TDECQ Reference FFE Constraints Regarding Comment r03-47

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Supporters

- Piers Dawe, Mellanox
- Johan Jacob Mohr, Mellanox

Introduction

- Limiting the number of receiver precursors helps to reduce module power and improve link performance given power constraint [sun_3cd_01a_0518].

- Comment #r02-8 on precursor 2 constraint for 50GBASE-FR and 50GBASE-LR was withdrawn in May meeting as we wanted to evaluate dispersion impact. This contribution presents dispersion and TDECQ measurement results for 50GBASE-FR (some analysis also convers 50GBASE-LR).

- Changing TDECQ EQ from 5-tap T/2-spaced to T-spaced FFE, and adding threshold adjustment are good for transmitter yield. As a consequence, it also requires more complicated receivers to cover more ISI and nonlinearity. Removing precursor2 relieves complexity pressure of receivers to some extent.

Fiber Dispersion Spec

Table 139–12—Fiber optic cabling (channel) characteristics

Description	50GBASE-FR	50GBASE-LR	Unit
Operating distance (max)	2	10	km
Channel insertion loss[a, b] (max)	4	6.3	dB
Channel insertion loss (min)	0	0	dB
Positive dispersion[b] (max)	3.2	16	ps/nm
Negative dispersion[b] (min)	−3.7	−18.6	ps/nm
DGD_max[c]	3	8	ps
Optical return loss (min)	25	22	dB

[a]These channel insertion loss values include cable, connectors, and splices.
[b]Over the wavelength range 1304.5 nm to 1317.5 nm for 50GBASE-FR and 50GBASE-LR.
[c]Differential Group Delay (DGD) is the time difference at reception between the fractions of a pulse that were transmitted in the two principal states of polarization of an optical signal. DGD_max is the maximum differential group delay that the system must tolerate.

Fiber Chromatic Dispersion Impact

- Spectral width of DML samples are measured to be no more than 0.3nm at -3dB and 0.6nm at -20dB.

- As a first-order estimation of pulse widening bound, 0.3nm spectral width results in 0.3*3.2=0.96ps pulse widening for 50GBASE-FR, and 4.8ps for 50GBASE-LR. Roughly 0.48ps and 2.4ps for leading edge. If taking 5 times of these pulse widening numbers as worst case, chromatic dispersion impact on precursor is 2.4ps for 50GBASE-FR, and 12.8ps for 50GBASE-LR.

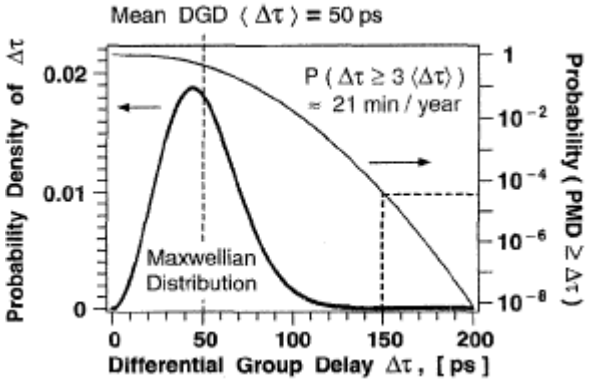
- Chromatic dispersion of 50GBASE-FR is 20% of 50GBASE-LR. As 50GBASE-LR should not have more than 2 precursors, dispersion impact of 50GBASE-FR must be much smaller.

Chromatic dispersion impact of 50GBASE-FR minimal for 50GBASE-FR.
A model for tighter bound is needed for 50GBASE-LR.

Polarization Mode Dispersion (PMD) Impact

- A question was raised in ad hoc meeting that polarization mode dispersion may impact precursors.
- For "modern fibers" in the last century, mean differential group delay (DGD) for 2km and 10km fiber is 0.14 and 0.32 ps. Actual DGD may vary, and 4*sigma is within about 0.56 and 1.28ps. [1]

Fiber Type	Mean DGD Coefficient $\langle \Delta\tau \rangle / \sqrt{L}$	Average DGD for $L = 625$ km
Modern Low PMD	≤ 0.1 ps / √ km	2.5 ps
Older High PMD	~ 2 ps / √ km	50 ps

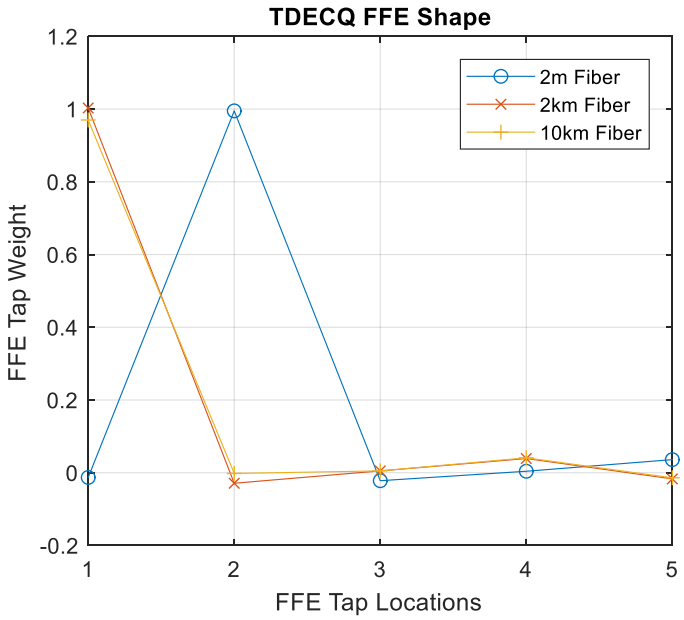


- PMD spec can also be found in public fiber product information. For example, PMD is specified as less than 0.06ps/sqrt(km) for a widely used SMF28.
- 802.3cd specifies DGD_max as 3ps for 50GBASE-FR, and 8ps for 50GBASE-LR.
- Worst widening on leading edge caused by chromatic and Polarization mode dispersion is 2.4+3=5.4ps for 50GBASE-FR, only 14% of 1 UI, 7% of 2 UI.

Polarization mode dispersion impact on precursor 2 is small for 50GBASE-FR.

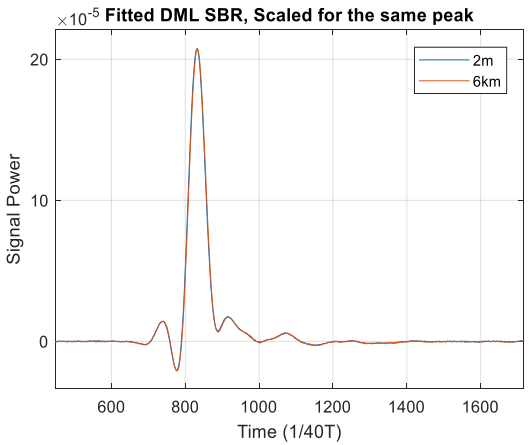
[1] Fred Heismann, "Tutorial: Polarization mode dispersion_ Fundamentals and impact on optical communication systems," *ECOC*, 1998.

Test 1 –Dispersion Impact on TDECQ FFE

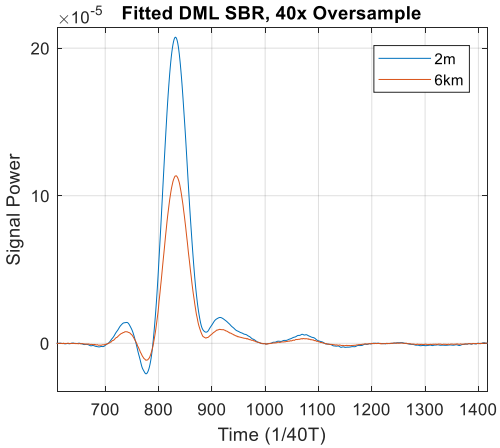


- TDECQ FFE shapes are recorded for a real 26GBd DML transmitter with 2m, 2km, and 10km fiber. Transmitter condition is the same during the test.
- TDECQ values are below TDECQ limit.
- No precursor 2 is involved. Impact on precursor 1 is also very small.
- Fiber dispersion parameters are being measured to check dispersion level of this system.

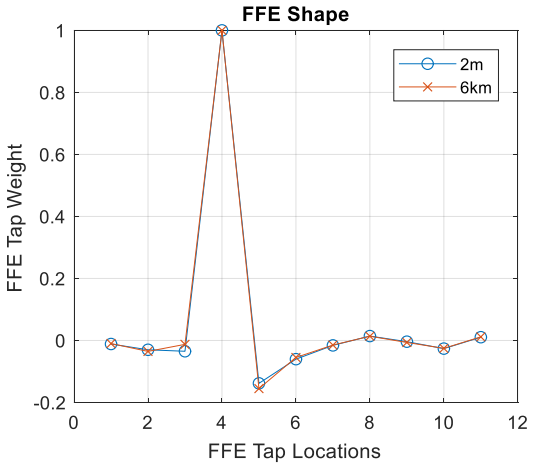
Test 2 – Dispersion Impact on Pulse Response



Scaled Single Bit Response



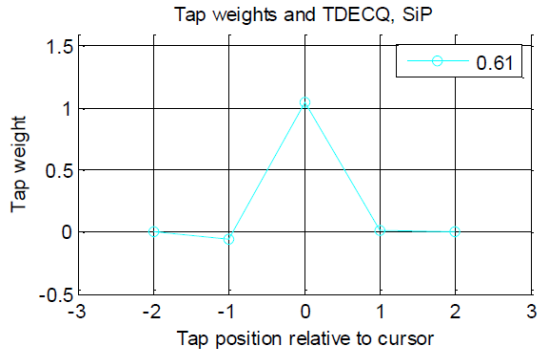
Single Bit Response

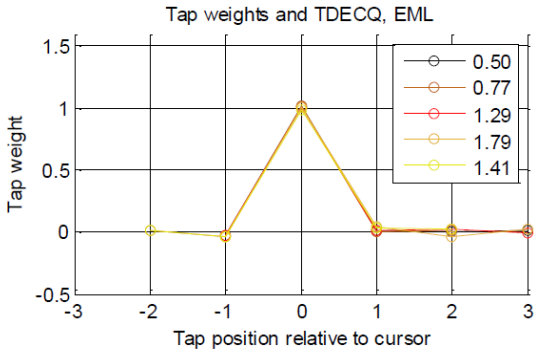


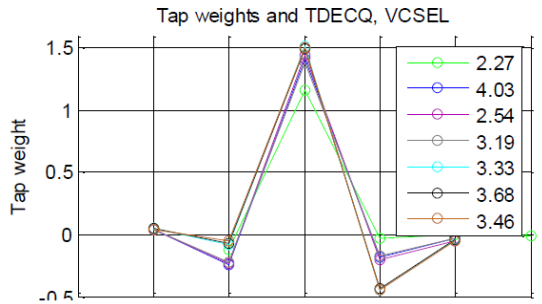
FFE Shape

- A different DML transmitter and fiber are randomly picked to spot check dispersion impact on real systems.
- Sigle bit responses are extracted for DML. A 6km fiber is used.
- SBR curves show some loss of 6km cable box. After scaling to the same peak, two SBR are very close.
- FFE precursor 1 and postcursor 1 have some difference. Difference of precursor 2 is only about 0.5%.

More TDECQ Measurement Results







- Main tap is in position 2 or 3
- Not position 1
- Solid circle shows larger of the two end taps

[dawe_3cd_01a_0518]

- More TDECQ measurement results for different transmitters have been reported recently.
- For SiPh, TDECQ is way below the threshold. Maximum weight of precursor 2 is only 0.5% of the main cursor.
- For EML, maximum precursor 2 weight is only 1% of main cursor.
- For VCSEL, TDECQ is on the high end. Maximum precursor 2 is 3.6% of main cursor. Postcursor 2 weight for the same transmitter is about 2.9%.
  - If TX FIR is applied to cover precursor 2, postcursor 3 will be covered and TDECQ should be lower. If 3.6% precursor 2 is not covered by FFE and postcursor 3 is assumed to be 1.9% (half of post 2) for the same transmitter, TDECQ will be about **0.1 dB** higher. TDECQ impact will be negligible if TX FIR is implemented or transmitter bandwidth is improved.

Conclusions

- Dispersion impact on precursor 2 is minimal for 50GBASE-FR. Device bandwidth will improve and receiver will not need heavy precursor 2 for good links. But current standard allows transmitters to create precursor 2 (e.g. by TX FIR), forces real receivers to implement expensive multiple precursors to ensure interoperability, and causes module power to stay high forever.

- For existing transmitters with sufficient bandwidth or TX FIR, impact on TDECQ is minimal. Calculation based on survey results shows TDECQ may increase about 0.1dB if there are slow transmitters without implementing TX FIR.

- To allocate receiver power more efficiently for better equalization and enable broader implementations, we propose:

  Limit the number of TDECQ FFE precursors to one for 50GBASE-FR.
  Consider relax 50GBASE-FR TDECQ threshold by extra 0.1dB because of this proposal.

Thanks!

Back Up Slides

Comment r02-8

Cl **139** *SC* **139.7.5.4** *P* **298** *L* **5** # r02-8

Sun, Junqing — Credo Semiconductor

Comment Type **GR** *Comment Status* **D**

Current spec allows TDECQ reference receiver to have up to two precursors. As explained in sun_3cd_042518_adhoc, this forces receivers to implement multiple precursors and choose power-hungry solutions. As a result, module power will be kept high forever to ensure interoperability with bad transmitters. On the other hand, precursor 2 impact on TDECQ is small and can be compensated by using TX FIR. Allowing no more than 1 precursors also helps to reduce test time.

SuggestedRemedy

Change:
Tap 1, tap 2, or tap 3, has the largest magnitude tap coefficient.
To:
Tap 1 or tap 2 has the largest magnitude tap coefficient.

Proposed Response *Response Status* **Z**

REJECT.

This comment was WITHDRAWN by the commenter.

Comment r02-8 was withdrawn in May meeting to study dispersion impact on precursors.

Comment r03-47

Cl **139** *SC* **139.7.5.4** *P* **299** *L* **22** # r03-47

Sun, Phil

Comment Type **T** *Comment Status* **D**

Current spec allows TDECQ reference receiver to have up to two precursors for 50GBASE-FR and 50GBASE-LR. As explained in sun_3cd_042518_adhoc, this forces receivers to implement multiple precursors and choose power-hungry solutions. As a result, module power will be kept high forever to ensure interoperability with bad transmitters. On the other hand, precursor 2 impact on TDECQ is minimal for 50GBASE-FR and small for 50GBASE-LR. Meanwhile it can be compensated by TX. Allowing no more than 1 precursor also helps to reduce test time.

SuggestedRemedy

"Add:
For 50GBASE-FR, Tap 1 or tap 2 has the largest magnitude tap coefficient."

Proposed Response *Response Status* **O**