Jitter Testing Challenges For Multiple Gb/s Serial Link

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Mike Li’s Biography

• Currently the CTO of Wavecrest.
• Pioneered jitter separation method (Tailfit) and DJ, RJ, and TJ concept and theory formation
• Many years experiences in semiconductor/IC test and measurement system and methodology design
• Recent interests in high performance test/measurement systems for multiple GB/s serial links (copper or optical fiber based)
• BS in physics, MSE in electrical engineering, and Ph.D. in physics.
• > 35 papers in refereed technical journals
• One granted and five pending patents
Paradigm Shifting In Data Tx and Rx

Global Clock

Source Synch.

Serial Link

- Skew
- Flight time
- Paths Match

< 1 Gb/s

> 1 Gb/s
A Serial Data Communication System

Transmitter

Data

Clock/PLL

Receiver

Medium

Data

CR/PLL

DC

DQ

Frequency (f)

Magnitude (dB)

$H_H(f)$: Jitter Transfer

$H_T(f)$: Jitter Tolerance

$\omega_0$
How Does A Receiver See Jitter?

- **Jitter** is referenced to a recovered bit clock
- Receiver has a jitter *transfer function*
- “Intrinsic” jitter referenced to an ideal bit clock is *not* the jitter “seen” by the receiver
- **BER** of the system should be estimated based on jitter “seen” by the receiver
- Jitter *overestimation* will cause serious yield degradation
Challenge I: What Constitutes A Valid Jitter Testing/Validation Method?

- Measure the jitter as the receiver “sees” !!!!
- CR/PLL and difference functions or their equivalents are required
Jitter Classification Scheme (Stochastic Process Based)

- Total Jitter (TJ)
  - Deterministic (DJ)
    - DCD & ISI
  - Random (RJ)
    - BUJ
    - Multi-Gaussian
  - Periodic (PJ)

BUJ: Bounded uncorrelated Jitter
Challenge II: How to Separate DJ and RJ Correctly?

\[ DJ = \mu_r - \mu_l \]

\[ \sigma_{RJ} = \frac{(\sigma_l + \sigma_r)}{2} \]
Jitter PDF and BER Function

- **Convolution** of DJ and RJ PDFs gives TJ PDF
- BER: metric for overall system performance
- BER: cumulative density function (CDF)
Challenge III: How To Measure TJ at BER $\leq 10^{-12}$

- Total jitter = UI – eye opening @ $10^{-12}$
A Valid Jitter Testing Method For Serial Data Communication

1. Measure total jitter PDF via an appropriate bit clock reference
2. Measure or extrapolate BER function to $< 10^{-12}$
3. Measure total jitter @ BER = $10^{-12}$ or smaller
4. Pass/Fail
Challenge IV: Test Jitter In Production

- Is the synchronous ATE ready for > Gb/s Asynchronous SERDES Jitter test?
  - Jitter and BER **MUST** be tested in production
  - A clock recovery unit/function is required
  - BER needs to be tested down to $< 10^{-12}$
  - ~ps accuracy, > 5HGz BW, multiple channel, diff.
  - Test time needs to be ~ seconds or less

- Is there a solution?
  - Open architecture (soon enough?)
  - Integration of exiting technologies
  - A hybrid approach (model + *in situ* test)