PIE Metrics & Mask Testing

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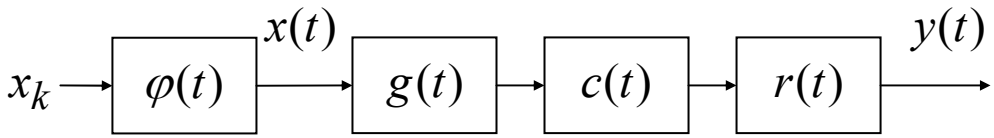
Introduction

- Motivation
  - What is the effect of different Tx pulse shapes on PIE metric?
  - Investigate in the context of mask testing, e.g. at fixed “mask margin”
- Caveats
  - This is work in progress …
  - PIE metric statistics are computed with each offset as a separate case
    - This is **NOT** the “consensus” method for computing percentiles.
    - Chosen to generate more cases → smoother curves → better sense of relative offsets
    - Absolute values of computed PIE metrics not valid per current group consensus
  - ⇨ Only relative PIE metric values are presented
    - Normalized 80th percentile of PIE-x to 0dB for the “standard” configuration

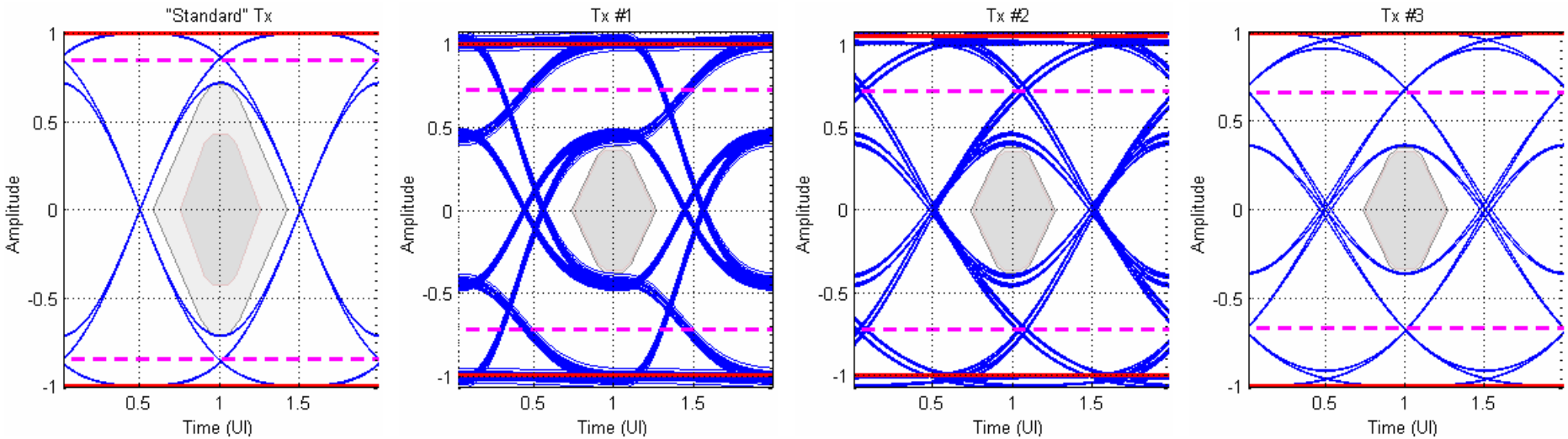
Simulation Methodology



- $x_k \in \{-1, +1\}$
- $\varphi(t)$ = unit rectangular pulse
- g(t) = transmit filter
- c(t) = channel response (fiber)
  - Cambridge 81-fiber model (Release 1.1)
  - 17μm – 23μm OSL
- r(t) = receive filter
- "Standard" Configuration
  - g(t) = 47.1ps risetime Gaussian
  - r(t) = 7.5GHz, 4th-order BT

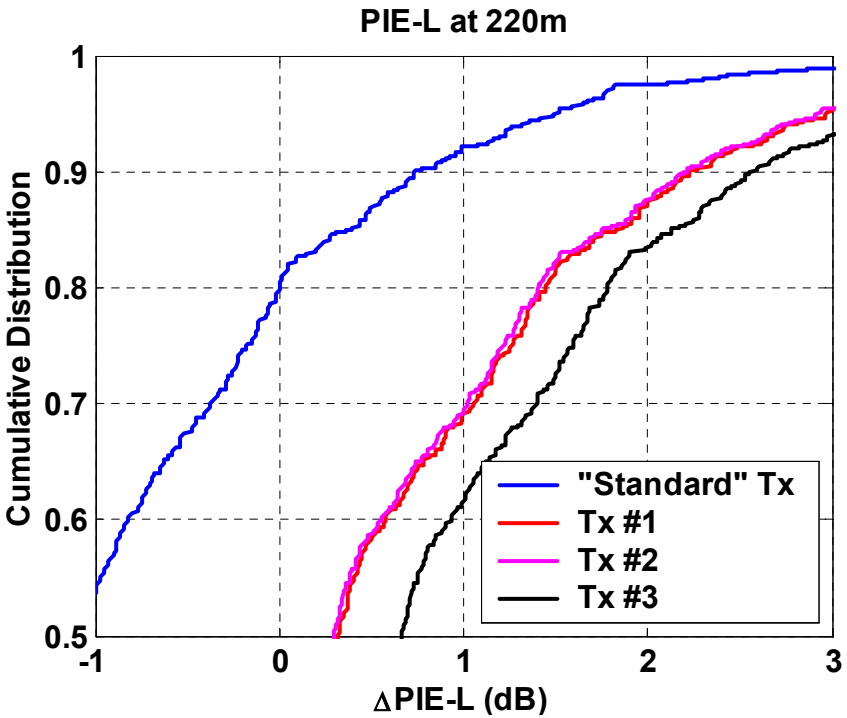
- TP2 eye mask
  - No channel
  - Includes 7.5GHz BT filter
- Simulation methodology
  - Investigate alternate g(t)
  - Compute eye diagrams
  - Compute PIE metrics
- Compare waveforms relative to PIE metric performance

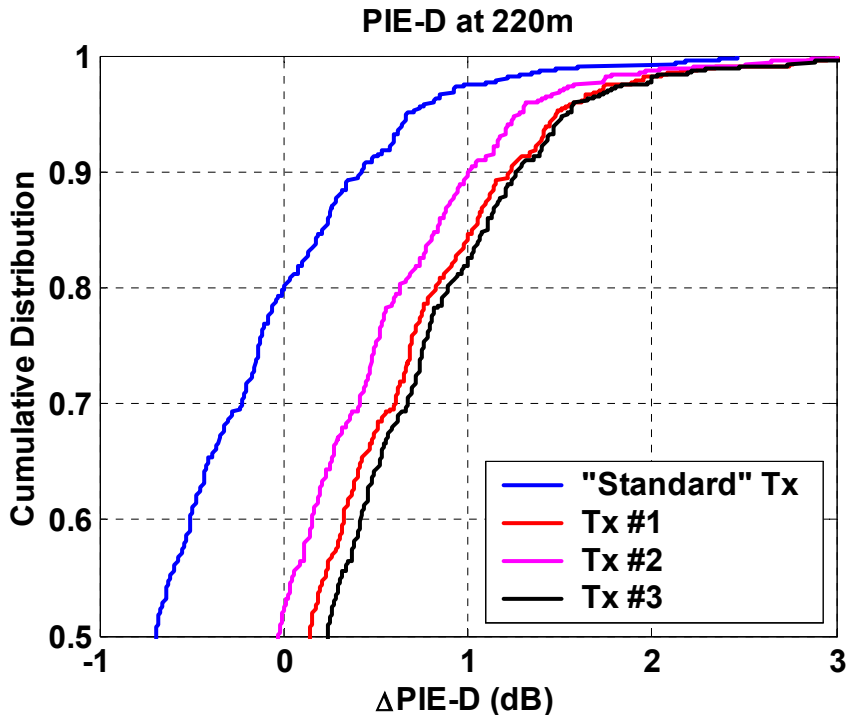
Simulated Eye Diagrams



- 10GBASE-LR mask
- OFSTP-4a mask scaling (Clause 52 definition)
- No noise included
- “Standard” configuration shows ~65% mask margin
- Choose a few examples that just pass the mask
  - All three examples have 5% mask margin
- LTI system only – nonlinear distortions not included

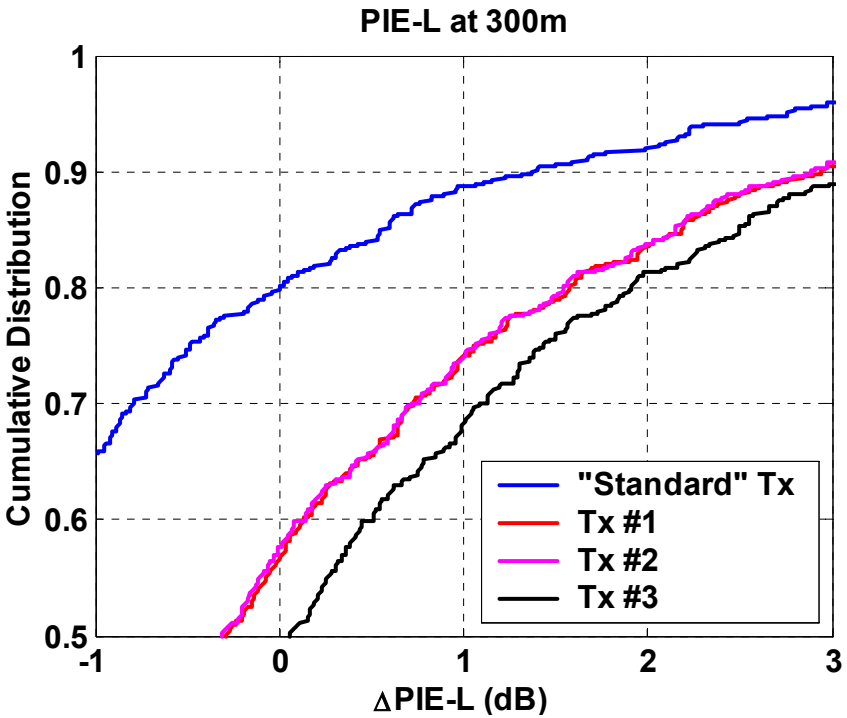
Relative PIE Metrics @ 220m

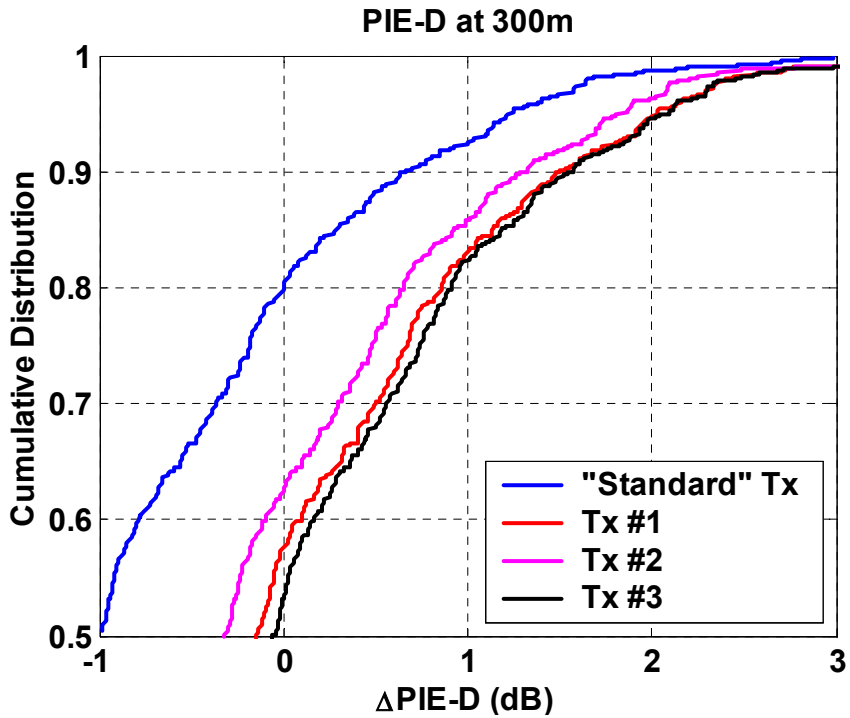




- PIE metric variation for different Tx pulse shapes (same mask margin):
  - ~0.35dB for PIE-L / ~0.25dB for PIE-D (@ 80th percentile)
- Offset between “standard” configuration and 3 examples
  - ~1.6dB for PIE-L / ~0.8dB for PIE-D (@ 80th percentile)

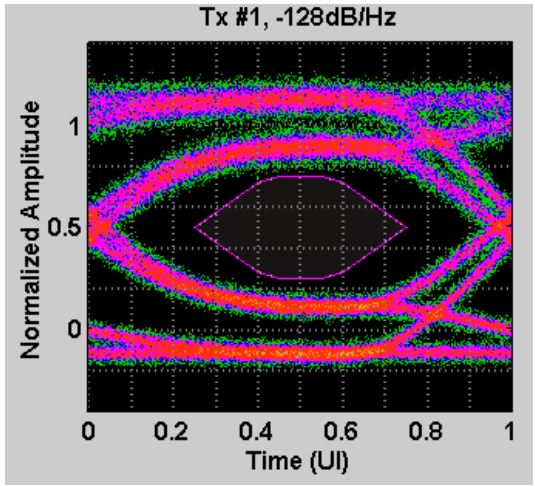
Relative PIE Metrics @ 300m

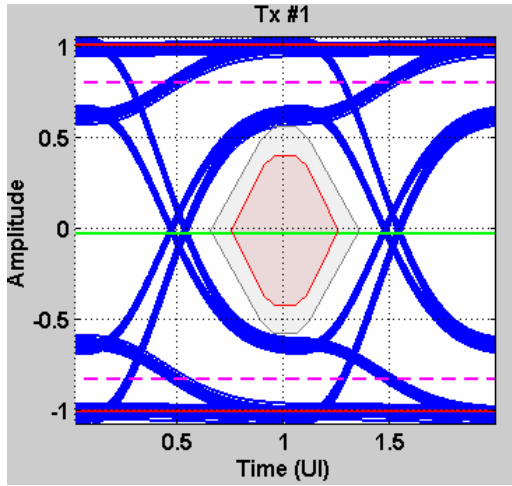




- PIE metric variation for different Tx pulse shapes
  - Variation between 3 examples insensitive to length
  - Offset relative to “standard” configuration insensitive to length

Noise & Mask Testing



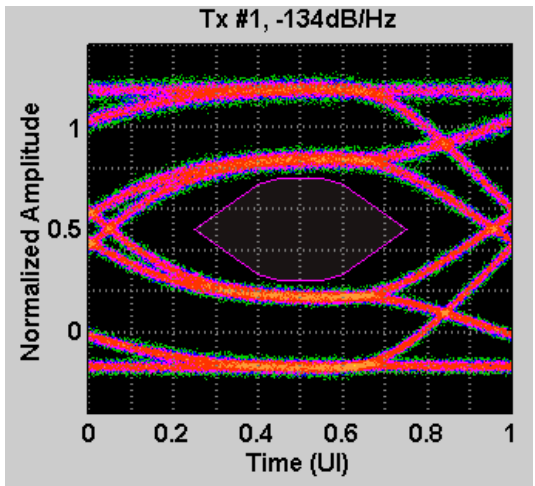


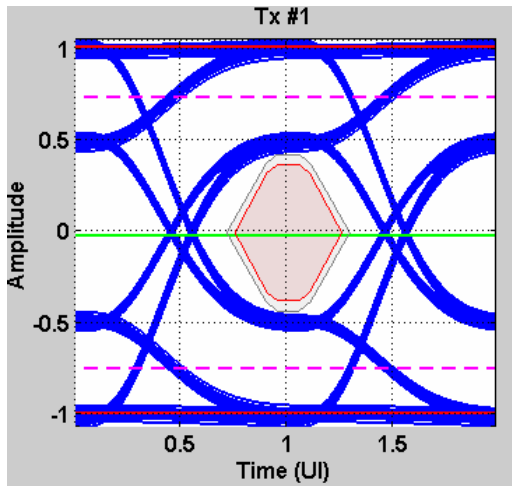
same mask margin

different ISI

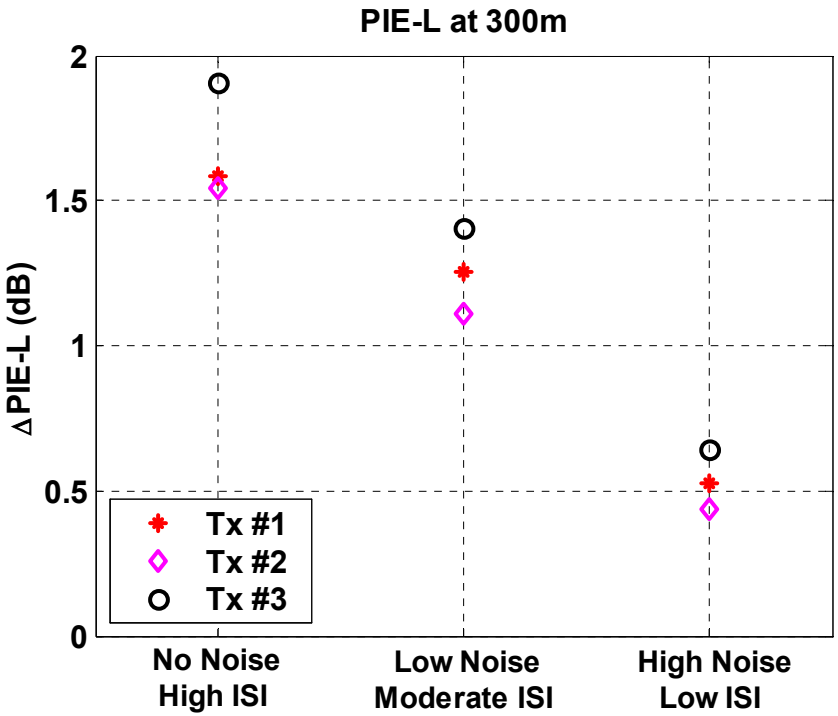
- Noise
  - RIN
  - scope noise
- Difficult to separate random & deterministic processes

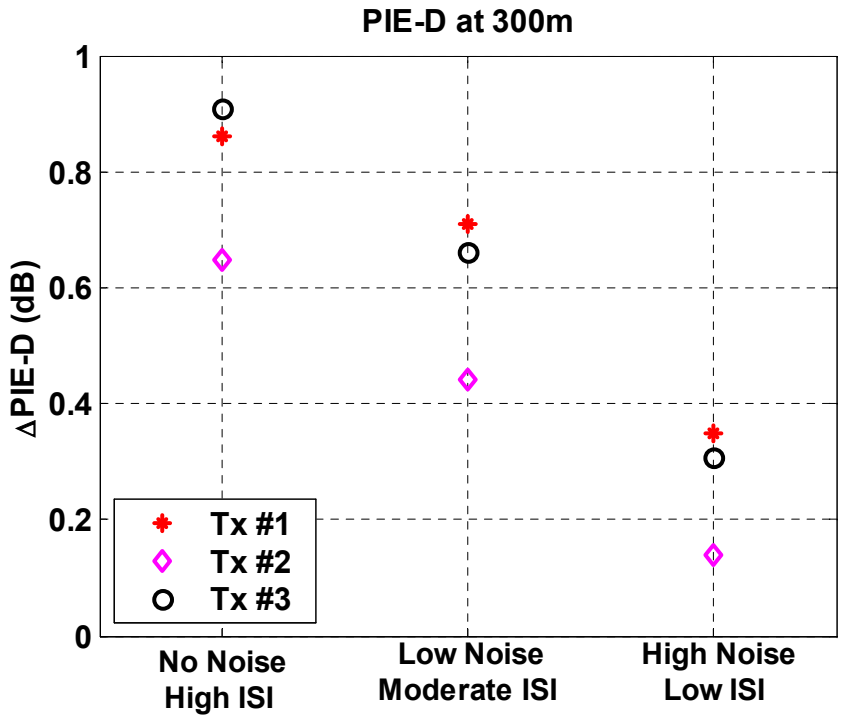
ΔPIE-L ~ 0.7dB
ΔPIE-D ~ 0.4dB





Relative PIE Metrics @ 300m





- Absolute ΔPIE-x decreases with increasing noise (& less ISI)
- Range of ΔPIE-x with increasing noise (& less ISI)
  - ~ constant for PIE-D
  - decreases for PIE-L

Summary

- Mask test allows more ISI than “standard” configuration used to calculate PIE-x
  - Is this effect included in budget?
- Mask test allows different pulse shapes with same mask margin with different PIE-x values
  - Is this effect included in the budget (e.g. in general “implementation” penalties)?
- Noise (e.g. RIN & scope noise)
  - Mask testing becomes a stochastic process
  - See *www.ieee802.org/3/efm/public/may03/optics/dawe_optics_2_0503* for an excellent presentation on the subject of mask testing, noise, repeatability, …
- Other impairments (nonlinear distortion, jitter,…)?