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

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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.

Experimental/Numerical Setups

(1) 25G EDB Setup
- 25G EDB Transmitter DSP
- PRBS
- Differential Pre-coding
- 25G EDB Receiver DSP
- 25G EDB
- EML/DML
- 20km SSMF
- OATT
- AMP
- 10G EML/DML
- APD
- OSC
- CDR
- EDB
- BER

(2) 25G NRZ Setup
- 25G NRZ Transmitter DSP
- PRBS
- Differential Pre-coding
- 25G NRZ Receiver DSP
- PRBS
- Differential Pre-coding
- 25G NRZ
- EML/DML
- 20km SSMF
- OATT
- AMP
- 25G EML/DML
- APD
- CDR
- BER

(3) 25G NRZ-NFC Setup
- 25G NRZ-NFC Transmitter DSP
- PRBS
- Differential Pre-coding
- 2X
- 25G NRZ-NFC Receiver DSP
- Resample
- CDR
- MLSE
- Modified De-coding
- Differential De-coding
- BER
- DAC
- AMP
- 10G EML/DML
- APD
- OSC
- Resample
- CDR
- MLSE
- Modified De-coding
- Differential De-coding
- BER
25G EDB over 10G EML/APD

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.
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)

- 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

BER=0.0012

BER= 0.0016

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

Ber = 8.919e-04

Ber = 7.013e-04

**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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