Digital Signal Processing for 100G/400G Optical Fiber Connectivity Links

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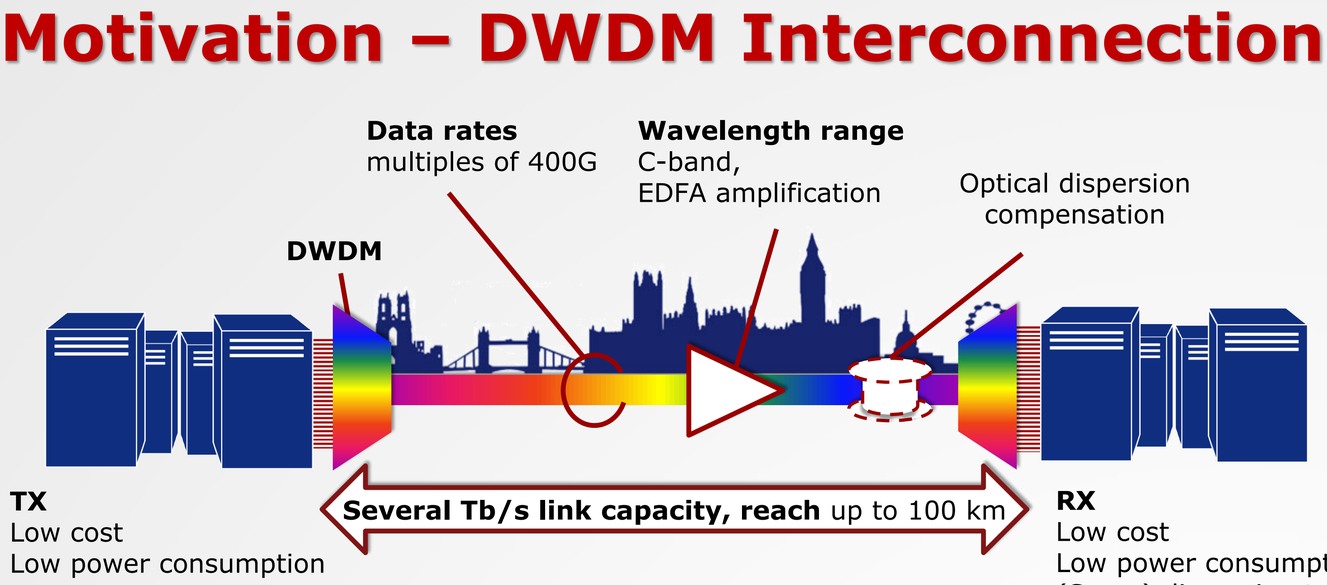
Digital Signal Processing for 100G/400G Optical Fiber Connectivity Links

Nicklas Eiselt[1,2], J. J. Vegas Olmos[1] and Idelfonso T. Monroy[1]

(1) Technical University of Denmark (DTU), Department of Photonics Engineering, Ørsteds Plads, Build. 343, DK-2800
(2) ADVA Optical Networking SE, Märzenquelle 1-3, 98617 Meiningen, Germany

niei@fotonik.dtu.dk

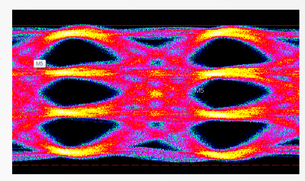
Motivation – DWDM Interconnections



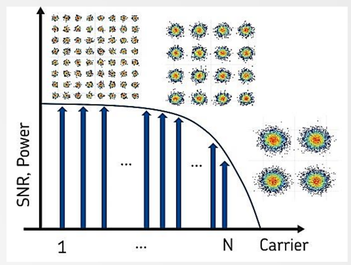
Low-Cost Approach
(Scale up from short reach)

- 400G direct detection
- 8x50G DWDM/ 4x100G WDM

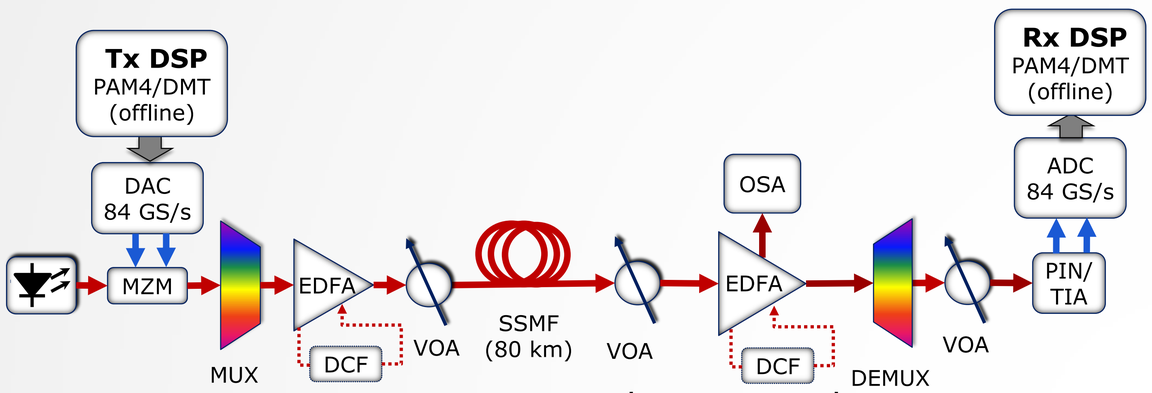
8 x PAM-4 @ 56 Gb/s



8 x DMT @ 56 Gb/s



Experimental Setup

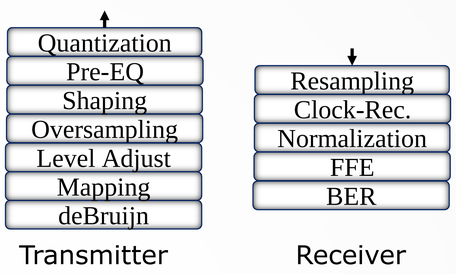


Parameter Setup

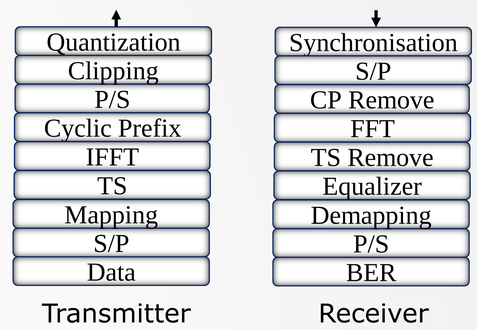
Data Rate	56 Gb/s
Frequency	194.25 THz
DAC/ADC	84 GS/s
MZM	$LiNbO_3$, > 35 GHz bw
PIN/TIA	30 GHz bw
MUX/DEMUX	39 GHz bw

DSP

Four-level pulse amplitude modulation (PAM-4)

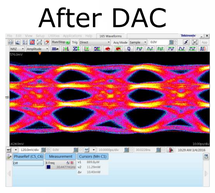


Discrete Multitone (DMT)

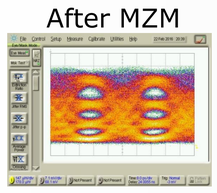


PAM-4 Eye Diagrams used for transmission

After DAC



After MZM



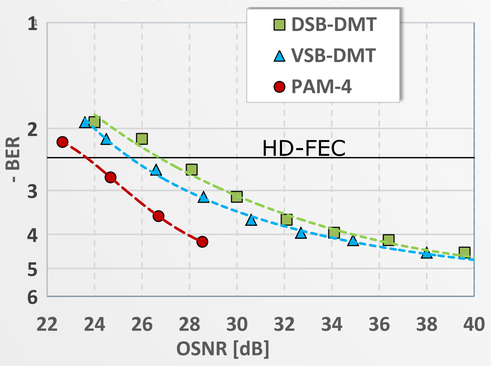
DMT Parameters

FFT length	1024
Oversampling	1.05
Max. used subcarriers	486
OFDC Frame	123 Symbols + 5 training symbols
Equalizer	1-tap, Decision-Directed
Bit & Powerloading	Chow's & Cioffi's algorithm

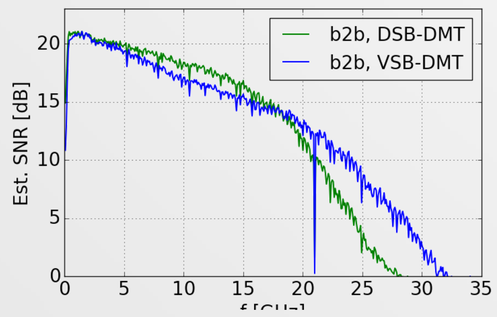
Experimental Results @ 56 Gbit/s

Optical b2b performance

BER vs. OSNR for b2b-mode

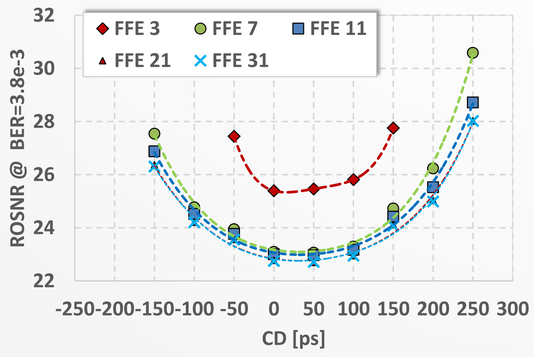


Estimated SNR of double sidband DMT (DSB-DMT) and vestigial sideband DMT (VSB-DMT) at optical b2b



Residual Dispersion & PAM-4

Required OSNR at the FEC-limit of 3.8e-3 vs. residual dispersion with different FFE tap count



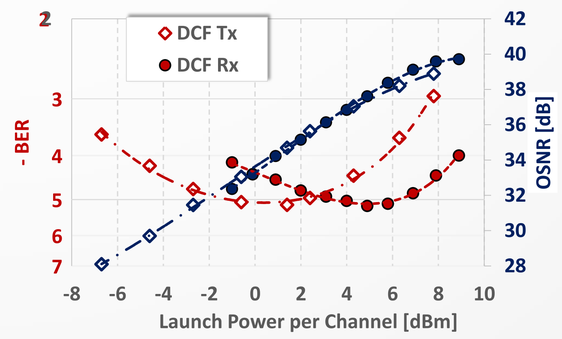
Results

Format	HD-FEC	OSNR b2b	OSNR 80 km
PAM-4	3.8e-3	~ 23.8 dB	~ 24.8 dB
DSB-DMT	3.8e-3	~ 25.7 dB	~ 27.2 dB
VSB-DMT	3.8e-3	~ 27 dB	~ 31 dB

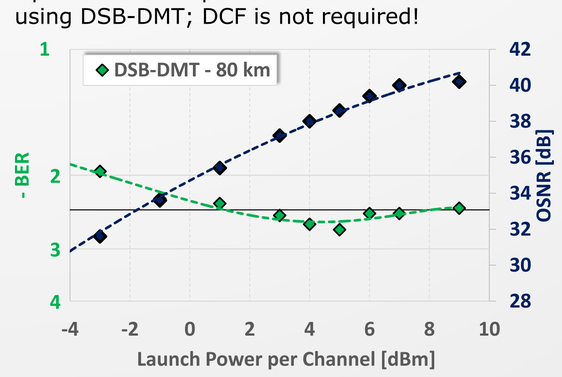
Transmission over 80 km SSMF

Launch Power

Optimum launch power into 80 km SSMF using PAM-4: Where to put the DCF?

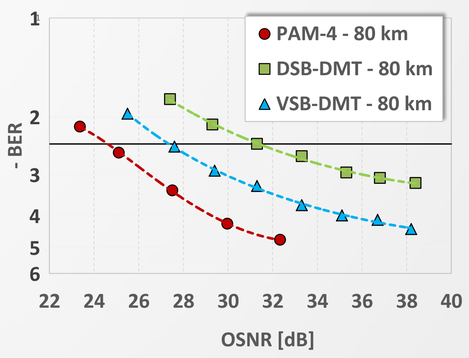


Optimum launch power into 80 km SSMF using DSB-DMT; DCF is not required!

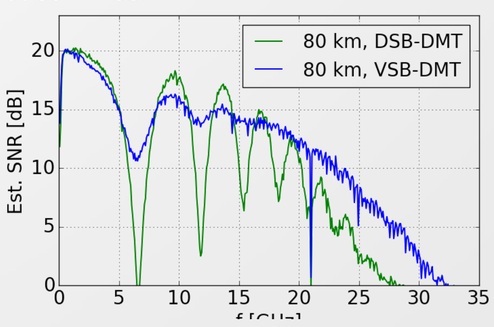


OSNR Performance

BER vs. OSNR at 80 km SSMF



Estimated SNR of double sidband DMT (DSB-DMT) and vestigial sideband DMT (VSB-DMT) at 80 km SSMF



Conclusion

- PAM-4 and vestigial sideband DMT show a lot of potential for a low-cost solution for next generation of inter-data center interconnections
- PAM-4 outperforms DSB-DMT and VSB-DMT in terms of required OSNR at the FEC-threshold for the b2b-case and even for 80 km SSMF
- DMT does not require any DCF → 5 dB higher power margin for DMT compared to PAM-4

Acknolowledgement

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DTU Fotonik
Department of Photonics Engineering

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[1] N. Eiselt, et al., „Experimental Comparison of 56 Gbit/s PAM-4 and DMT for Data Center Interconnect Applications", Photonische Netze, 17. ITG Fachtagung, 2016, Leipzig