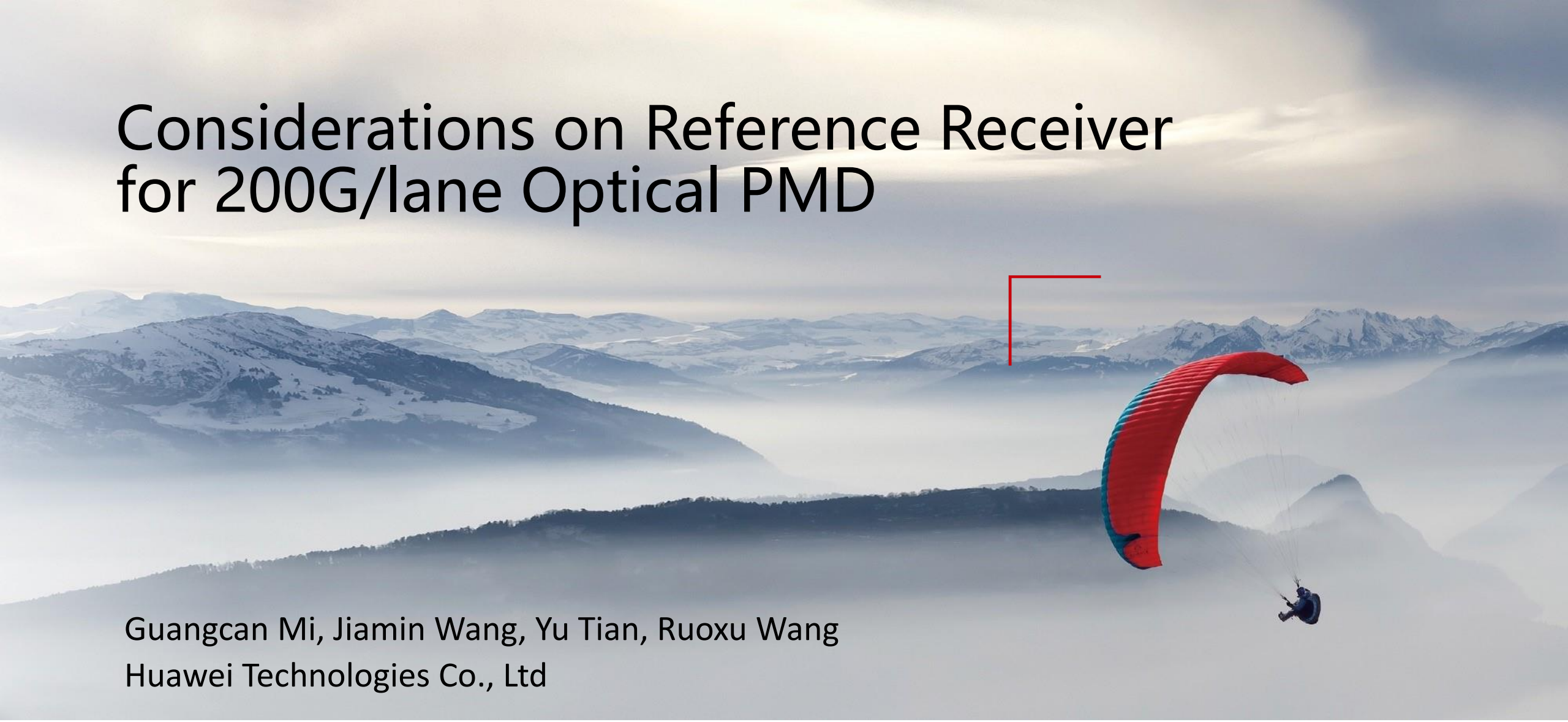
Considerations on Reference Receiver for 200G/lane Optical PMD



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IEEE 802.3dj 2023 April Ad Hoc

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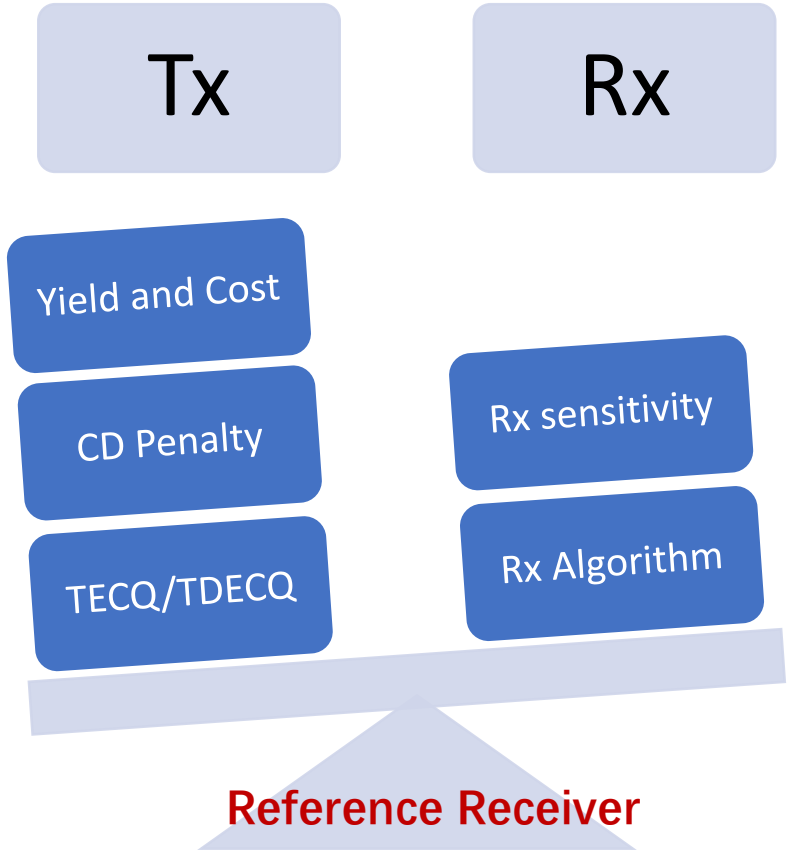
Introduction

- The TF has passed a motion on FEC for a series of 200G/lane optical PMDs in March. Going towards the baseline discussion, where to land for TDECQ and the dispersion penalty becomes more relevant.
- Real receivers are much more likely to implement powerful equalizers for 200G/lane optics, as has been discussed in this TF. Reference receiver, as a common ground for Tx characterization, should to some extent reflect the Rx ability and enable TDECQ to better predict the link penalty at the Tx side.
- In welch_3dj_02a_2303 and welch_3dj_03a_2303, baselines for optical PMDs below 2km were proposed based on 5tap FFE reference receiver. Is this 5-tap FFE reference receiver defined during 53GBaud PAM4 still serving its purpose well, when 200G/lane optics not only doubles the BW but comes with many impairments relative to 100G/lane.
- Most recently, it was also suggested to leave the reference receiver as TBD in the discussion of 800GBASE-LR4 baseline in rodes_3dj_optx_01_230413, in acknowledgement of the higher impairments and challenges of 200G/lane.
- Accordingly, this contribution tries to call for the consideration on enhancing the reference receiver. We present the simulation of TDECQ with respect to FFE with different tap numbers, using the transmitter chirp as a variable.

Specs affected by the reference receiver definition

	PSM	WDM	
wavelength	1310nm	FR4 @ CWDM*	LR4 @ LWDM*
200GE	200GBASE-DR1, 200GBASE-FR1		
400GE	400GBASE-DR2, 400GBASE-DR2-2		
800GE	800GBASE-DR4, 800GBASE-DR4-2	800GBASE-FR4	800GBASE-LR4
CD	-2.61~1.81 ps/nm	-11.7~6.6 ps/nm	-28.36 ~ 9.37 ps/nm
Remarks	• Latency • Low Cost	• Dispersion Penalty • Maintain cost effective	• Dispersion Penalty • Tight Power Budget

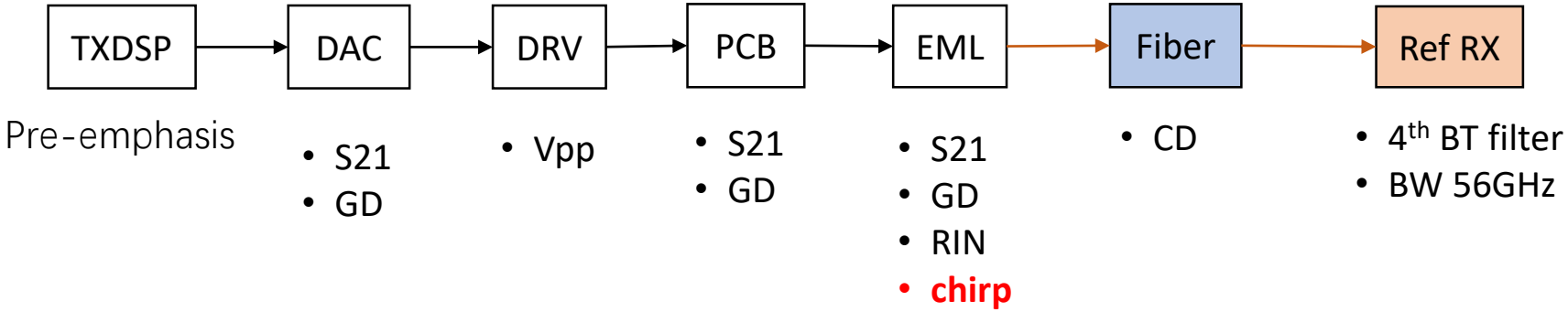


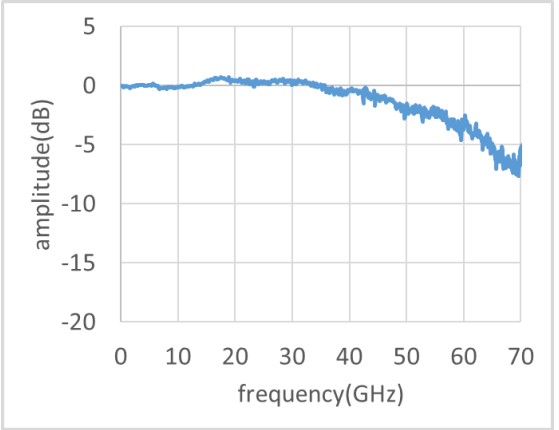
- The reference receiver needs also to adjust to the differences,
  - Unified methodology
  - **"Full"** **X taps of FFE + advanced algorithm(DFE/MLSE, etc..)**
  - **"lite"** **X→Y and/or bypassed**

More work needed

*: The 802.3dj TF has not decided on the wavelength plans for FR4 and LR4. This contribution considers CWDM and LWDM based on baseline proposals.

Simulation Setup





Item	Value
Code	PRBS15 (shorter time)
Data rate	112GB
DAC BW	56 G (ideal Bessel)
Overall GD	10ps
PCB BW	1.62dB loss @ 56G
DRV+EML BW	56 G (measured)
RIN	-149

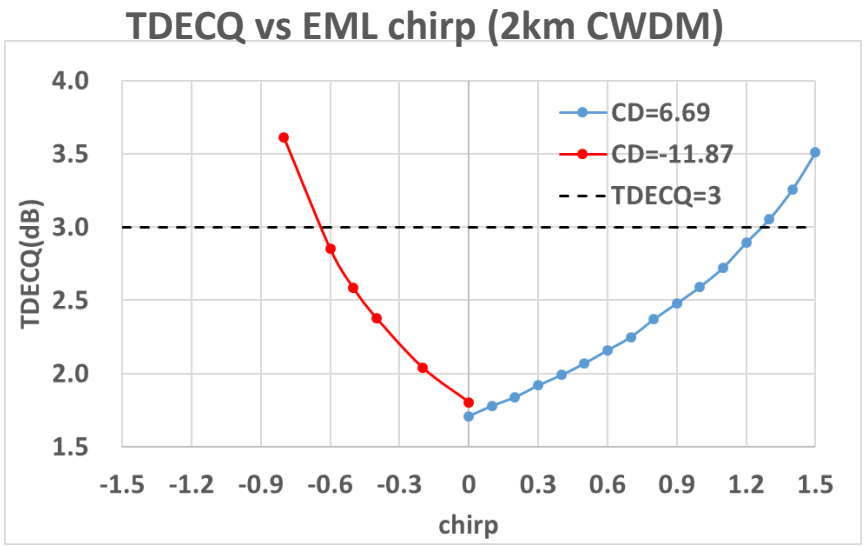
- We have used BER = 2e-3 as the PMD BER threshold throughout the simulation. As pointed out in he_3dj_optx_01a_230413 , the optical PMD BER threshold could range from 1.76e-3 to 3.74e-3, depending on the final decisions on AUI BER and FEC details. Even though the exact value of TDECQ may change with the BER threshold, the qualitative influence of equalizer on TDECQ is expected to be the same.
- 200G/lane doubles the BW requirement on components. One common approach to boost the BW is to use induction peaking, which comes at the price of increased GD. We have considered the impairment due to the GD component in this simulation, which has a stronger influence to the link performance for 200G/lane than for 100G/lane.

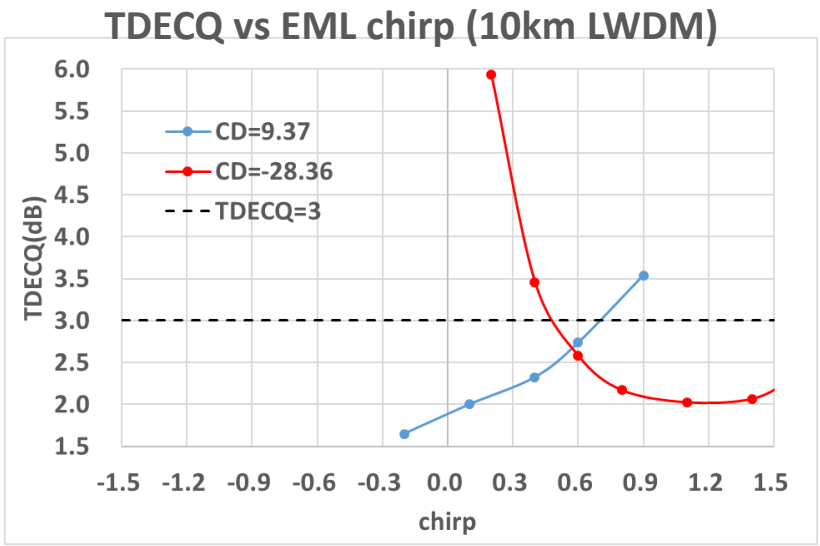
Simulation Setup

We take the EML chirp as a variable of the Tx, and examine how the TDECQ changes in response to different equalizer settings. For each equalizer settings we plot the TDECQ against chirp.

Since PRBS15 pattern was used in the simulation instead of SSPRQ as required for TDECQ measurement, a lower TDECQ value is observed in general. Therefore TDECQ = 3dB was chosen to be the threshold, allowing some margin from the pattern difference.

As an example, the 21 tap FFE result is shown below





TECQ = 1.59dB

- Tx Chirp is an important parameter for characterization of EMLs. The chirp of an EML module is usually tuned to balance the overall performance among ER, non-linearity, and CD penalty. Chirp will have a distribution over different chips and modules.
- More detailed introduction of Chirp on link performance can be found in johnson_3df_01a_221011, and johnson_optx_01_0319 .

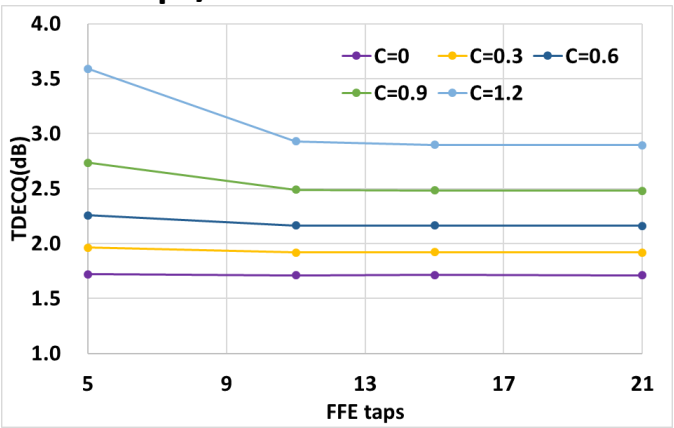
TDECQ vs FFE taps under different EML chirp

Positive CD

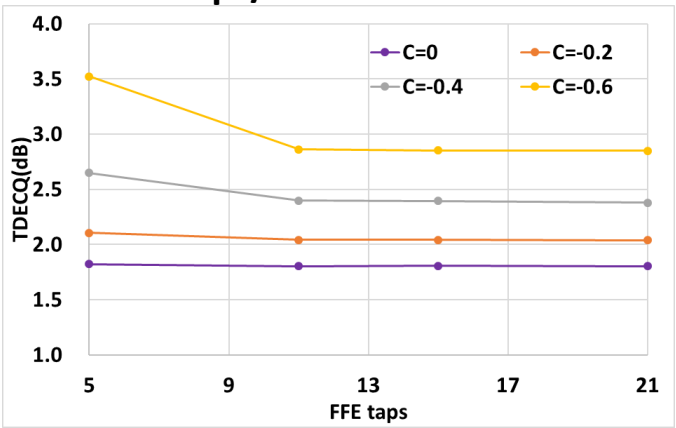
Negative CD

2km

CD = 6.9ps/nm

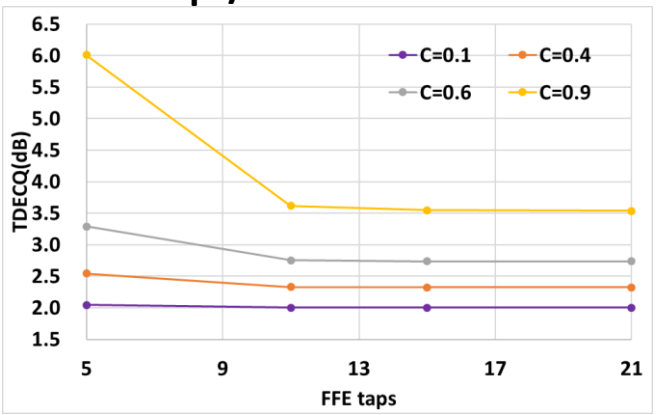


CD = -11.87ps/nm

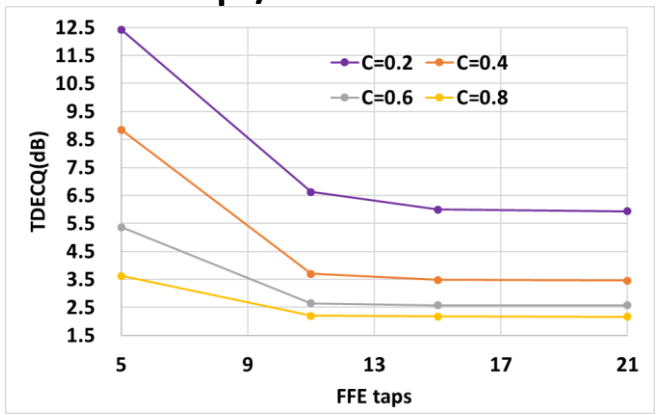


10km

CD = 9.37 ps/nm



CD = -28.36 ps/nm



CD for 2km	-11.87 ~ 6.69
CD for 10km	-28.36 ~ 9.37

- FFE with lengths< 9 taps
  - significant changes of TDECQ with different chirp value under both positive and negative CD
  - very different deltas with respect to longer equalizers
- In the case of 10km,
  - FFE with lengths <9taps, all chirp value failed to pass the TDECQ check in the full CD range,
  - Longer equalizer >9taps, Tx with chirp of 0.5~0.7 could pass this extreme CD test.
- Minimum Requirement on Ref. Rx:
  - the calculated TDECQ could reflect the penalty of Tx impairments to the link.
  - 9 taps could be a reasonable starting point.
- Increasing the tap number of FFE in Ref. Rx:
  - Avoid screening out Transmitters that are capable of closing the link but failing the standard test due to a high calculated TECQ/TDECQ value.

Summary

- This contribution tries to identify the necessity of an enhanced reference receiver. The analysis is based on the simulation of TDECQ with respect to the number of taps in FFE, and uses EML chirp as the Tx impairment variable.
- The preliminary simulation result suggests at least a stronger FEE with 9+ tap need be considered. A pure FFE reference receiver faces limitations for 10km use case and requires further study.
  - "Full" X taps of FFE + advanced algorithm(DFE/MLSE, etc..)
  - "lite" X→Y and/or bypassed
- Further consensus building is obviously required to decide on the advanced algorithm and the comprehensive definition of the reference receiver. That calls for more experimental analysis of power penalty, TDECQ and CD penalty be brought to the TF.