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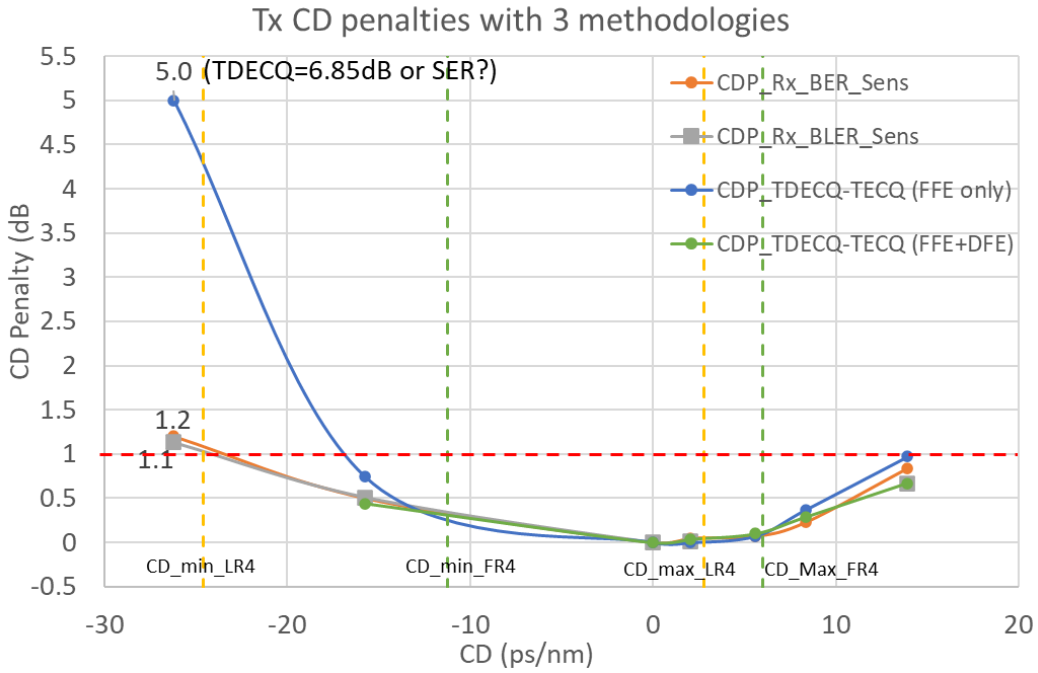
Considerations of 400G PAM4 CD Penalty and Measurement

Michael He, Hao Liao, and Rang-Chen(Ryan) Yu

TeraHop

Background

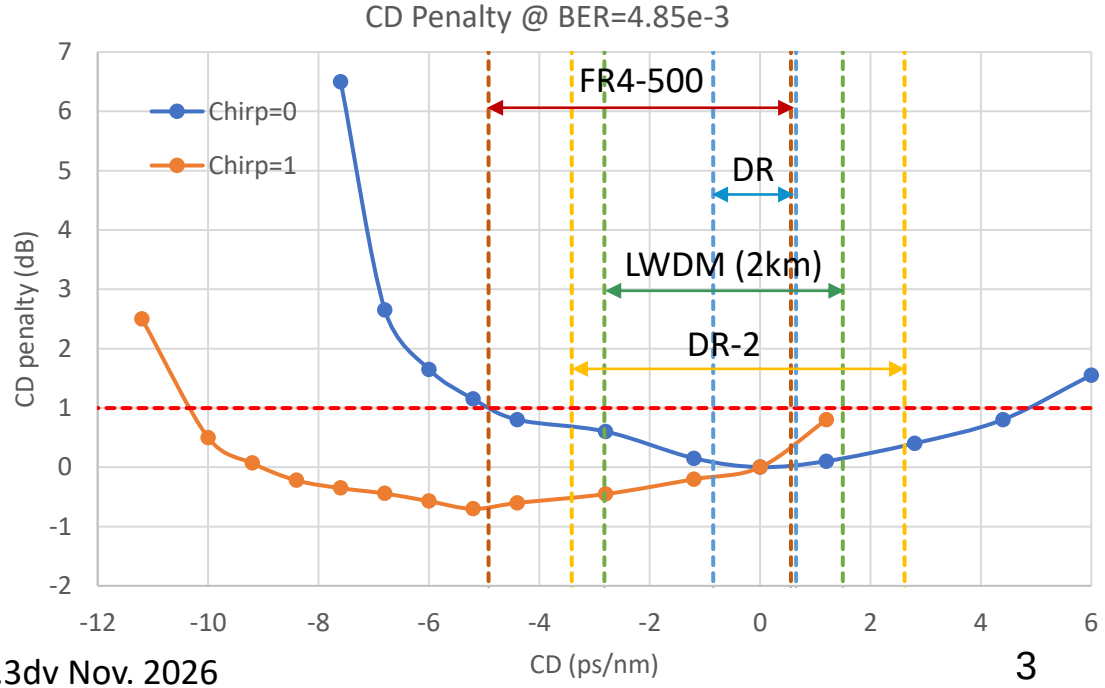
- Recall of he_3dj_01b_2511 which indicates for 200G/L optical PMD link the CD penalty gap between TDECQ-TECQ and BER sensitivity penalty is extremely large at corner case of LR4
- For 400G/L optical link, the CD penalty will be much sensitive. Although the current 802.3dv scope only covers DR option, however 2km single WL or WDM options are still be very interested by industry and could be included in the future CFI dambrosia_e4ai_03_260825
- The contributions yu_3dj_01_2505, johnson_e4ai_01a_250227, and berger_e4ai_01_261027 all show that FR4 (CWDM4) wavelength range is not workable for 400G PAM4 2km distance, and DR-2 also only applicable for limited chirp range (<0.4) due to high CD penalty.

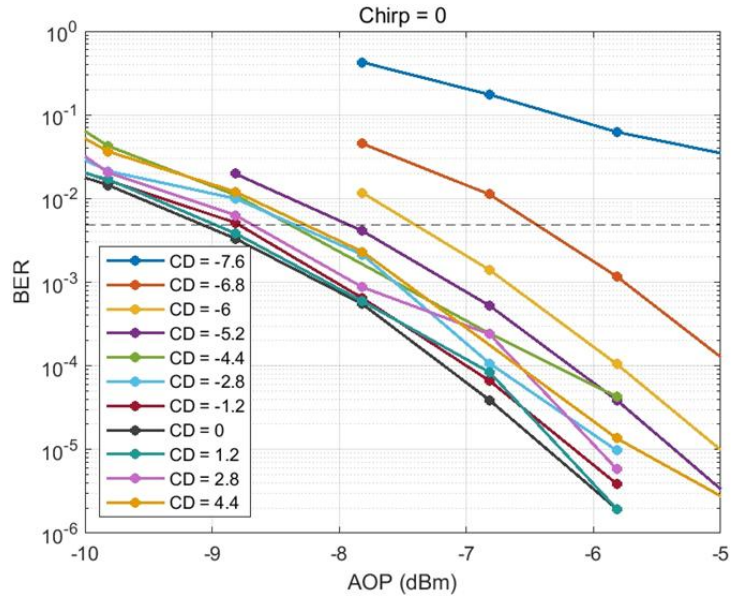


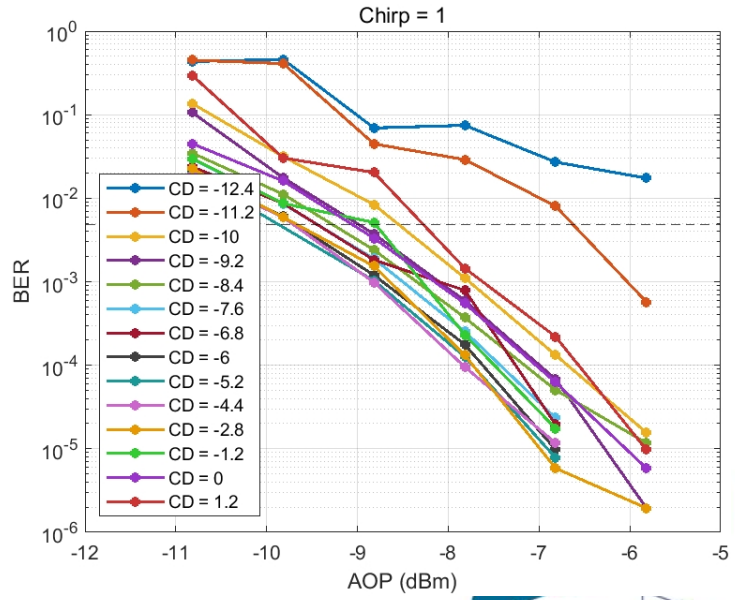
Simulated 400G PAM4 CD Penalty with Chirp

- The overlap region of chirp=0 & 1 (probable EML chirp limit) shows worst case CD penalty for 400G PAM4
- DR option is well within the 1dB penalty limit. So basically TDECQ shall almost be the same as TECQ
- However, FR4-500 and LWDM (2km) are just barely applicable, and DR-2 will be out of the 1dB penalty at max CD limit

- Symbol Rate = 212 Gbd
- DAC/ADC BW = 106 GHz
- ENOB = 5.5 dB
- Ideal EA modulator
- TIA IRND = 15 pA/sqrt (Hz)
- FIR = 0,1,0
- FFE = 48-taps
- 1-tap DFE + 2-tap MLSE

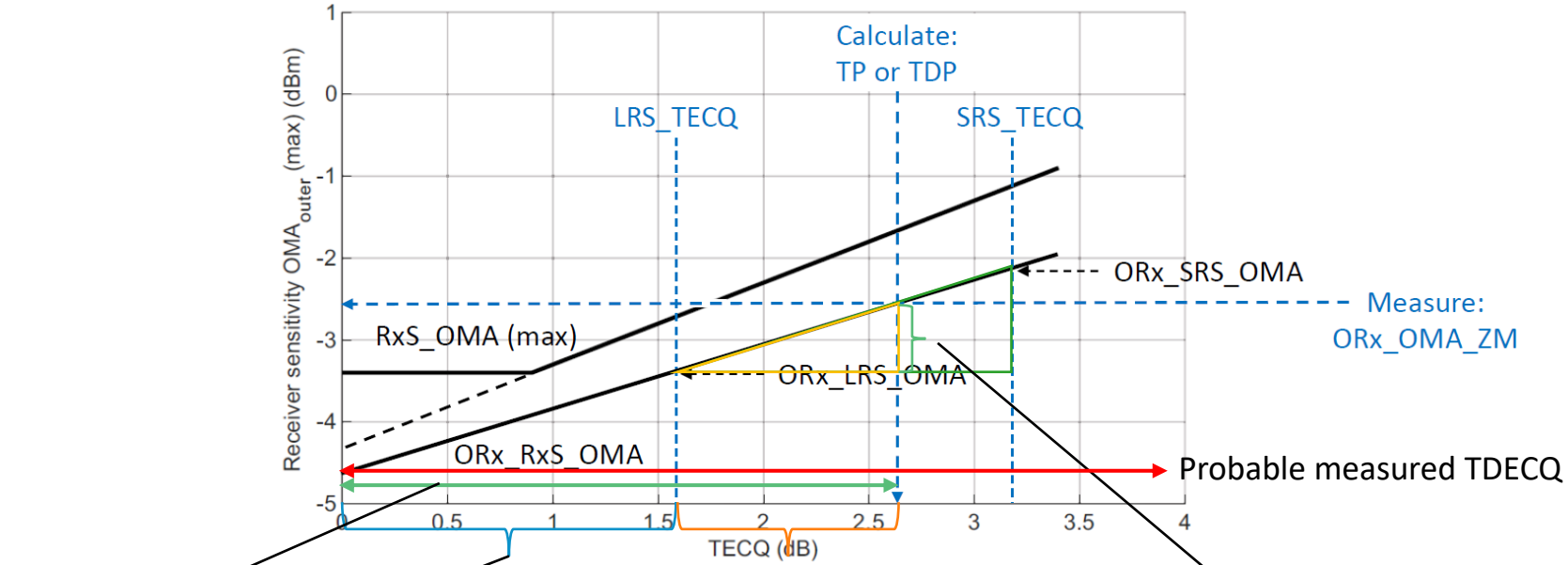






TFT defined TDP Methodology

- Transmitter Functional Test (TFT) relies on LRS and SRS to calibrate the relationship of Rx sensitivity VS TDECQ
- LRS_TECQ will still be retained as TP of LRS Tx
- TDP of the DUT is calculated based on sum of BER/BLER sensitivity induced penalty to the LRS Tx and LRS_TECQ



It's calculated!

$$TDP = LRS_TECQ + \frac{(SRS_TECQ - LRS_TECQ) * (ORx_OMA_ZM - ORx_LRS_OMA)}{(ORx_SRS_OMA - ORx_LRS_OMA)}$$

Ref: cole_3dv_01_261022

Conclusion and Discussion

- 200G PAM4 CD penalty test data show big gap for CD penalty btw TDECQ and BER/BLER method at corner case of LR4
- CD issue is much more serious for 400G PAM4. Fortunately, DR (500km) shall not have CD issue.
- For more CD stringent options (FR4-500, DR-2, etc.), TFT defined TDP is a more reliable methodology leverages BER/BLER measured data and calculation to mitigate the uncertain TDECQ data at CD corner cases

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THANK YOU