Deterministic Jitter (DJ) Definition and Measurement Methods: An Old Problem Revisited

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For IEEE P802.3ba, 40G/100G Meeting
January, 2009, New Orleans, LA

Problem Statement

IEEE 802.3ba D1.0 jitter specifications were specified in terms of conventional TJ and DJ. However, in the D1.1 editor's notes, it is recorded that proposals were made to replace DJ with the so-called 99% jitter. 99% jitter is nothing but a semi-TJ at higher probability (approx 10^{-4}) that has a mixture of both DJ and RJ. In the case when the DJ pk-pk occurs at a smaller probability (e.g., 10^{-8}), 99% jitter will not be able to bound the DJ, and much larger DJ exists in the Tx or Rx can break the link. 99% jitter is not only unnecessary, but also a wrong metric to estimate/bound the DJ. Meanwhile, this presentation reviews some of the basic and well-established theorems on jitter components, and restates DJ definition and measurement methods. DJ parameter is solid, it has been and will continue be working well for high-speed serial links.
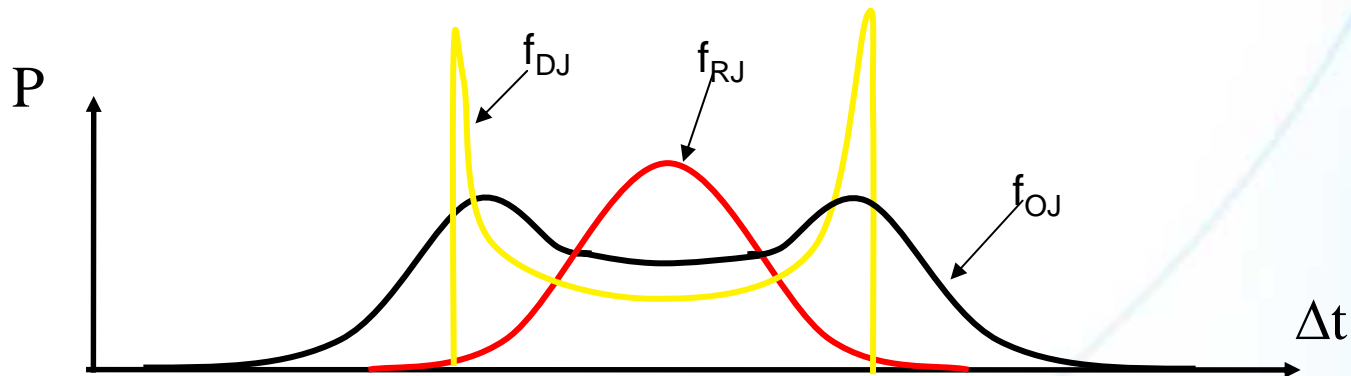
Jitter Component Classification Tree
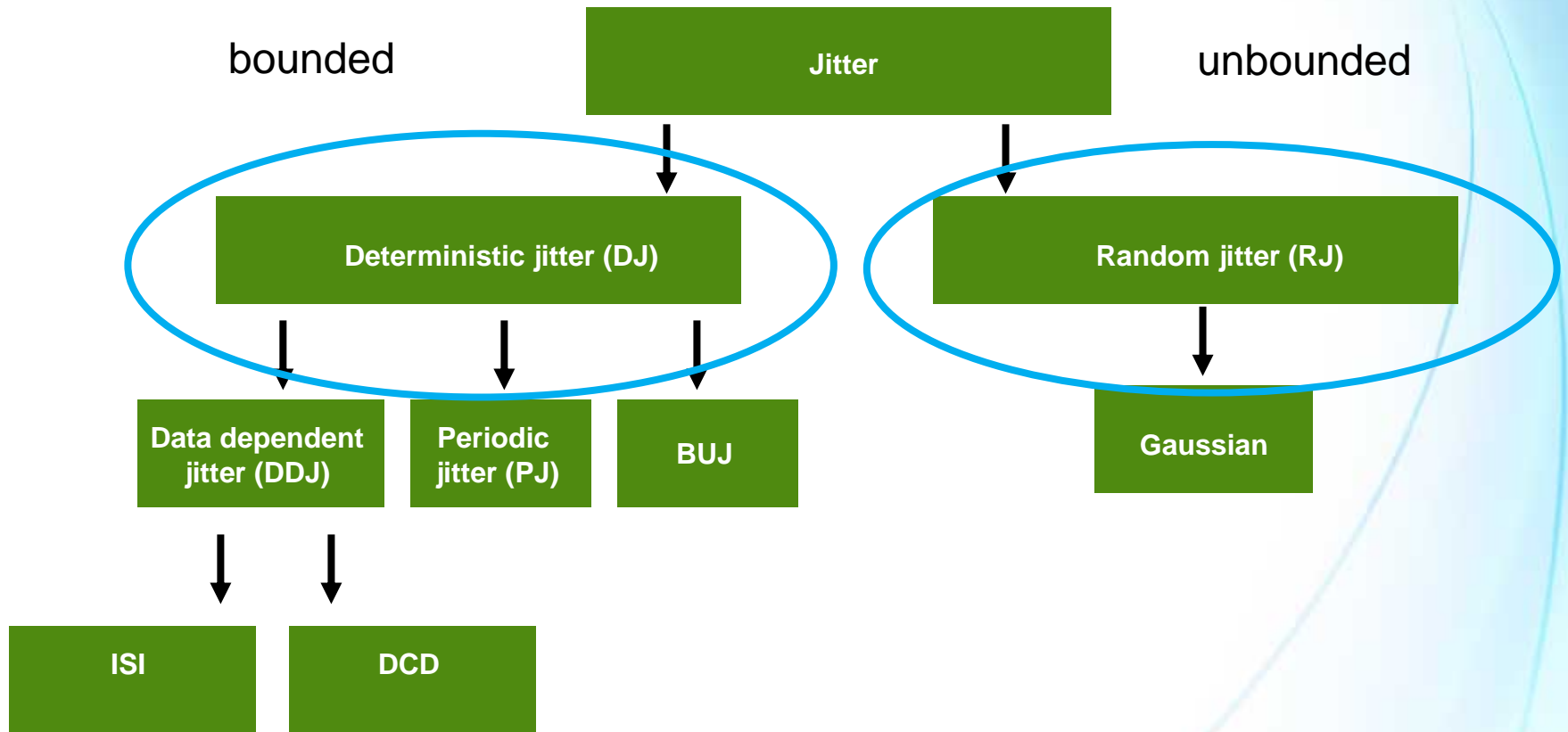
From Li, DesignCon 2000

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Law for Jitter PDFs: Convolution

- The overall jitter PDF is equal to the convolution of RJ PDF with the DJ PDF, as shown in this equation:

$$f_{OJ}(\Delta t) = f_{DJ}(\Delta t) * f_{RJ}(\Delta t) = \int_{-\infty}^{\infty} f_{DJ}(u) f_{RJ}(\Delta t - u)\, du$$
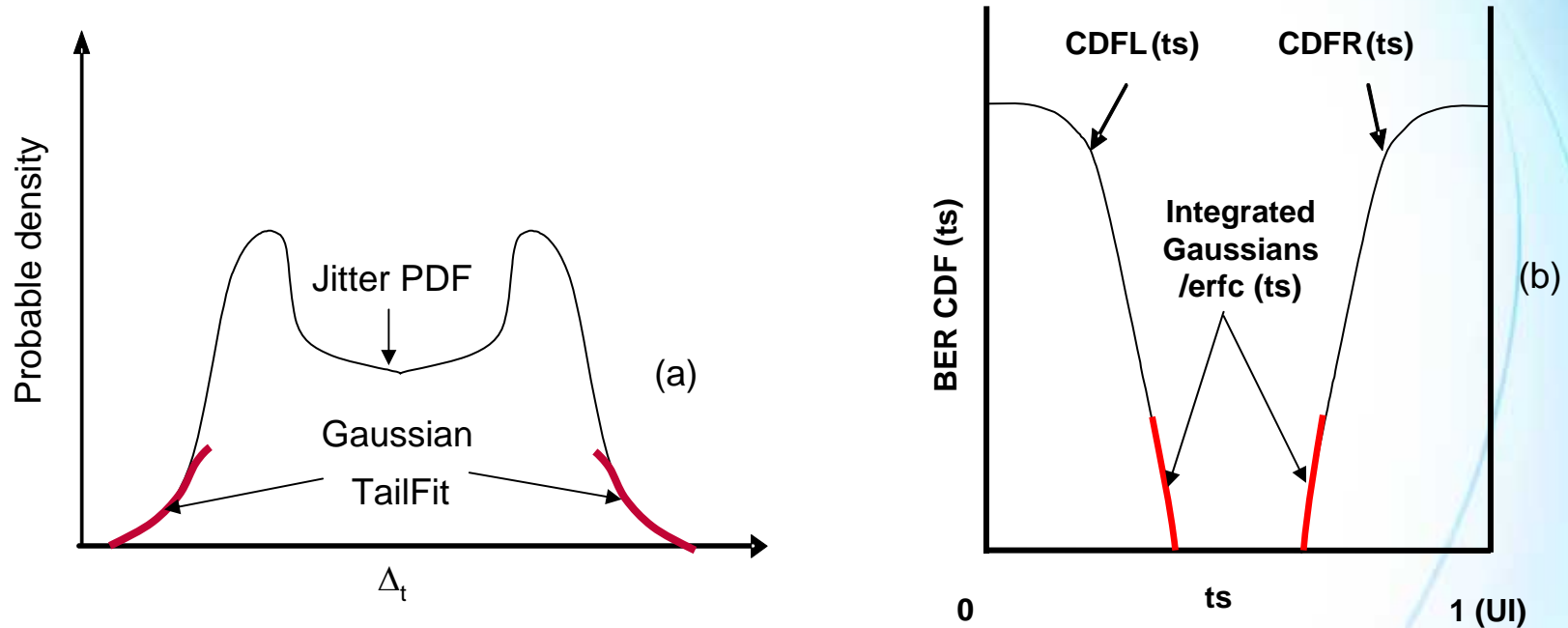
DJ Definition

$$f_{DJ}(\Delta t) = f_{OJ}(\Delta t) *^{-1} f_{RJ}(\Delta t)$$

Where $*^{-1}$ denotes **deconvolution**

# DJ Measurement Method I: From Jitter PDF or BER CDF

- Measure overall jitter PDF with a scope or TIA, or BER CDF with a BERT
- Fit Gaussian for jitter PDF, or integrated Gaussian for BER CDF at tails to obtain RJ σ
- Obtain DJ PDF via deconvolution and associated pk-pk (directly from jitter PDF, or derivative of BER CDF)
- Note that fitting needs to start from the probability level where DJ pk-pk levels-off and downward to warrant accuracy

DJ Measurement II: From Jitter Spectrum
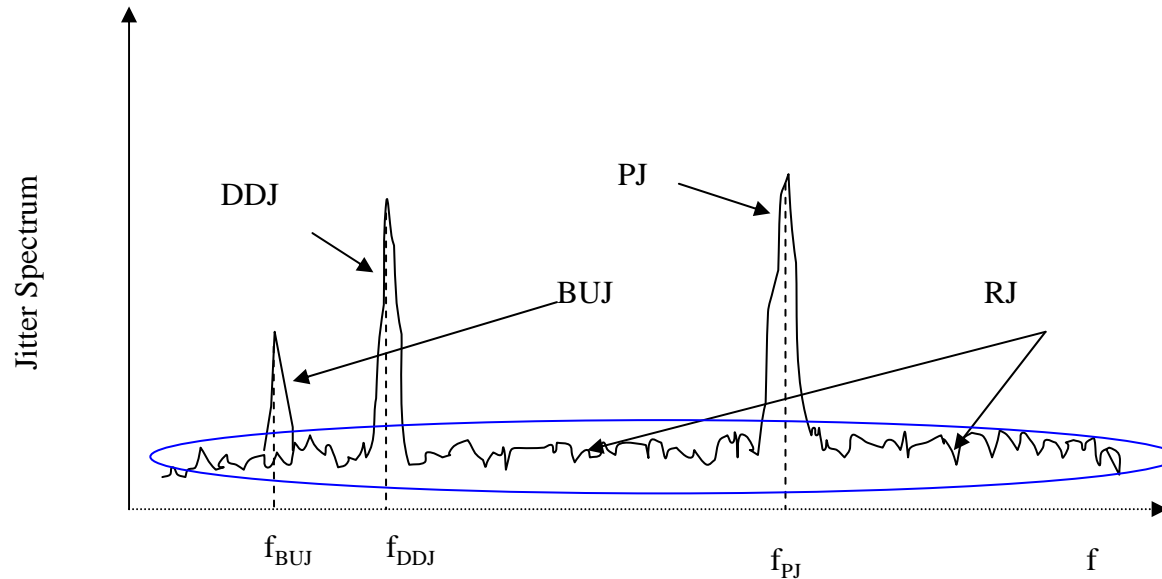
- Measure jitter spectrum as shown with a Real-Time Scope or TIA and subtract RJ background spectrum
- Do FFT^{-1} to the residue DJ spectrum and find its pk-pk (e.g., max-min) in time-domain

Problems with 99% Jitter
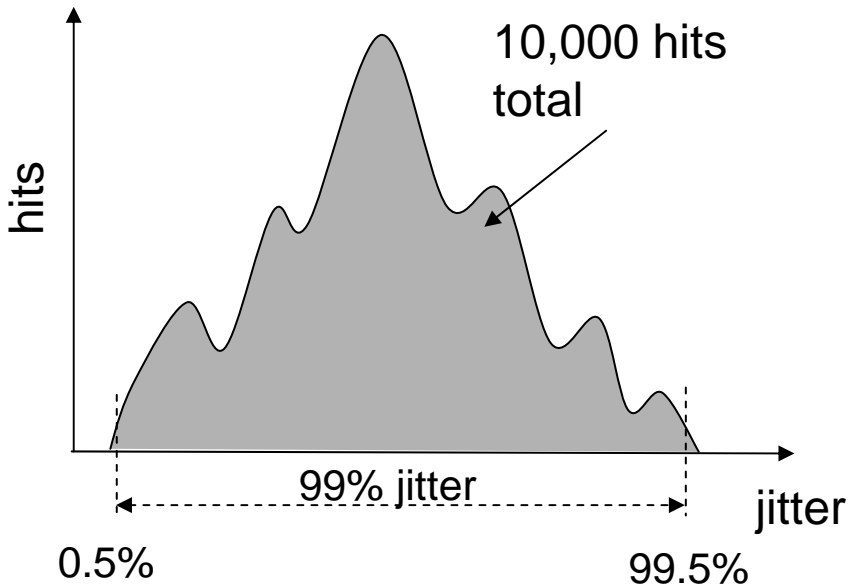
99% jitter definition:
99% is defined as the time from the 0.5th to the 99.5th > percentile of the jitter histogram. Histograms should include at least > 10 000 hits, and should be taken over about 1% of the signal > amplitude
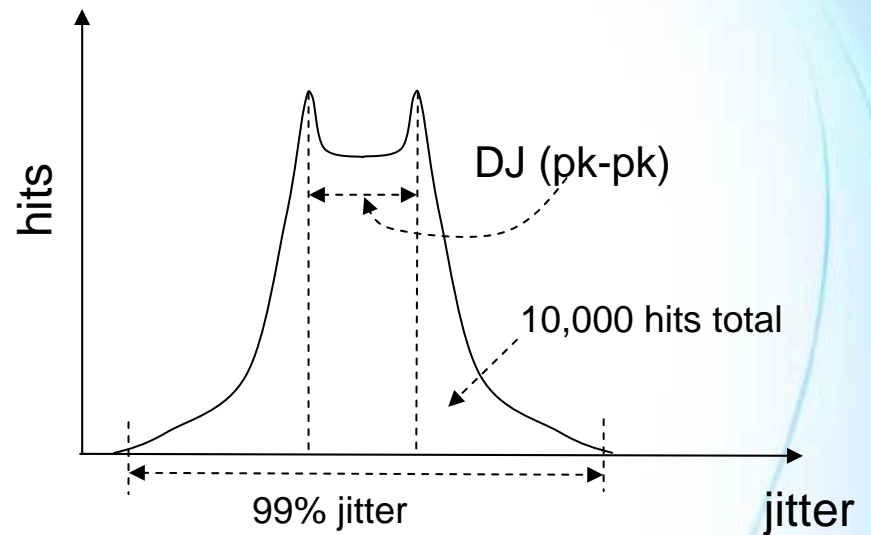
- Based on a overall jitter PDF that is a mix of DJ and RJ, a wrong start to bound DJ
- No physical or mathematical justifications, bad observable for DJ estimation
- Definition is based a specific histogram, not generic and scalable to multiple measurement platforms
- For a jitter PDF with its DJ pk-pk levels-off beyond 10,000 hits, this method under-estimates DJ
- For a jitter PDF where RJ is dominant over DJ, this method over-estimates DJ
- Overall it is a wrong metric to quantify or bound DJ

Examples Show 99% Jitter Does Not Work
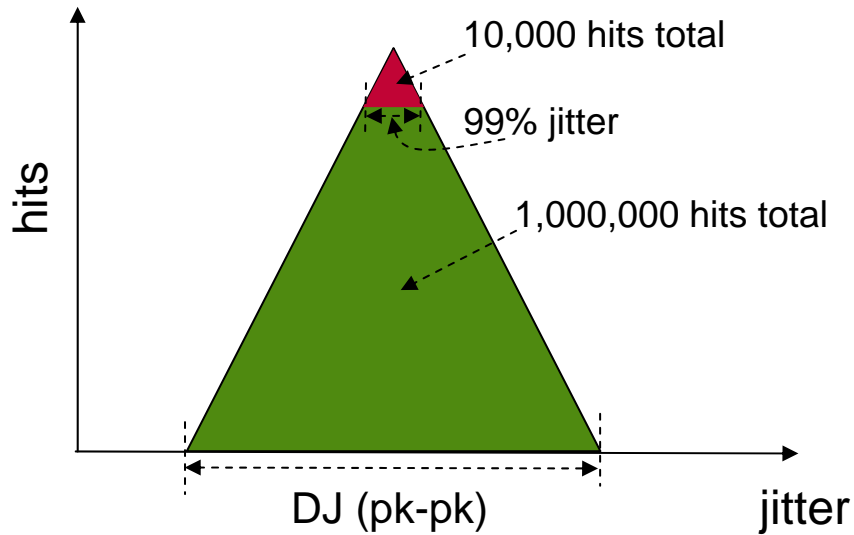
(a)

(b)

- (a) shows that 99% jitter grossly under-estimates DJ
- (b) shows that 99% jitter grossly over-estimates DJ

Summary and Conclusion

- **DJ definition, measurement methods are restated**
  - Based on solid and proven math and physics for DJ mechanisms
  - Measurement methods are accurate, generic, and scalable to multiple instrument platforms, have been developed and validated by several T&M vendors already, no new T&M equipments are required
- **99% jitter has many serious problems and should not be used for jitter specification**
  - Based on a total jitter PDF that is a mix of DJ and RJ, a wrong start to bound DJ
  - No physical or mathematical justifications, bad observable for DJ estimation
  - Definition is based a specific histogram, not generic and scalable to multiple measurement platforms
  - For a jitter PDF with its DJ pk-pk levels-off beyond 10,000 hits, this method under-estimates DJ
  - For a jitter PDF where RJ is dominant over DJ, this method over-estimates DJ
  - Overall it is a wrong metric to quantify or bound DJ

References

1. M. Li, "Jitter, Noise, and Signal Integrity at High-Speed", Prentice Hall, 2007 and references therein
2. PCIe Jitter White Paper, 2004: http://www.pcisig.com/specifications/pciexpress/technical_library

3. PCIe Jitter and BER White Paper, 2005: http://www.pcisig.com/specifications/pciexpress/technical_library

Thank you