Extended Reach Comparison Base & Enhanced Tx

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Overview

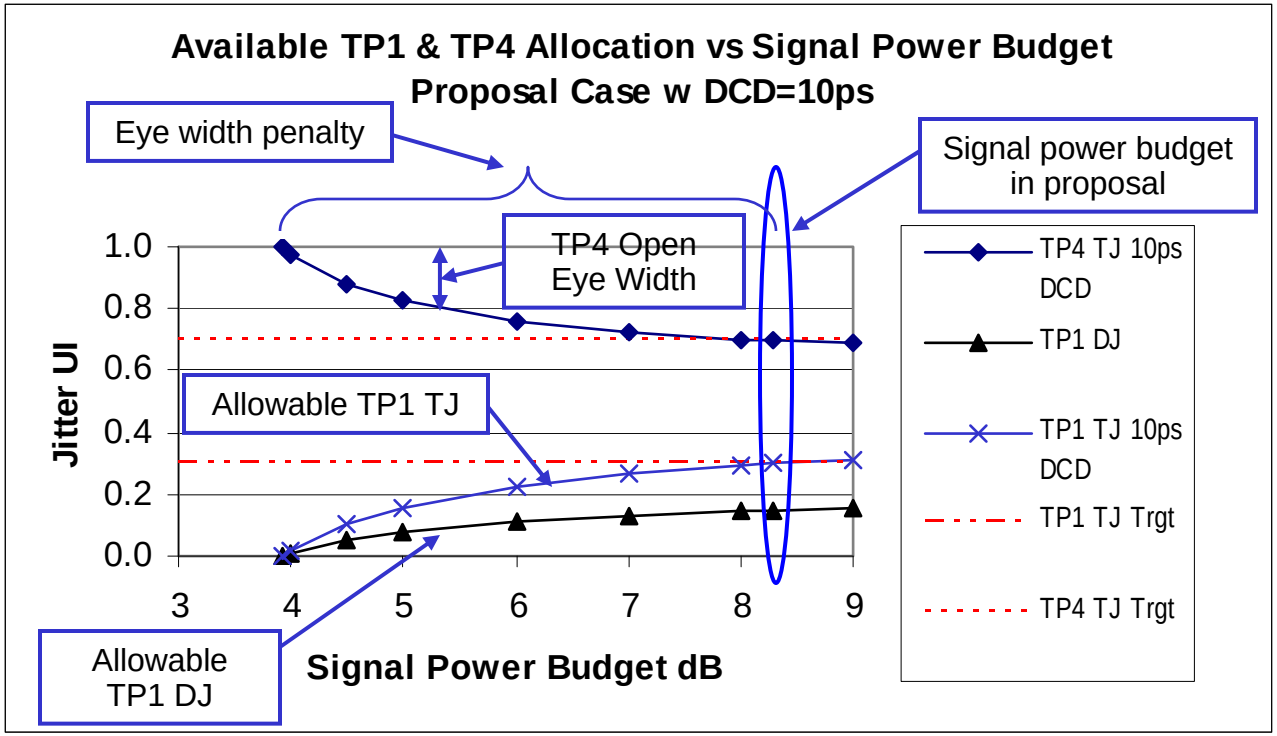
- The objective is to prepare and show a more direct comparison of transmitter implementation difficulty among the proposals based on limiting receivers; the enhanced Tx proposal, the CDR proposals and the FEC proposals.
- To meet this objective, the same link model and criteria, i.e. jitter allocations at TP1 and TP4 is used.
- Since the external CDR proposal and FEC proposals do not require any change to the base proposal, this is essentially a comparison of the enhanced Tx and base cases.

Link Model
Background

- The 10GbE link model, 10GEPBud3_1_16a, available at http://www.ieee802.org/3/ae/public/adhoc/serial_pmd/documents/ was used for the analysis presented in the following pages.
- Jitter in the following pages follows dual-Dirac methodology and, where used, DJ is intended to be dual-Dirac DJ.
- Since the 10GbE link model is open, available to all and reasonably well-regarded, it is a useful tool for comparing various proposals and tradeoff among attributes.
- The 10GbE module was extended to include the effects of RJ at TP1 and Rx contributed DJ and convert noise penalties into the associated RJ, permitting determination of RJ, DJ and TJ at TP4.

Link Model

Jitter Allocations & Signal Budget



- The figure shows the relationship between available jitter allocation and signal power budget.
- Target jitter allocations are set at TP1 TJ = 0.30 UI & TP4 TJ = 0.70 UI.
- The base case includes an 8.3 dB signal power budget and, as shown above, can support jitter allocations of TP1(DJ) = 0.15 UI, TP1(TJ) = 0.30 UI and TP4(TJ) = 0.70 UI.

Link Model Base Case
Transmitter Attributes (Each Lane)

- Min OMA: -3.0 dBm
- Min ER: 3.0 dB
- Min Center Wavelength: 840 nm
- Max RMS Spectral Width: 0.65 nm
- Max Transition Time (20%, 80%): 35.6 ps
- Max RIN12OMA: -130 dB/Hz
- RIN Coefficient: 0.70
- Mode Partition Noise Coefficient: 0.30
- Min Optical Reflection Tolerance: -12 dB
- TP1 Jitter Allocation: TJ = 0.300 UI, DJ = 0.150 UI
- TP2 Jitter Allocation: TJ = 0.491 UI, DJ = 0.284 UI

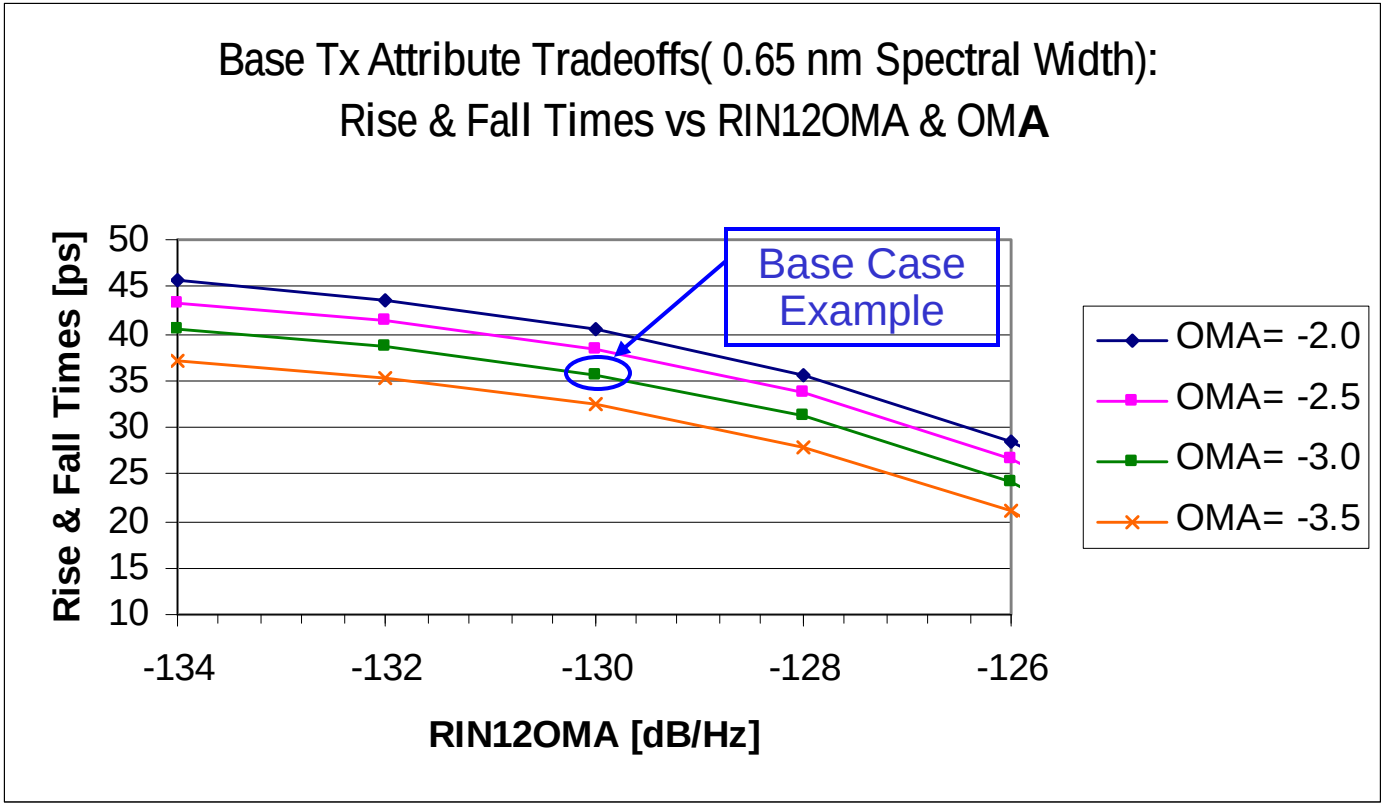
Link Model Base Case
Receiver Attributes (Each Lane)

- Max Sensitivity: -11.3 dBm
- Min Bandwidth: 7500 MHz
- RMS Base Line Wander: 0.025
- Max Rx Reflection: -12 dB
- TP3 Jitter Allocation: DJ = 0.284 UI, DCD = 0.103 UI
- TP3 Jitter Allocation: TJ = 0.530 UI
- TP4 Jitter Allocation: TJ = 0.700 UI
- TP4 Jitter Allocation: DJ = 0.367 UI

Link Model Base Case
Link Attributes (Each Lane)

- Signal Rate: 10.3125 GBd
- BER: < 10^{-12} (Q = 7.034)
- 100 m of OM3
- 1.5 dB connector loss allocation
- Signal Power Budget: 8.3 dB
- Attenuation = 0.36 dB
- Center Eye Penalties
  - Pisi = 1.45 dB
  - Pdj = 0.22 dB
  - Pmn = 0.30 dB
  - Pmpn = 0.02 dB
  - Prin = 0.15 dB
  - Pcross = 0.14 dB
- 0.30 UI Eye Width Penalty = 4.17 dB

100 m MMF Base Case
Tx Attributes Tradeoffs



The above figure shows the relationship between the transmitter output rise and fall times and RIN12OMA for different output OMA levels required to support the base jitter allocations over 100 m of OM3. All other transmitter, receiver and link attributes are as defined in the base case in the above pages.

Base & Required Enhanced Tx Attribute: 250 m OM4

Case	Spectral Width, nm	OMA, dBm	RIN12OMA, dB/Hz	Rise & Fall Times, ps
Base 100 m OM3	0.65	-3.00	-130.0	35.6
Enhanced Tx 250 m OM4	0.55	-1.30	-130.0	30.0
Enhanced Tx 250 m OM4	0.55	-2.32	-135.0	30.0
Enhanced Tx 250 m OM4	0.55	-2.82	-135.0	25.2
Enhanced Tx 250 m OM4	0.45	-2.30	-130.0	30.0
Enhanced Tx 250 m OM4	0.45	-2.80	-132.5	30.0
Enhanced Tx 250 m OM4	0.45	-2.80	-130.0	26.1

Conclusion: Supporting base case TP1 & TP4 jitter allocations over 250 m of OM4 appears too challenging for multilane optical transmitters. Tighter RIN12OMA and rise and fall time specs are not consistent with current technology and multilane devices. The higher minimum OMA requirements do not appear feasible.

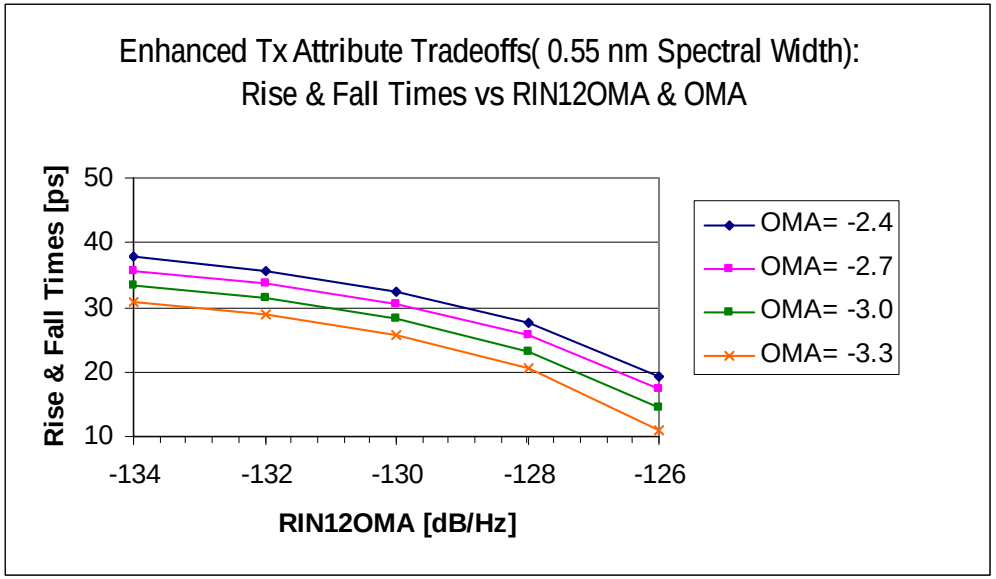
Base & Enhanced Tx Comparison

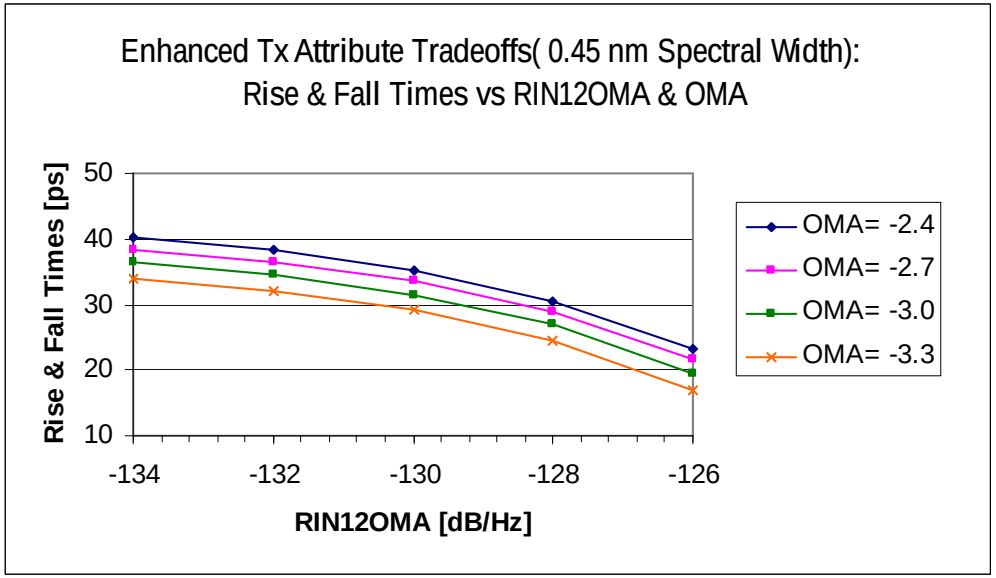
Case/Attribute	Base	Enhanced Tx			
Reach, m	100	200	200	250	250
Spectral Width, nm	0.65	0.45	0.55	0.45	0.55
Tx OMA, dBm	-3.00	-3.00	-3.00	-2.30	-1.30
RIN12OMA, dB/Hz	-130.0	-130.0	-130.0	-130.0	-130.0
tr & tf, ps	35.6	31.5	28.3	30.0	30.0
Center of Eye Penalties					
Pisi, dB	1.45	1.26	1.21	1.43	1.64
Pdj, dB	0.22	0.21	0.21	0.22	0.22
Pmn, dB	0.30	0.30	0.30	0.30	0.30
Pmpn, dB	0.02	0.07	0.14	0.16	0.33
Prin, dB	0.15	0.13	0.12	0.13	0.14
Pcross, dB	0.14	0.14	0.16	0.18	0.28
Eye Width Penalty, dB	4.17	3.96	3.93	4.17	4.69

Since a 250 m OM4 link does not look feasible, a 200 m OM4 link is considered. Aggressive combinations of OMA, RIN12OMA and rise and fall time are still required.

Enhanced Tx Case
Tx Attributes Tradeoffs

- The figures to the right show the relationship between the transmitter output rise and fall times and RIN12OMA for different output OMA levels and spectral widths for required to support the base jitter allocations over 200 m of OM4. All other transmitter, receiver and link attributes are as defined in the base case in the above pages.
- A requirement of less than 35 ps rise & fall times combined with RIN12OMA less than -130 dB/Hz appear more challenging than the triple tradeoff in 802.3ae.





Base & Required Enhanced Tx Attribute: 200 m OM4

Case	Spectral Width, nm	OMA, dBm	RIN12OMA, dB/Hz	Rise & Fall Times, ps
Base 100 m OM3	0.65	-3.0	-130.0	35.6
Enhanced Tx 200 m OM4	0.55	-3.0	-130.0	28.3
Enhanced Tx 200 m OM4	0.55	-3.0	-138.3	35.6
Enhanced Tx 200 m OM4	0.55	-1.83	-130.0	35.6
Enhanced Tx 200 m OM4	0.45	-3.0	-130.0	31.5
Enhanced Tx 200 m OM4	0.45	-3.0	-133.1	35.6
Enhanced Tx 200 m OM4	0.45	-2.35	-130.0	35.6

Conclusion: Supporting base case TP1 & TP4 jitter allocations over 200 m of OM4 presents significant challenges to the optical transmitter. Tighter RIN12OMA and rise and fall time specs do not appear consistent with current technology and multilane devices. Higher minimum OMA requirements will narrow the operating range leading to additional testing. All will lead to additional yield loss.