

# PAMx specs and penalties

Following on from Tremblay\_01\_0312\_NG100GOPTX.pdf (PAM 4,8 & 16 for 2km 100Gb/s  
Single Mode Optical Links with a 4dB loss budget)

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## Summary Table: Spec requirements and Penalties

	PAM-16	PAM-8	2λ x PAM-4	Comments
No of Lasers	1	1	2	
No of receivers	1	1	2	
Tx rise/fall time	12ps	8ps	12ps	
Rx 3dB BW	25GHz	32GHz	25GHz	
Tx & Rx THD	1.9%	2.9%	6.7%	Linear RX essential
Tx RIN	-152dB/Hz	-147dB/Hz	-140dB/Hz	Good quality DFBs
Tx SMSR	45dB	40dB	35dB	Good quality DFBs
Rx Elec Xtalk	-46dB	-42dB	-25dB	RF packaging critical for 8/16
Rx group Delay	+/-1.6ps	+/-2.5ps	+/-4.2ps	Linear phase receiver
Error Floor at Pmax	3x10 <sup>-7</sup>	10 <sup>-7</sup>	10 <sup>-8</sup>	FEC is essential
Simulated Power Penalty	3.1dB	3.5dB	2.9dB	
Worst case dynamic Range	1.9dB	5.5dB	9.1dB	Only 4,8 meet 4dB path loss

Each spec item has been adjusted to target approx 3dB composite penalty when all impairments are simulated together

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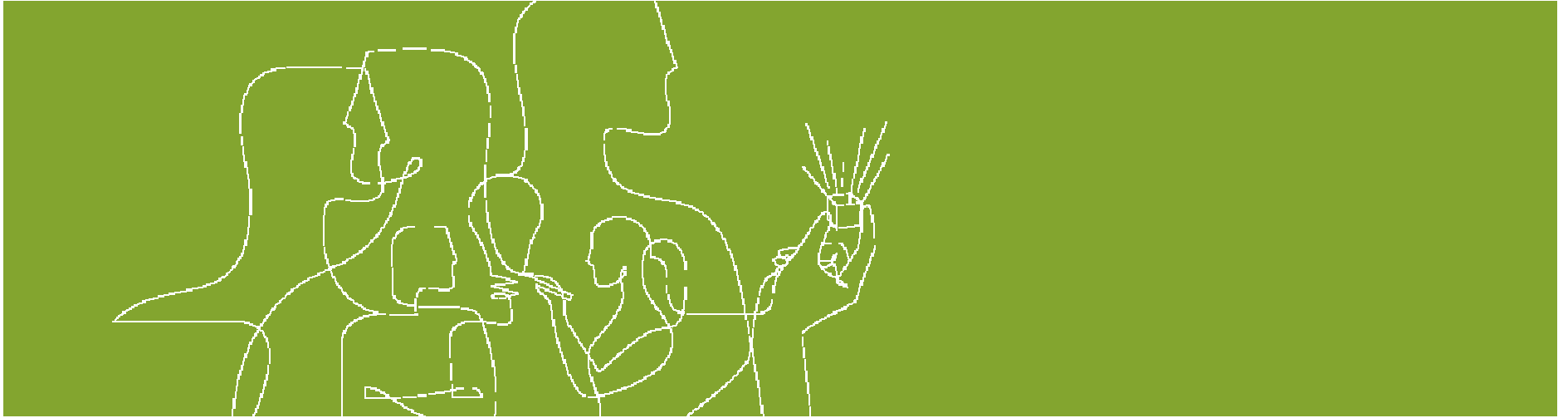
# Conclusions

- PAM-16 without FEC requires a high SNR that is incompatible with practical optical receiver overload limits. With FEC the dynamic range is improved but not enough to budget for 4dB path loss and 3-4 dB of impairment margin.
- PAM-8 without FEC is similarly too restrictive on dynamic range but PAM-8 with FEC seems capable of working with a reasonable loss budget.
- PAM-4 with FEC provides 13dB dynamic range. Without FEC 11dB is achievable
- PAM-8 would need to achieve <2.9% max THD for 1dB optical penalty and PAM-16 would need <1.9%. These represent challenging targets particularly given the need to operate at high peak-peak photocurrents to maintain adequate SNR.
- Threshold optimization would improve :
  - PAM-8 requirement from 2.9% to 5%.
  - PAM-4 requirement from 6.7% to 11%

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# Conclusions

- PAM-8 Operation at 112Gb/s with an 8pS rise time Tx requires Rx bandwidths of the 30-35GHz. Improvement over current 25G modulator rise times (12pS) will be necessary.
- -147dB/Hz RIN and 40dB SMSR specs will be required for the Tx for PAM 8. This is telecom grade performance and will attract a price premium. -140dB/Hz RIN and 35dB SMSR specs will be required for the Tx for PAM 4. This is achievable with current DFBs.
- $< \pm 2.5$  pS Rx group delay ripple out to at least 20GHz will be required for PAM-8 to maintain a good eye and low penalty. Threshold optimization may be required. For PAM-4  $< \pm 4$  pS Rx group delay ripple out to at least 20GHz will be needed.
- Dual wavelength or dual polarization schemes will need 35dB optical adjacent-channel rejection
- A possible alternative is DQAM based upon a variant of DQSPK hardware i.e differential encoder, MZ Tx & DLI + balanced Rx



Thank You

