)



- Cycle-to-cycle jitter: the difference of one period and its adjacent one
  - Event: Three consecutive rising or falling edges
  - Ideal value = average C2C

$$J_{CC+}(k) = T_k - T_{k-1}$$
$$= t_k - 2t_{k-1} + t_{k-2}$$
$$= TimeJ(k) - 2.TimeJ(k-1) + TimeJ(k-2)$$

Relate C2C to TIE or Timing Jitter

$$J_{CC-}(k) = T_{k-1} - T_k$$

About C2C Jitter

- C2C jitter is the difference of two adjacent clock period and it dominated by the high frequency jitter

- Can be measure by real-time oscilloscope

- C2C jitter is not sensitive to low frequency jitter or slow frequency modulation of oscillator frequency
  - Often Used to specify jitter intrinsic jitter performance of spread spectrum clocks

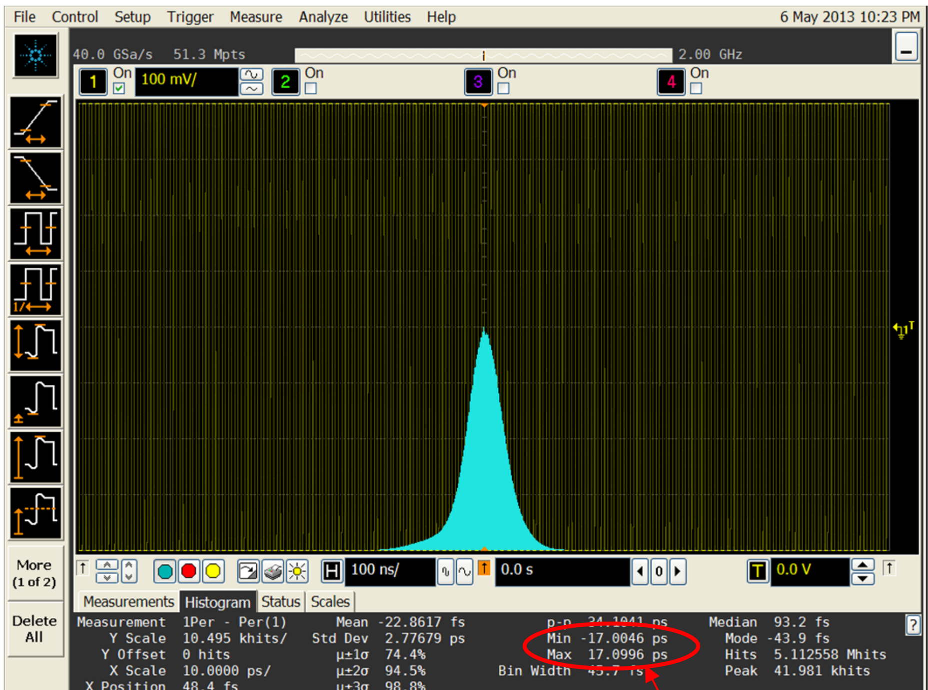
- C2C jitter is not the same as “Cycle Jitter”
  - Cycle Jitter is the same as “Period Jitter”

C2C Jitter in a Spread Spectrum Clock

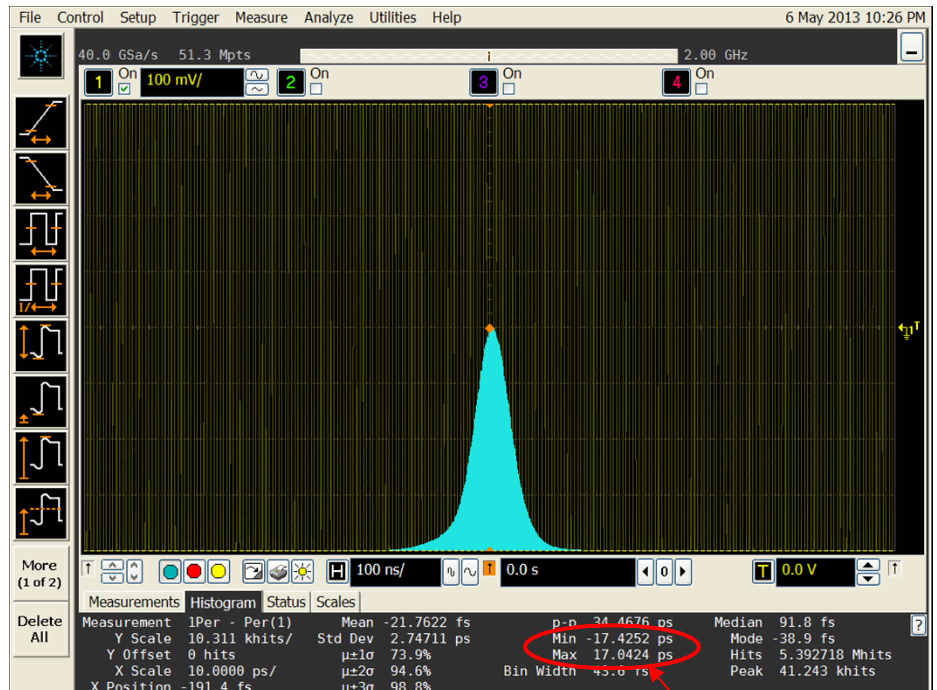
- C2C jitter changes little with spread spectrum clock (SSC) mode enabled or disabled
- C2C jitter is not sensitive to low frequency phase noise

SiT9001-125MHz SSXO with 2% down spread

Spread Spectrum Disabled



Spread Spectrum Enabled



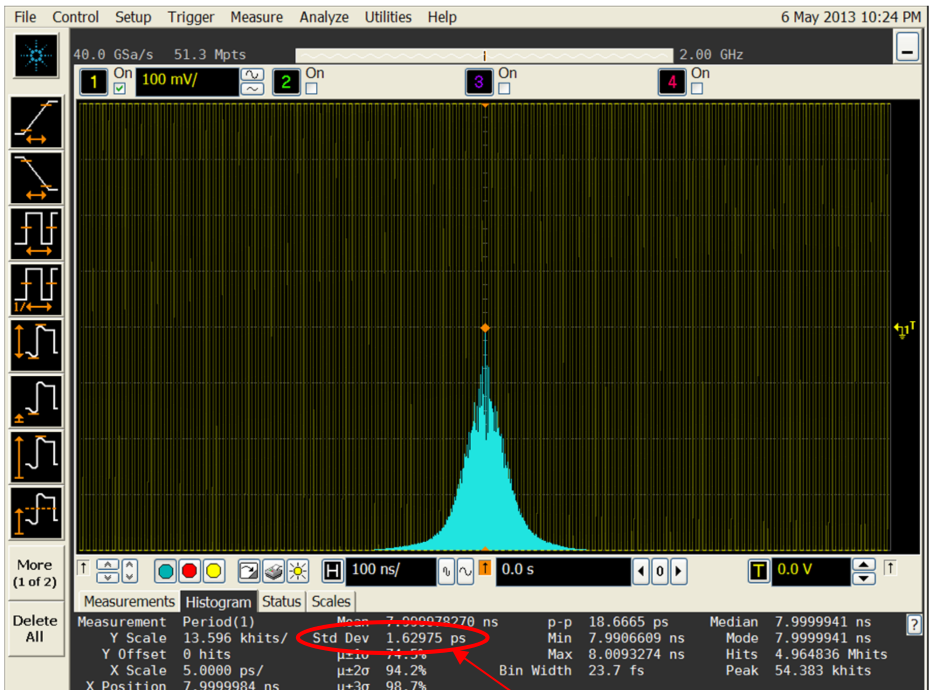
C2C jitter 17ps max *C2C jitter 17ps max*

Period Jitter in a Spread Spectrum Clock

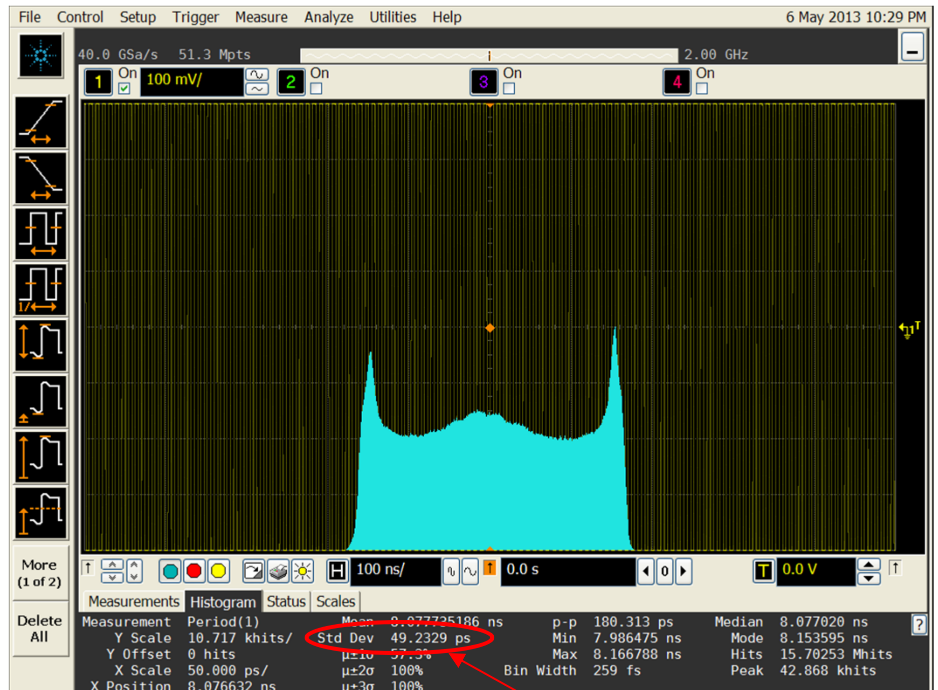
- Period jitter *changes significantly* when SSC enabled
- C2C jitter is the difference of two adjacent periods and it *remains steady* with slow SSC frequency modulation.

SiT9001-125MHz SSXO with 2% down spread

Spread Spectrum Disabled



Spread Spectrum Enabled

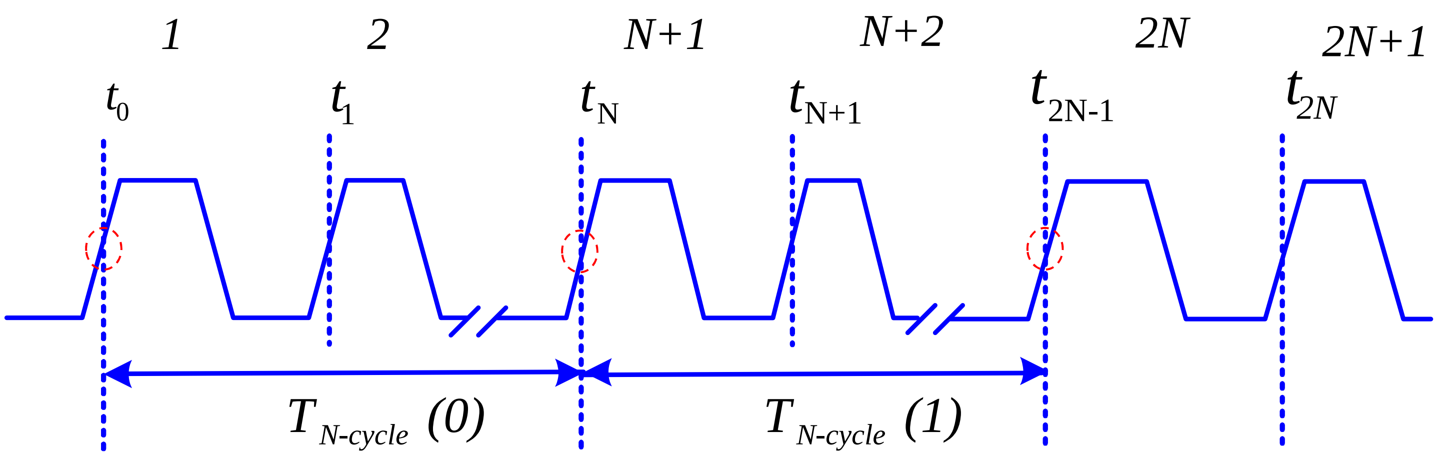


Period jitter 1.63 ps rms

Period jitter 49 ps rms with SS

Jitter Definitions and Terminology

Long Term Jitter (LTJ)

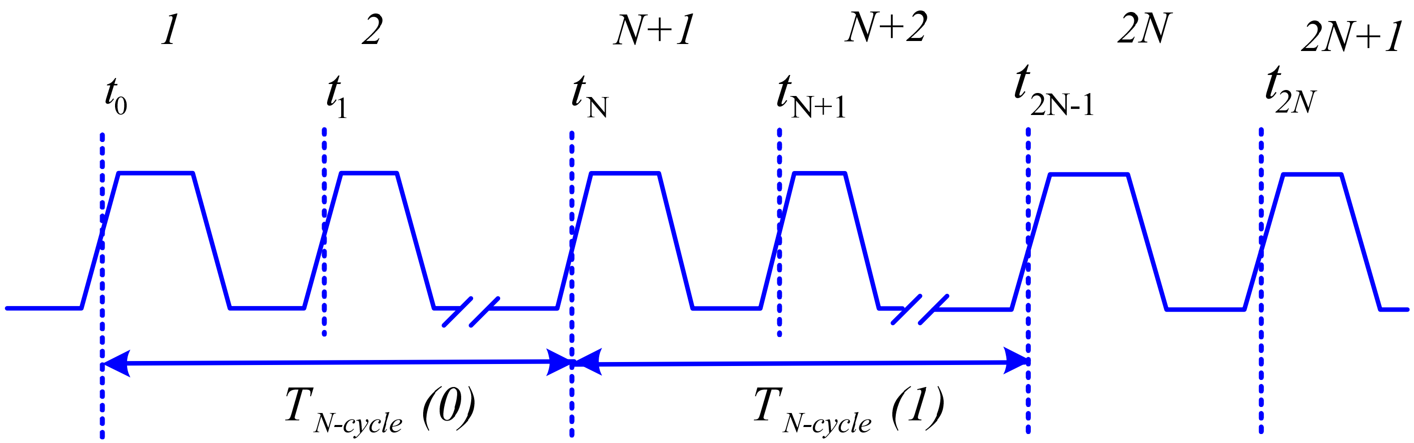


$$LTJ_{N\text{-}cycle}(i) = T_{N\text{-}cycle}(i+1) - T_{N\text{-}cycle}(i)$$

- Long term jitter: variations of timing intervals between the first edge and the last edge of N consecutive clock cycles.
  - Also known as “accumulated jitter” or “N-cycle jitter”
  - Can be specified by accumulation time of N-cycle, for example:
    - LTJ@100 μs for 100 MHz clock means N = 10,000
    - LTJ@10 μs for 62.5 MHz clock means N = 625

Jitter Definitions and Terminology

Long Term Jitter (LTJ)



$$LTJ_{N\text{-}cycle}(i) = T_{N\text{-}cycle}(i+1) - T_{N\text{-}cycle}(i)$$

$$= (t_{i+N} - t_i) - N \times T_C$$

Ideal value = Number of cycles (N) * average period (T_C)

$$= TimeJ(i+N) - TimeJ(i)$$

Relate LTJ to TIE or Timing Jitter

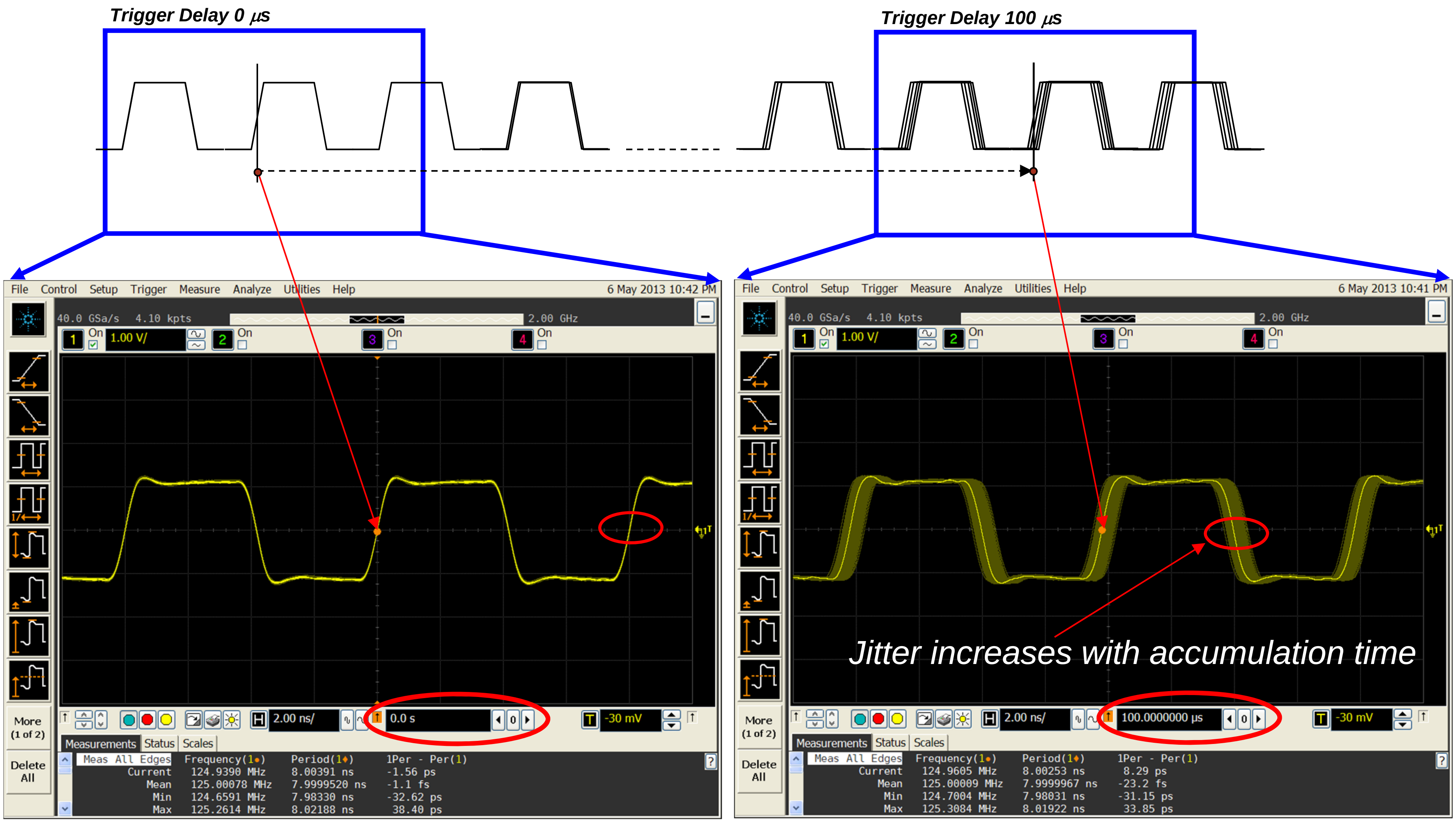
$$= \sum_{j=i}^{N+i-1} J_{PerJ}(i)$$

Relate LTJ to Period Jitter

- Long term jitter: sensitive to low frequency phase noise integrated over long accumulation time

Observe LTJ on Real Time Scope

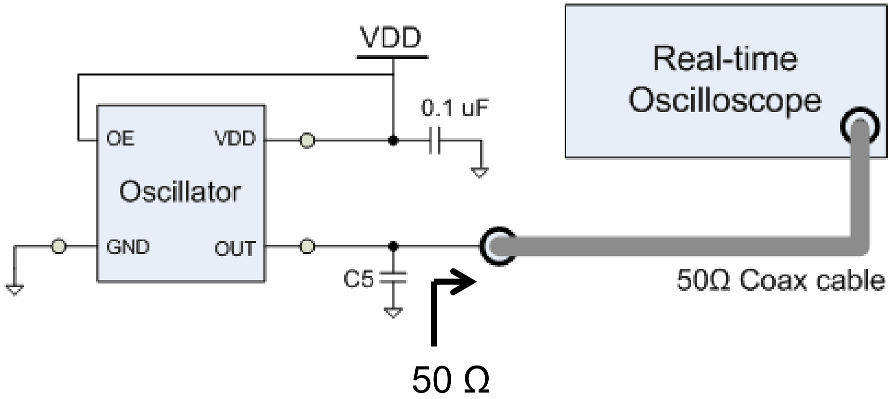
- Set “Trigger Delay” to observe 100 μs LTJ of a 125 MHz clock



SiT9001-125 MHz SSXO with spread spectrum disabled

LTJ Measurement Setup with Real-Time Oscilloscope

Setup:
Direct connection to oscilloscope
50Ω loading to the oscillator output

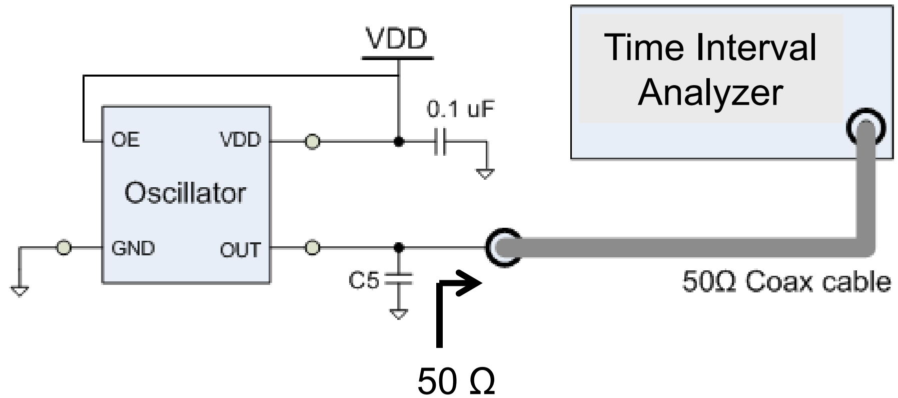


- Measure LTJ with Real Time Oscilloscope
  - Use oscilloscope with low time base error (< 0.5 ps rms)
  - Optimize oscilloscope settings to reduce measurement error
  - High sampling rate increases the sample size and slows down measurement

LTJ Measurement Setup with Time Interval Analyzer (TIA)

Setup:
Direct connection to TIA
50Ω loading to the oscillator output

SiTime jitter measurement setup



- Measure LTJ with TIA
  - Based on counter-timer approach
    - Can achieve high equivalent time base resolution in sub-ps range
  - Sampling rate on input clock signal much lower than real-time scope
  - Achieve faster LTJ measurement for long accumulation time
  - Can also be used for serial link diagnostics and compliance testing

Measure LTJ on TIA

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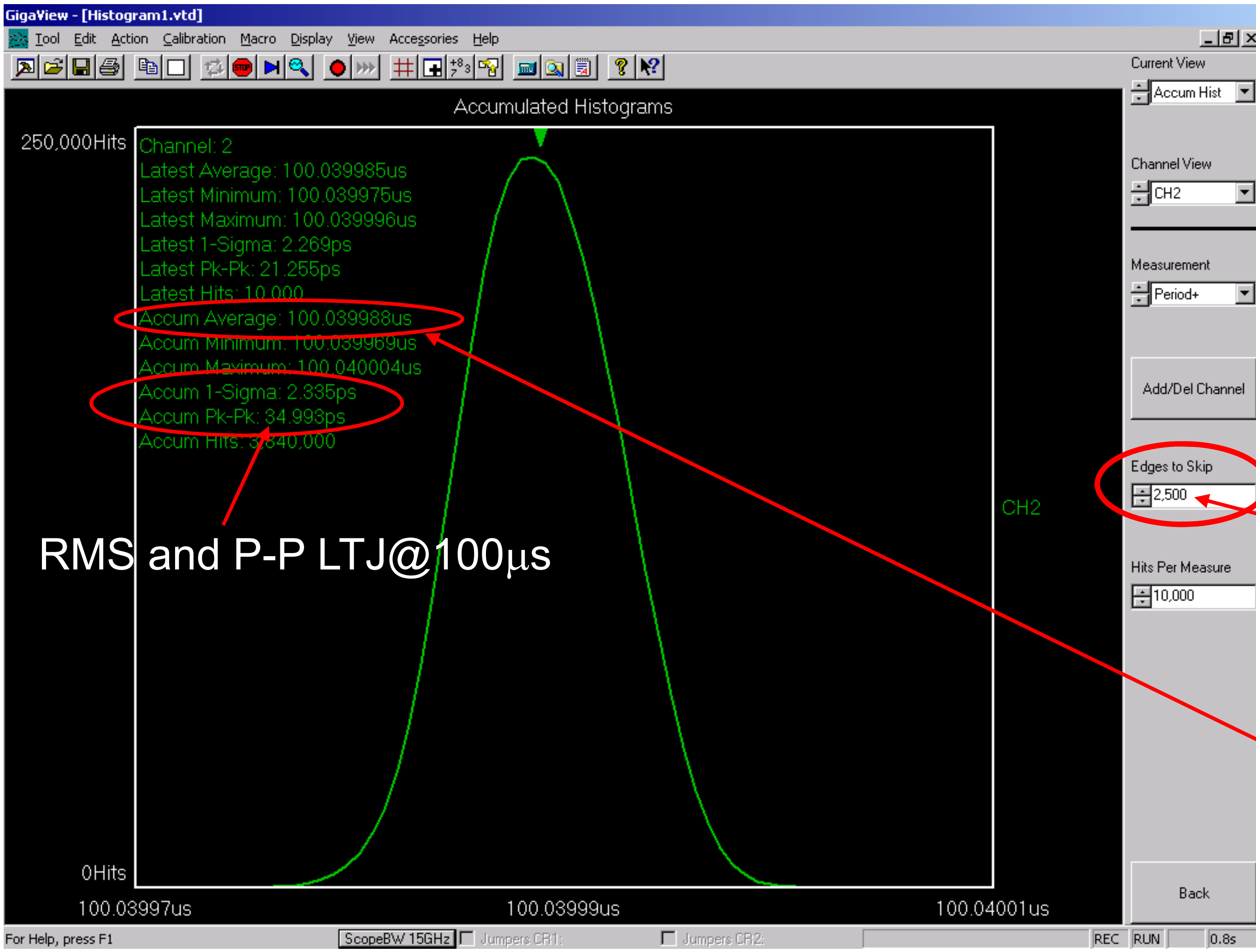
- Set N = 2500 to measure LTJ@100 µs on a SiT8208-25 MHz clock



25 MHz Clock Period

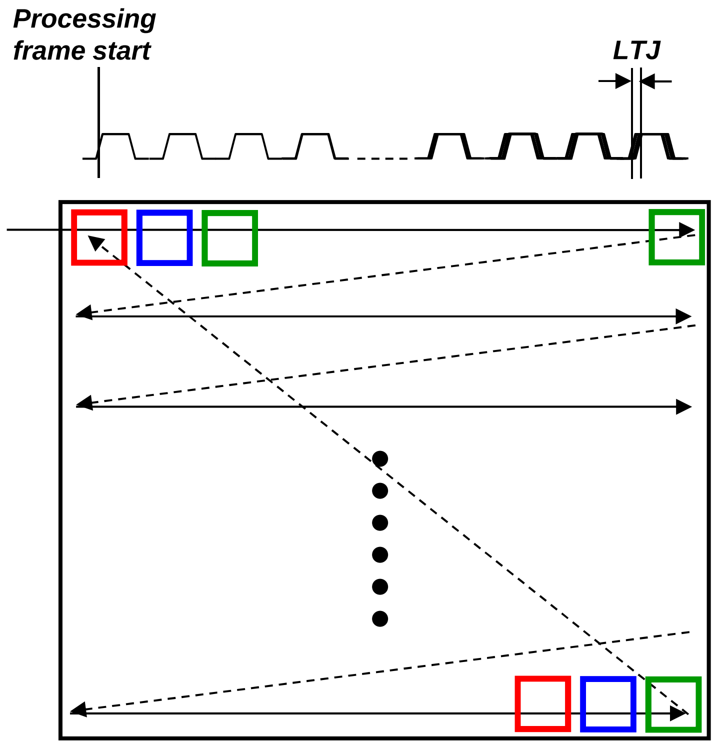
$N \times T_C$
$= 2500 \times (1/25E6)$
$= 100\ \mu s$

Accumulation Time for N-cycle

TIA Model: Wavecrest SIA-4000

Who cares about LTJ

- Applications that require synchronization of timing events over relatively long time interval or many clock cycles
  - Analog and digital video
  - DDR for achieving phase locking in DDR interface



Summary

- C2C jitter reflects the high frequency jitter of the clock signal and is not sensitive to slow frequency modulation of a spread spectrum XO
- Long term jitter, defined by accumulation time or N-cycle, is sensitive to low frequency phase noise
- Applications care about LTJ when multiple timing events need to be synchronized over relatively long time interval

Contact Information

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  Technicalsupport@sitime.com

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