Exploring the Transmitter Parameter Space for 100m Links for 100GBASE-SR10 and 40GBASE-SR4

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Supporters

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Motivation

- 100m links are not the same as 300m links
- 100m links are jitter limited, not ISI limited
- Although there is power margin, the jitter margin is tight, even at 100m
  - We need to propagate the signal to the ASIC with sufficient eye opening

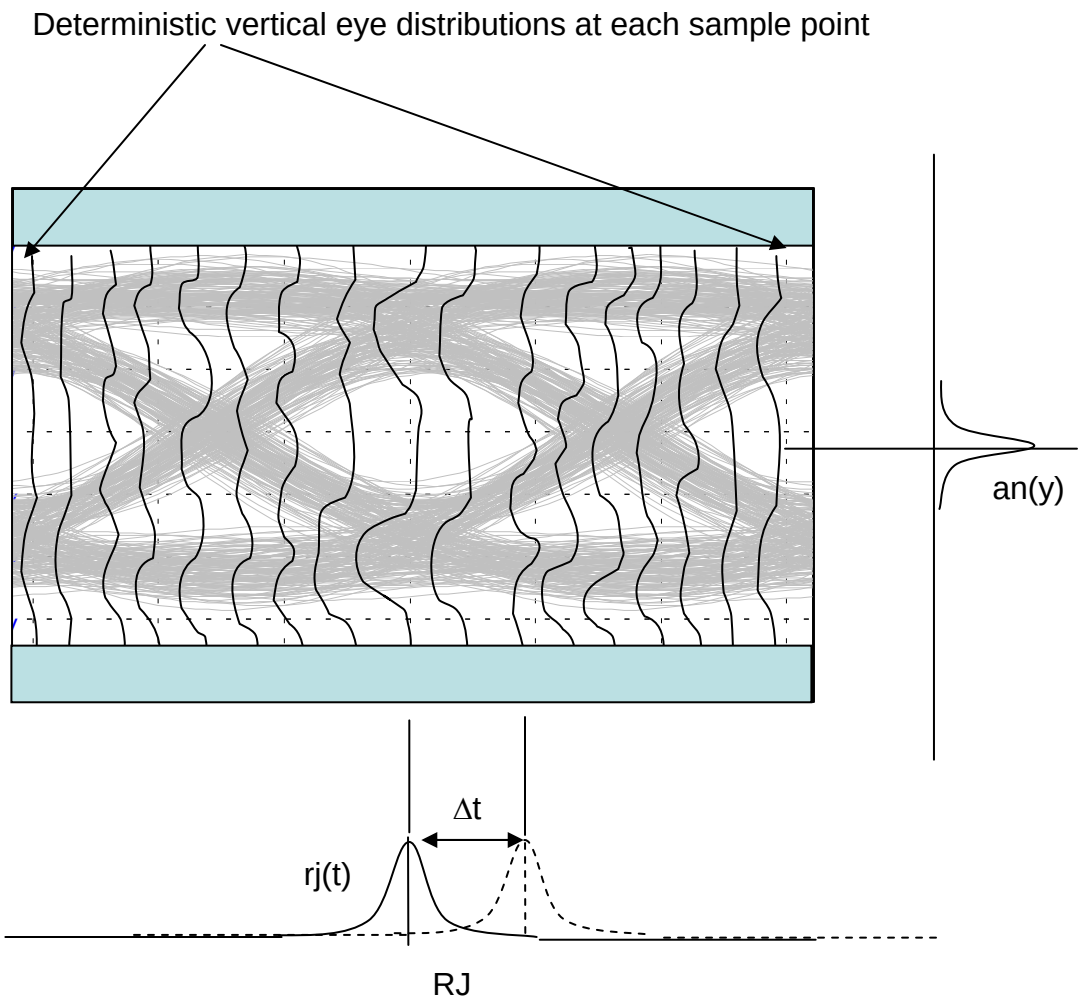
Model and Inputs

- Model based on manuscripts published in May 2003 issue of JLT
  - Pepeljugoski et al, “Modeling and simulation of Next Generation Multimode Fiber Links”, IEEE J. Ligtwave Technology 21(5), pp. 1242-55, May 2003.
  - Pepeljugoski et al, "Development of System Specification for Laser Optimized 50-um Multimode Fiber for Multigigabit Short-Wavelength LANs", IEEE J. Ligtwave Technology 21(5), pp.1256-75, May2003
- Transmitter inputs:
  - Min OMA: -3dBm
  - Vary laser r.m.s. linewidth: 0.55nm or 0.65 nm
  - Vary rise/fall time: 35 or 40ps
  - RIN OMA: -128 or -132 dB/Hz
    - RIN noise dominates at -128dB/Hz
  - Launch Conditions: Monte Carlo (from a pool of 2000 sources)
  - TP1 DJ = 0.14UI
  - TX DJ contribution = 0.13 UI (TP2 DJ = 0.27 UI)
  - RJ at TP1 = 0.14 UI pk-pk at 1e-12
- Receiver inputs:
  - Bandwidth 7.5 GHz
  - Sensitivity: -11.3 dBm
  - RJ = 0.21 UI (but, are we double counting?)
- Fiber inputs:
  - Delays: Monte Carlo (from a pool of 5000 fibers)
  - Connector offset: Monte Carlo
  - Connector Loss: 1.5 dB
- Total of 40000 links simulated

Methodology

- Use same approach used in Ethernet spreadsheet to calculate noise standard deviations, but:
  - Calculate BER directly from signal waveforms and noise standard deviations
    - All noises assumed with Gaussian pdf (standard deviations of signal dependent noises normalized accordingly)
    - Find equivalent noise standard deviation in standard manner
    - Find RJ (Gaussian) and AM noise convolution
      - AM noise contribution to jitter is calculated
- Extract information (eye width, margin contours) for jitter budgeting

Eye Diagram BER Analysis



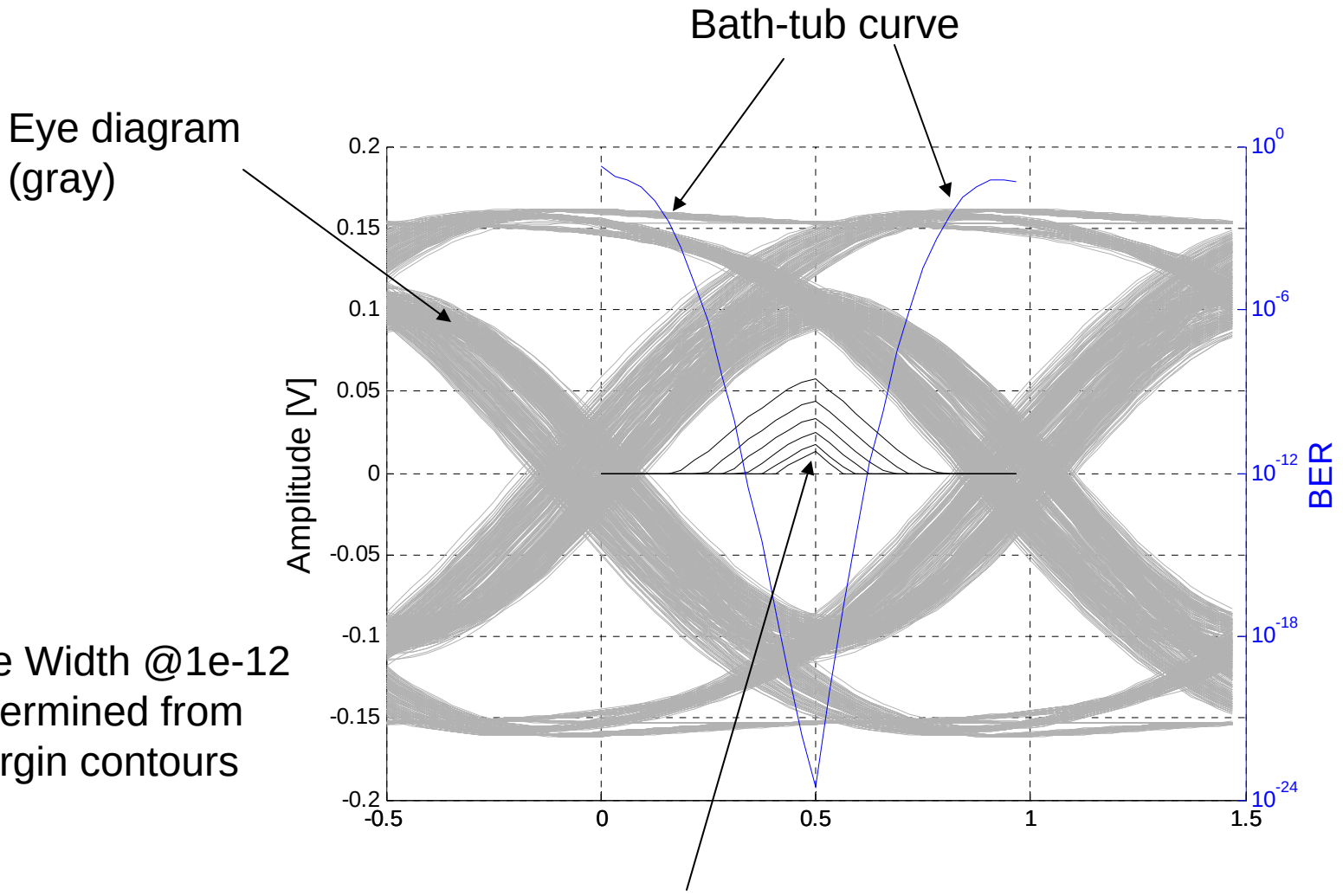
1) Add non-deterministic noise to vertical PDFs by convolving amplitude noise with signal waveform

2) Build RJ weighted sum of vertical PDFs at each of the sampling points that form the eye window (2UI here).

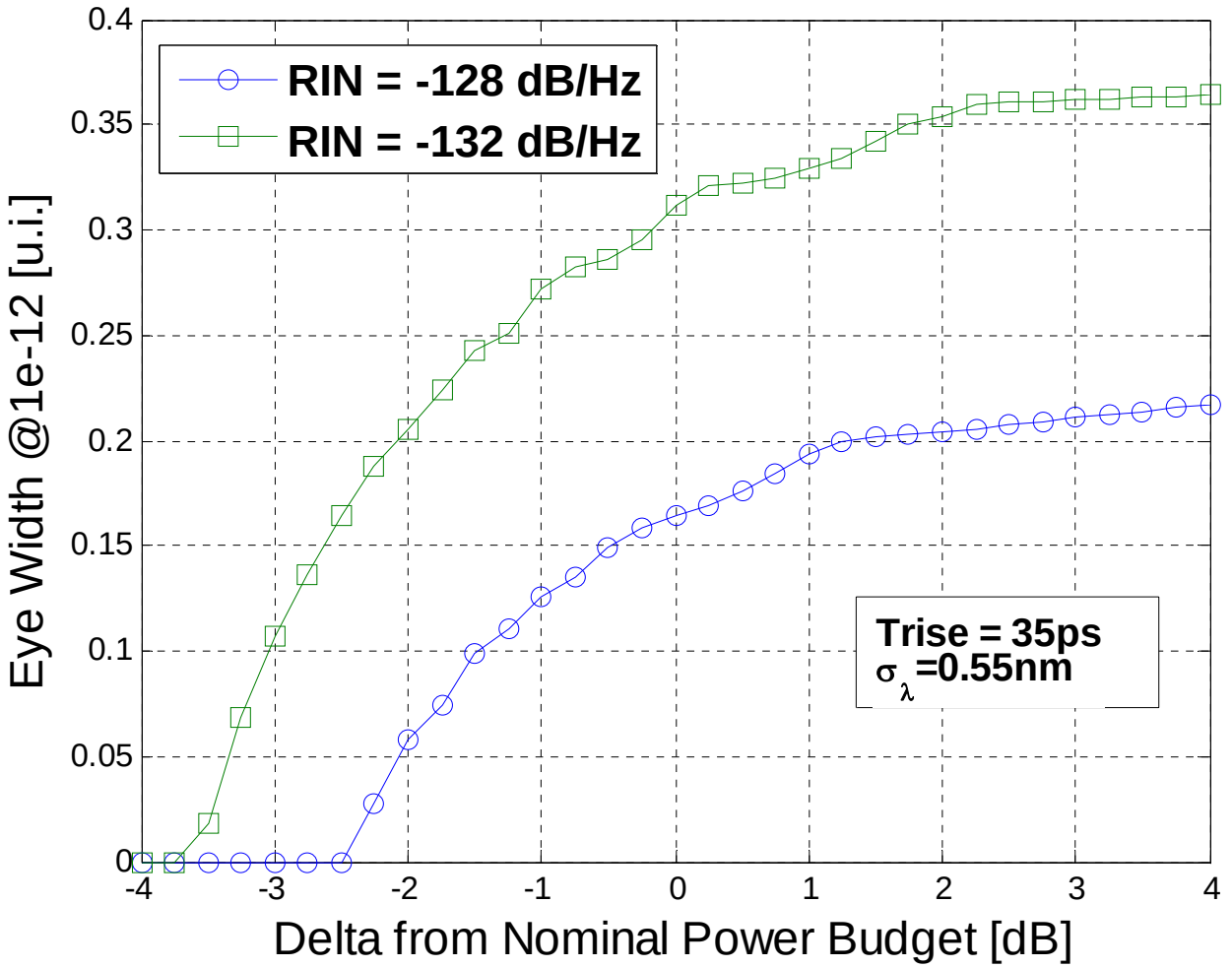
3) Compute BER at each sampling point from the area of the pdf below threshold

T. Beukema, "Challenges in Serial Electrical Interconnects at 5 to 10Gb/s and Beyond", IEEE SSCS Seminar, Ft. Collins CO March 2007

Sample Eye Diagram, Bath Tub Curve



Eye Width vs. Power Budget



0 dB point is the nominal (8.3 dB) power budget, with ~3.5dB margin

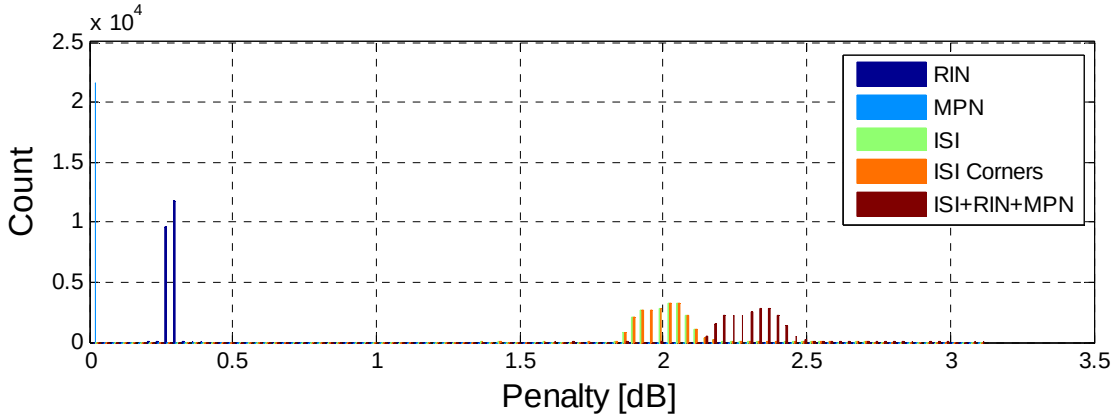
Worst Case Link Results*

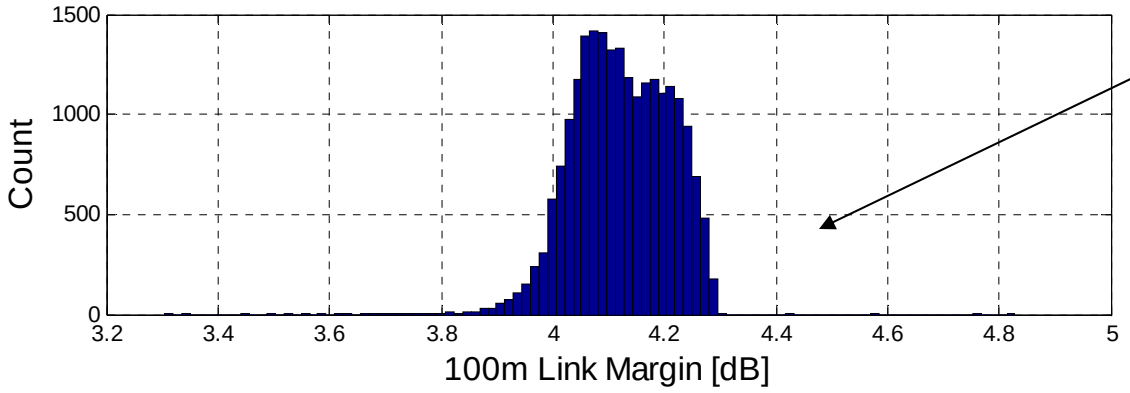
σ_λ [nm]	Trise [ps]	RIN [dB/Hz]	Min. Eye Width [u.i.]	Max ISI pen. [dB]
0.65	40	-128	0.12	2.72
0.55	40	-128	0.14	2.69
0.65	35	-128	0.16	2.51
0.55	35	-128	0.17	2.48
0.65	40	-132	0.28	2.72
0.55	40	-132	0.29	2.69
0.65	35	-132	0.29	2.51
0.55	35	-132	0.31	2.48

*Compliant links – both sources and fibers
Eye widths rounded to 2 significant digits

Why isn't the link power budget margin an indicator of performance?

- Power budgeting (vertical eye closure) neglects the jitter – the link may have vertical margin, but not jitter margin

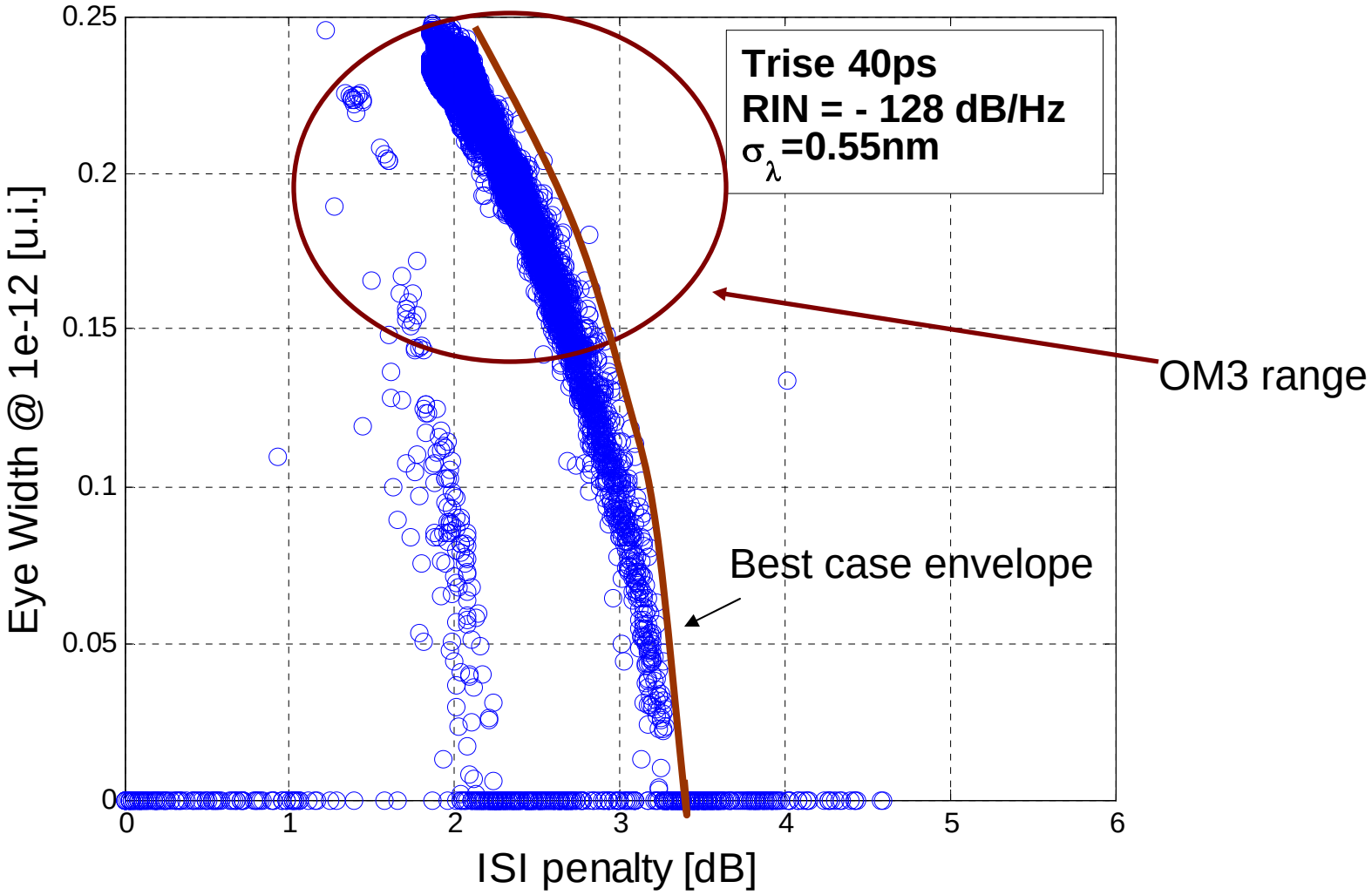




Lot of link power margin (> 3dB)

Link Margin is vertical eye closure margin, equivalent to column W in spreadsheet

Vertical Eye Closure Budgeting Alone not Sufficient



- Even the best case Eye Width vs. ISI envelope shows that at 3.3 dB ISI the eye is almost closed

Summary

- 100m links require different approach centered on jitter budgeting, not power budgeting alone
  - Vertical eye closure alone is not adequate
  - 8.3 dB power budget with allocation for jitter reduction seems adequate
  - Low RIN is crucial for jitter control
    - -128 dB/Hz is considered high
- If needed, this group needs to consider other options, like link extenders, FEC, that can help maintain healthy jitter budget and relax module specs
  - Side benefit of FEC may be support for longer link lengths