Security Level:

The Impact of Differential Pre-coding on 25-Gb/s EDB, NRZ, and NRZ-NFC

Shuchang Yao, Xiang Liu, Dekun Liu

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Background

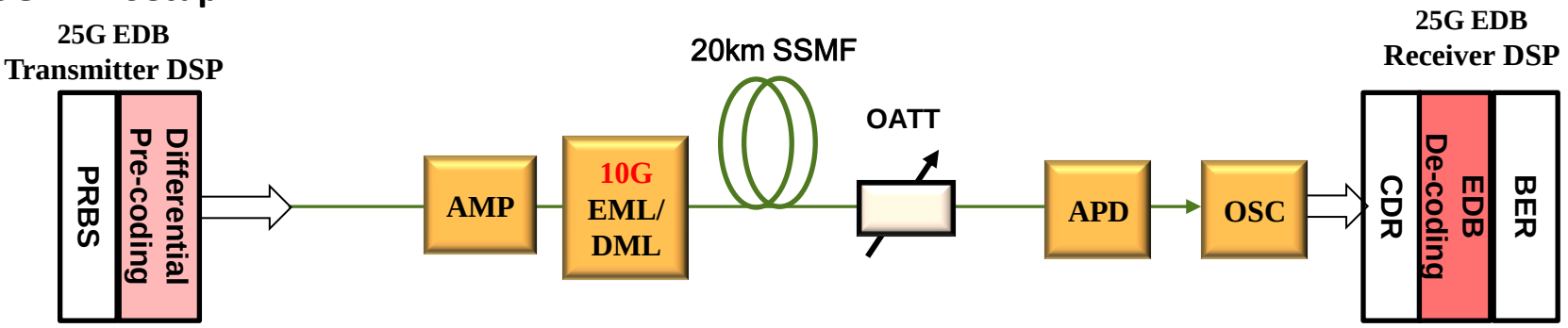
- Electronic duobinary (EDB) and non-return-to-zero (NRZ) are two candidates for 25Gb/s per wavelength transmission in PON.
- For EDB, differential pre-coding is desired at the transmitter, but this causes doubled error counts for NRZ. On the other hand, NRZ decoding with DSP-based channel equalization may benefit from differential pre-coding by avoiding error propagation [1].
- Our recently proposed NRZ with narrow-filter-compensation (NFC) employs an effective digital signal processing (DSP) scheme to support the 25Gb NRZ transmission using 10G-class optics [2], but its performance under differential pre-coding has not been reported.
- In this contribution, we study the impact of differential pre-coding on the performance of EDB, NRZ, and NRZ-NFC under various conditions.

[1] Vincent Houtsma, Dora van Veen and Ed Harstead, "Unified Evolution-Ready 25/50/100 Gbps-EPON Architecture Proposal ," IEEE P802.3ca 100G-EPON Task Force, Whistler, BC, Canada, May, 2016.

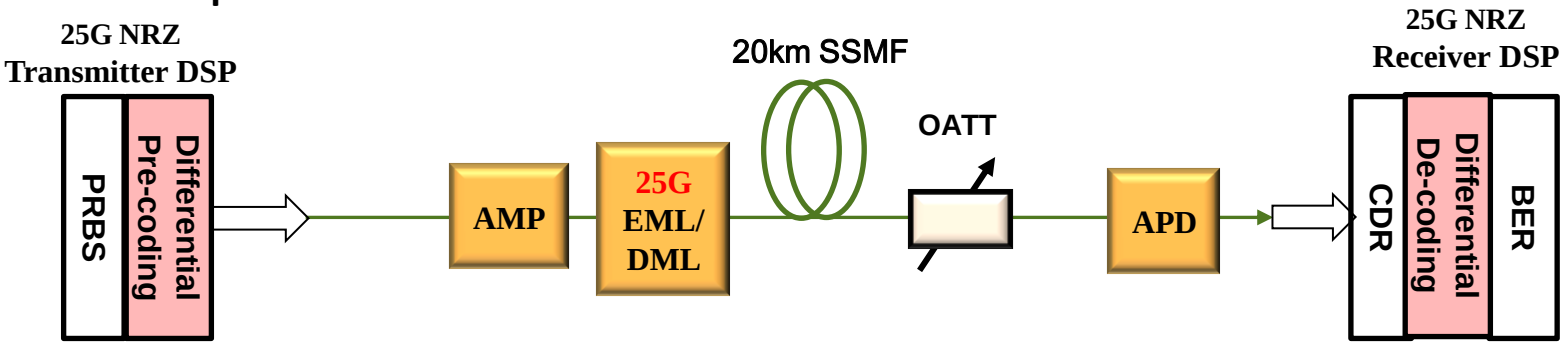
[2] Tao Minghui, Lei Zhou, Shuchang Yao, Ding Zou, Shengping Li, Huafeng Lin, and Xiang Liu, "28-Gb/s/λ TDM-PON with Narrow Filter Compensation and Enhanced FEC Supporting 31.5 dB Link Loss Budget after 20-km Downstream Transmission in the C-band," Proc. OFC, paper Th1I.4, Anaheim (2016).

Experimental/Numerical Setups

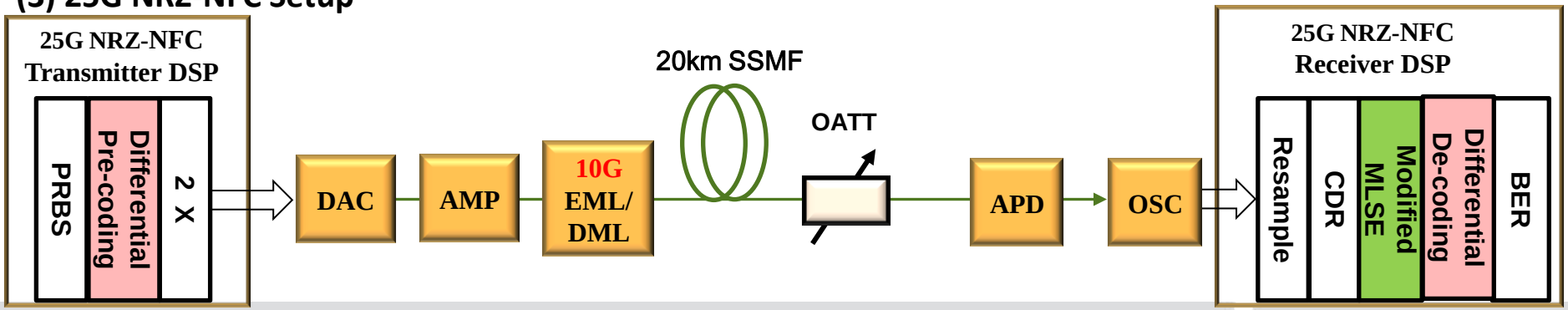
(1) 25G EDB Setup



(2) 25G NRZ Setup



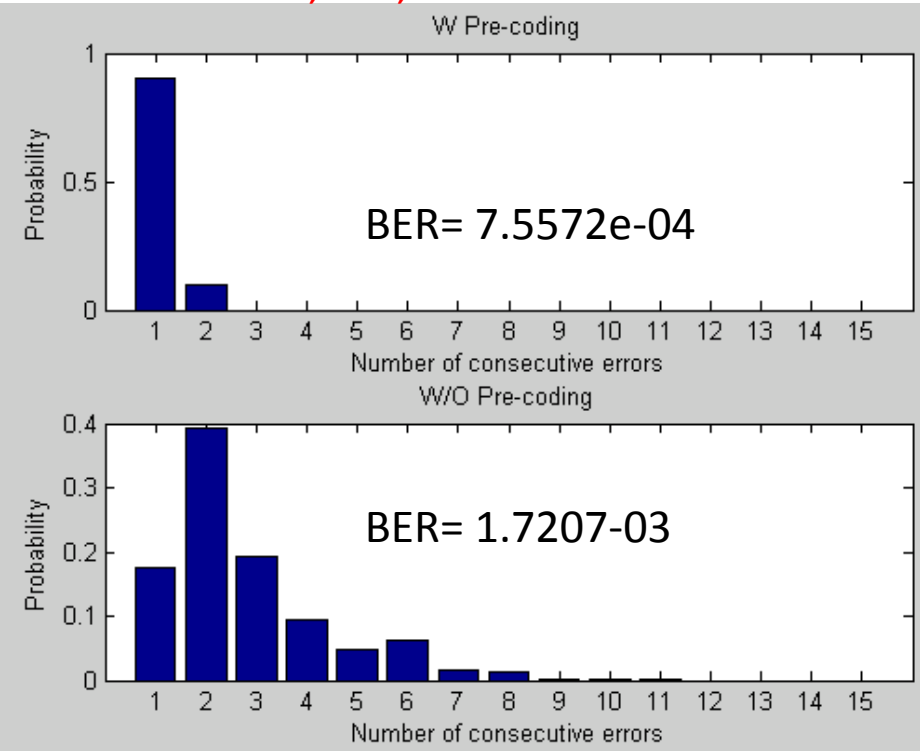
(3) 25G NRZ-NFC Setup



25G EDB over 10G EML/APD

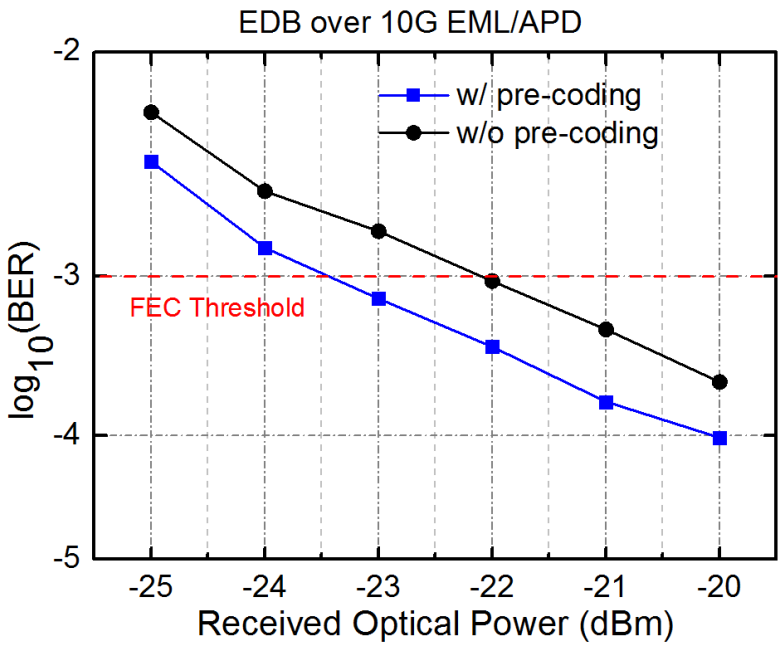
Error distribution

Cband,B2B, ROP=-23dBm



Comparison for BER VS ROP

Experiment

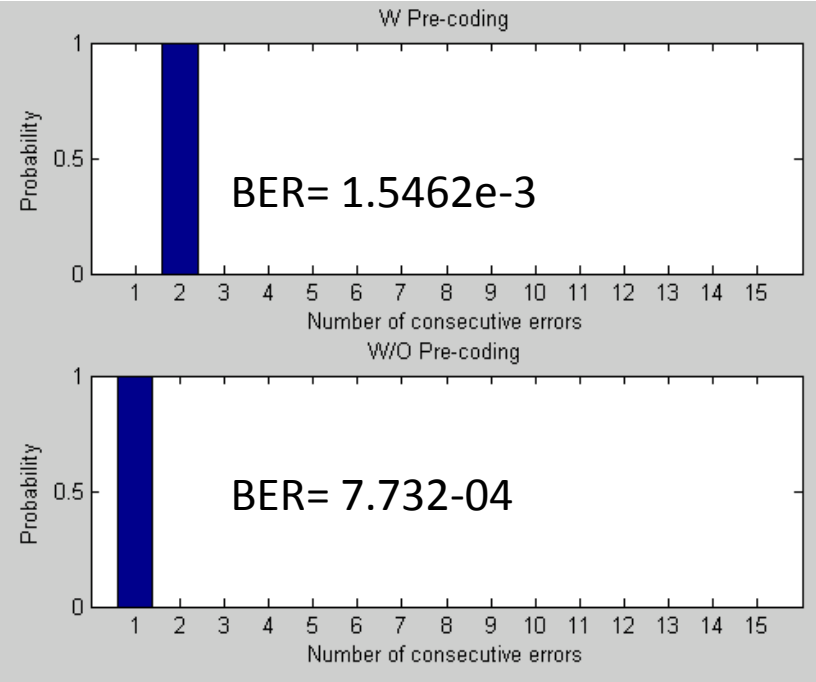


- For EDB, feedback decoding brings significant error propagation.
- Pre-coding can help with the error propagation and brings around 1.3dB gain at the FEC threshold .

Regular 25G NRZ over 25G EML/APD

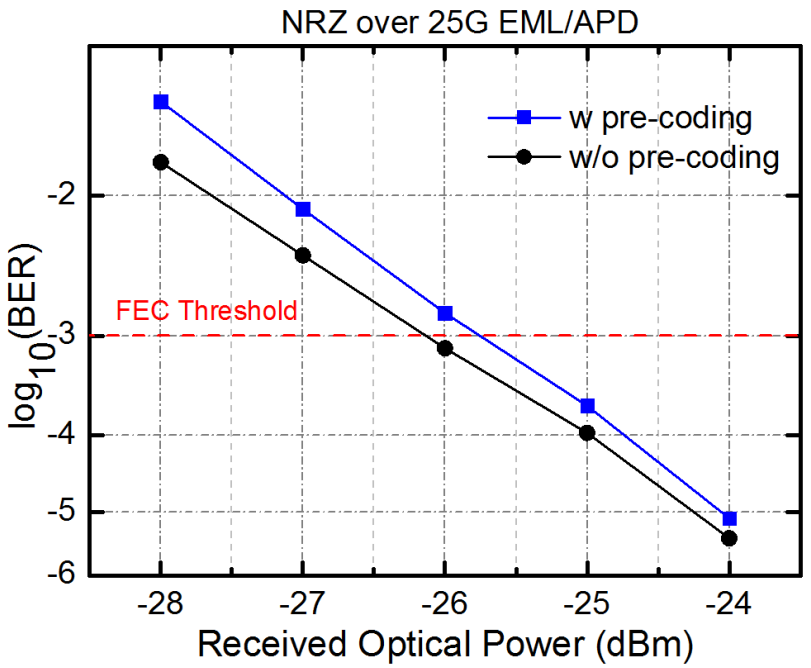
Error distribution

Oband,20km, ROP=-26dBm



Comparison for BER VS ROP

Simulation

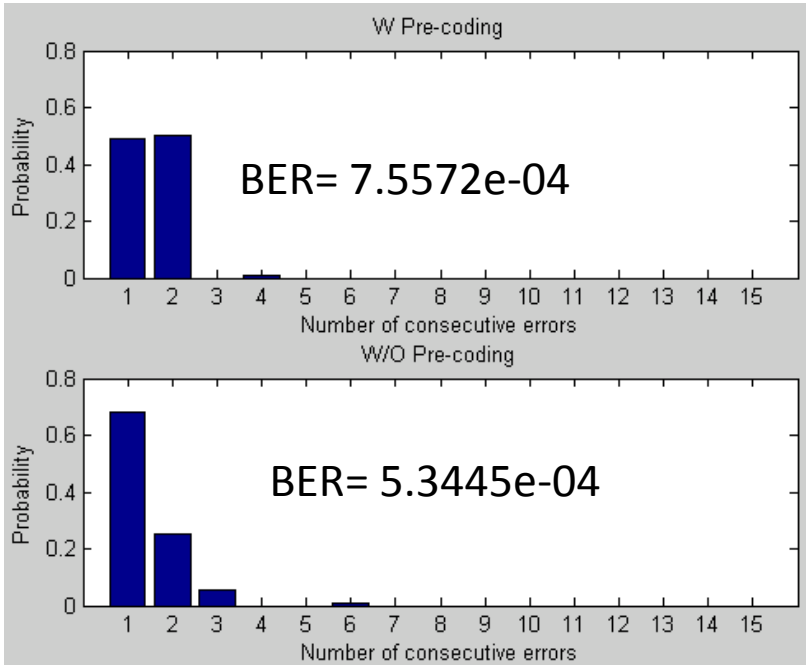


- For regular NRZ with sufficient bandwidth and without any DSP, most errors are single errors before pre-coding. But they are doubled after decoding. This leads to around 0.3dB degradation by differential pre-coding ,which can be even larger when high-gain FEC is applied.

25G NRZ-NFC over 10G EML/APD – B2B (no dispersion)

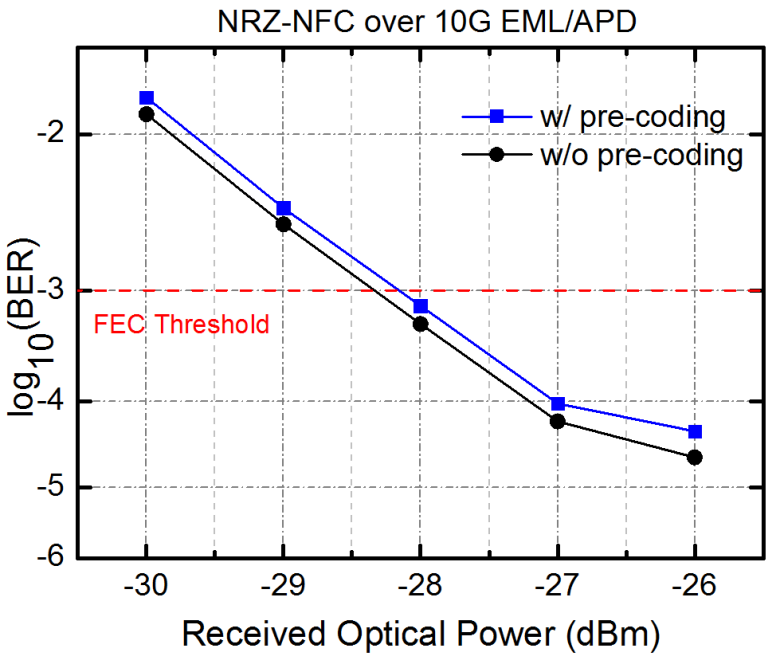
Error distribution

ROP=-28dBm



Comparison for BER VS ROP

Experiment

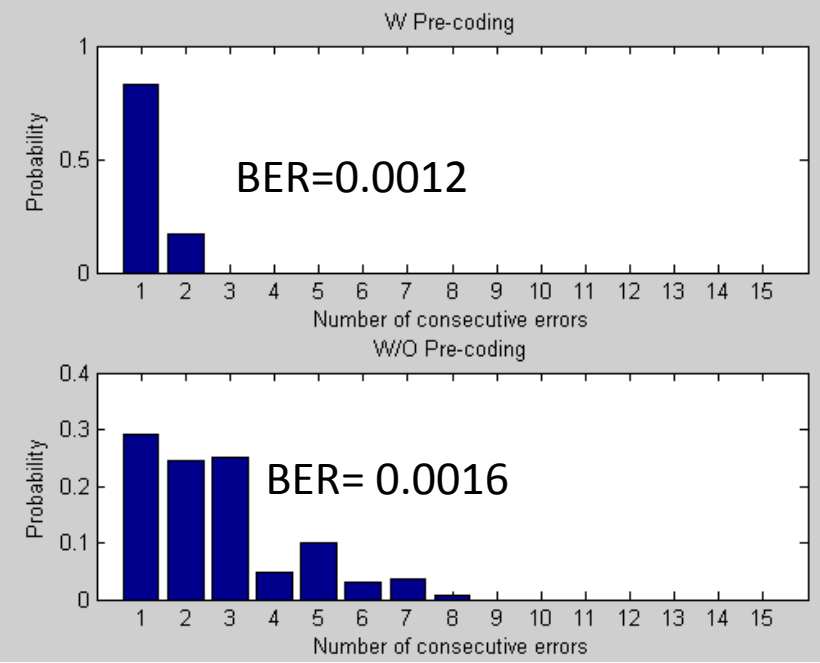


- With well designed MLSE, the error propagation of NRZ-NFC can be well controlled.
- As differential pre-coding makes single errors doubled, NRZ-NFC system works even better without pre-coding for B2B transmission.

25G NRZ-NFC over 10G EML/APD – 20km, C-band (340ps/nm dispersion)

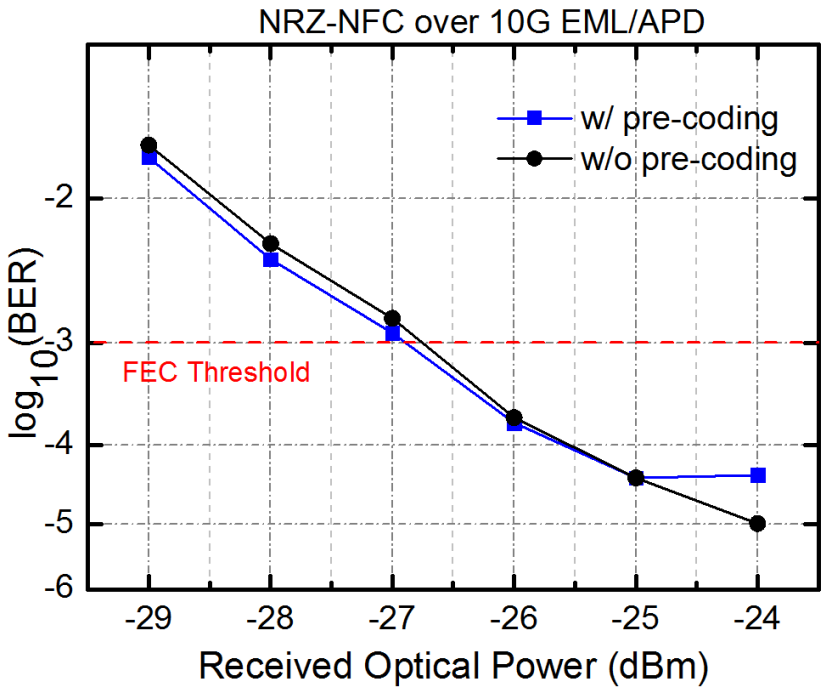
Error distribution

ROP=-27dBm



Comparison for BER VS ROP

Experiment

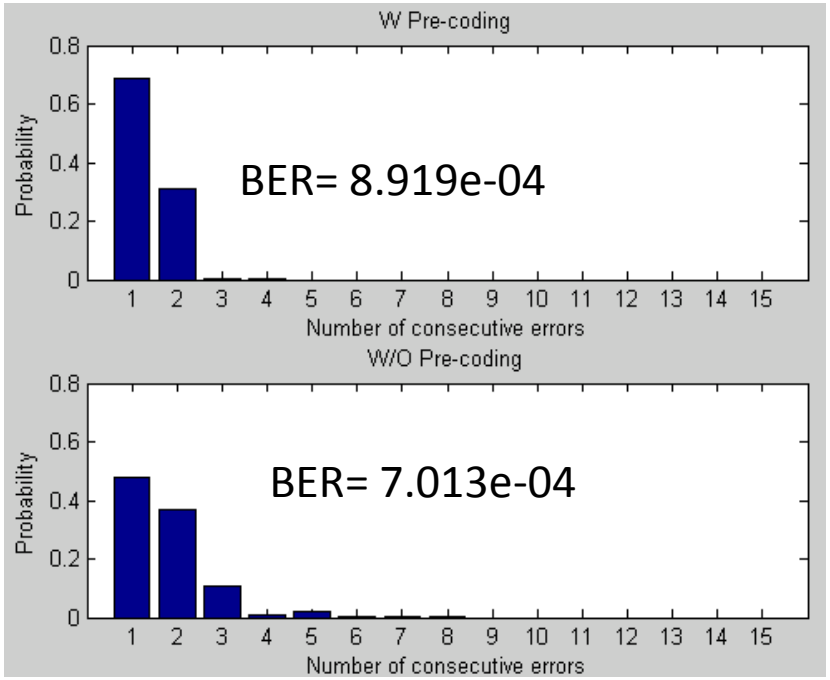


- In dispersive channels, pre-coding can be beneficial, but with well-designed MLSE, only a small performance gain of ~0.15dB can be observed at the FEC threshold.

25G NRZ-NFC over 10G DML/APD – 20km, O-band (<100ps/nm dispersion)

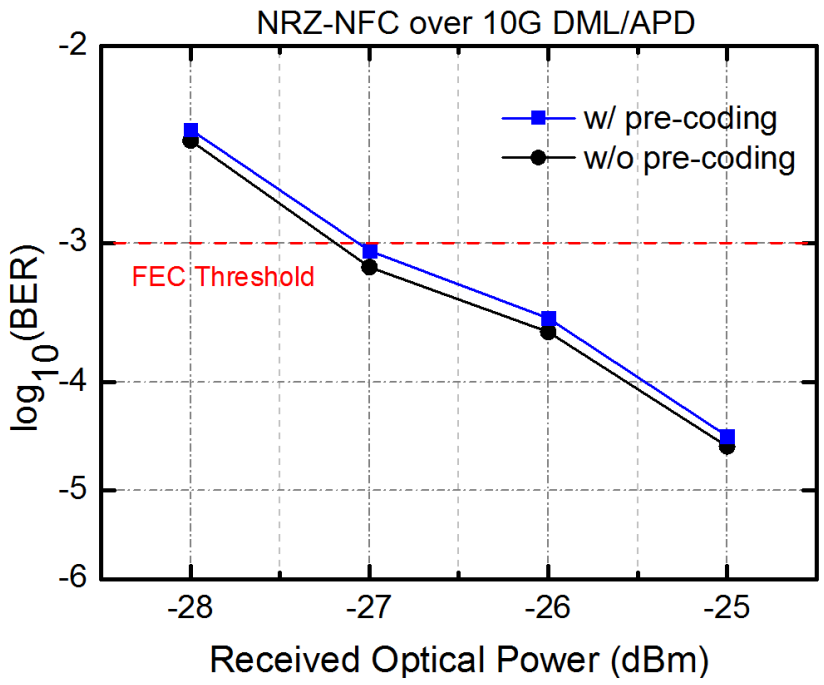
Error distribution

ROP=-27dBm



Comparison for BER VS ROP

Experiment



- For O-band transmission, error propagation is not a big problem.
- With pre-coding, a performance degradation of 0.1dB is observed at the FEC threshold.

Summary

- Differential pre-coding is required for EDB for significant performance improvement.
- It also provides some performance gain for bandwidth-limited NRZ with MLSE under dispersive transmission, but the performance gain is very small (~0.15 dB) for well-designed MLSE.
- When the dispersion effect is small (such as O-band transmission), differential pre-coding provides no performance gain , and may cause performance penalty.
- For conventional NRZ without severe bandwidth limitation (and thus without MLSE), differential pre-coding cause performance penalty, and the penalty can be >0.3 dB for high-gain FEC.
- Theoretically, the optimal pre-coding depends on channel response. It only resembles to differential pre-coding for duobinary channel response.
- Based on the above, we suggest that we do not decide on whether or not to add a pre-coding function at the transmitter at this early stage.

Thank you

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