Understanding Pre-post Coefficient Difference Limit Equation

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Ciena

Supporter list

- Mike Dudek, Marvell

In reference to comment # I-220

Cl **180**	*SC* **180.9.6.3**	*P* **482**	*L* **24**	# I-220

Maniloff, Eric — Ciena Corporation

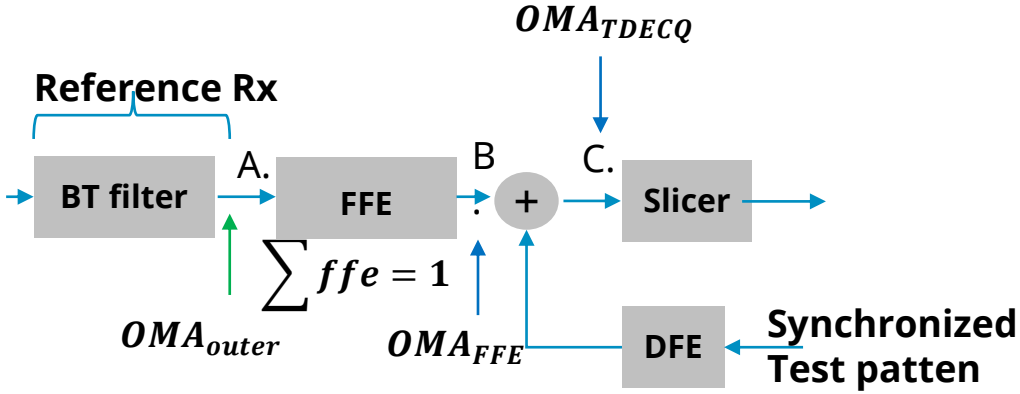
Comment Type **TR** *Comment Status* **X**

DFE Normalization 1: Labeling location

SuggestedRemedy

In Table 180-16, line 24, p482 : the DFE coefficient b(1) should be referenced to OMA_TDECQ /2. Note: to be consistent with figure 180-10, and the normalized b(1) tap value, the synchronized PAM4 test pattern should have an outer amplitude of +/- OMATDECQ/2 . Make similar changes in Clauses 181, 182, 183.

Proposed Response *Response Status* **O**



Resolution: Approve remedy suggested in
https://www.ieee802.org/3/dj/public/26_03/alloin_3dj_02a_2603.pdf
and supported by directional Straw Poll #7 vote results in:
https://www.ieee802.org/3/dj/public/26_03/motions_3dj_2603.pdf

Straw Poll # 7

I support the proposed definitional modifications to Table 180-16 regarding the DFE coefficient limit and normalization footnote as outlined in alloin_3dj_02a_2603 slide 14.

Yes

No

Result: Y: 66 N: 12

Summary

- DFE normalization was added in the IEEE 802.3 dj draft 2.2, after the addition of the DFE tap to the TDECQ reference equalizer.

- The proposal to align the DFE normalization scheme to the DFE channel model used for DFE error propagation analysis corrects the pre-post coefficient difference limit equation, which otherwise is erroneous.

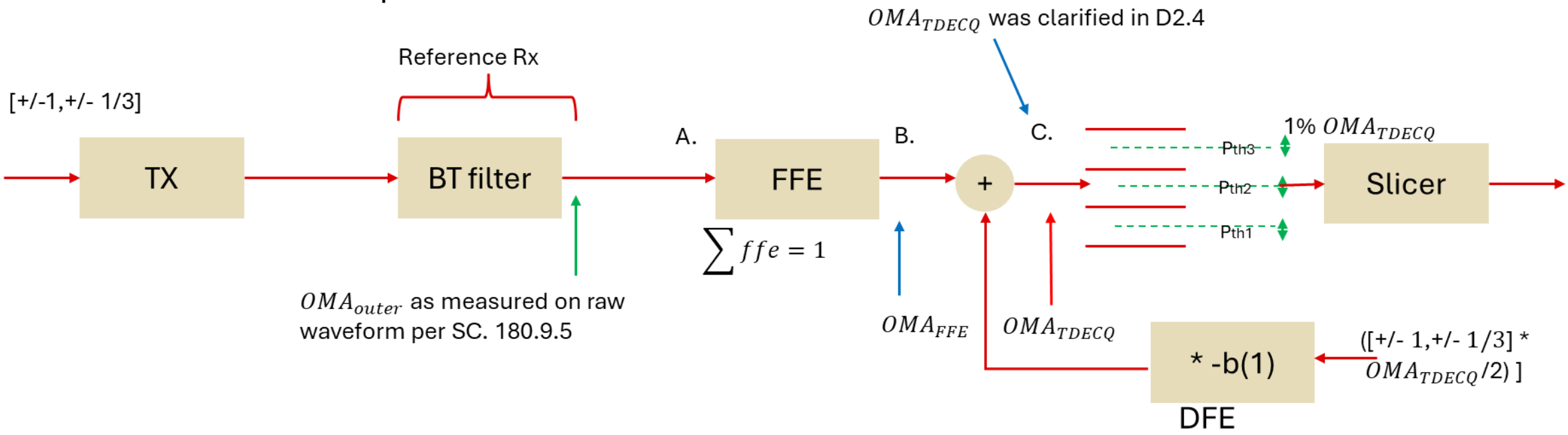
- An explanation of what is the quantity derived from the pre-post coefficient difference limit equation is provided. Understanding how limits to this quantity constraint the TDECQ search helps devise alternative options for the TDECQ optimizer in case the implementation of the equation pauses some practical concerns.

Outline

- Proposed DFE tap normalization
- Pre-post equalizer coefficient limit equation
- Interpretation of the pre-post equalizer coefficient quantity
- Pre-post equalizer coefficient limit equation and results
- Concern raised against draft D3.0 wrt. Coefficient limit equation
- Conclusion and recommendation

Proposed DFE tap normalization

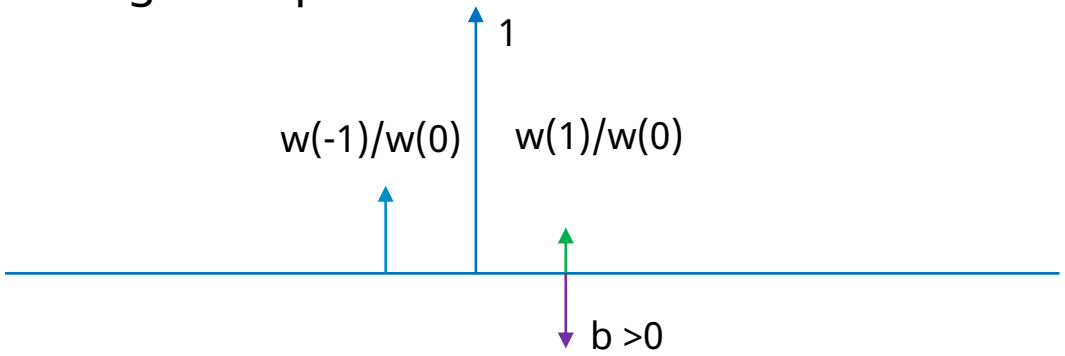
- In https://www.ieee802.org/3/dj/public/26_03/alloin_3dj_02a_2603.pdf [1],the proposed DFE tap normalization has been presented.



- A directional straw poll largely supported this proposal : https://www.ieee802.org/3/dj/public/26_03/motions_3dj_2603.pdf

Pre-post equalizer coefficient difference limit

The pre-post equalizer coefficient difference limit equation that was amended to reflect the addition of the DFE tap b in draft 2.2 to |w(1)/w(0) – b(1) – w(–1)/w(0)| where w(i) are the FFE coefficients and b(1) is the DFE tap now normalized wrt. $OMA_{TDECQ}/2$ was kept as is, as the proposed normalization in [1] corrects two approximations that existed in the original equation.



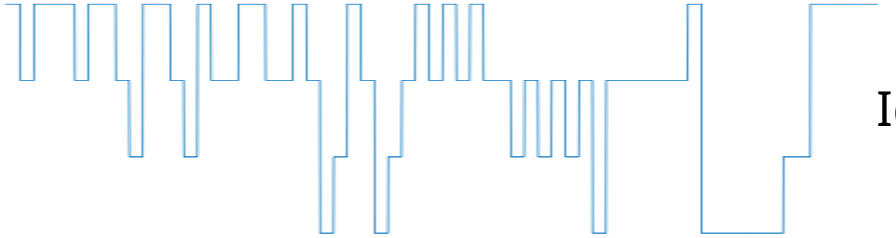
The addition of the DFE tap to the equation is necessary when the reference receiver has a DFE tap b, such that the quantity that it represents retains its intrinsic meaning.

Qi? What is the meaning of the quantity "w(1)/w(0) – b(1) – w(–1)/w(0)" ?

Ans: it is a fraction of a baud or UI, and as such it carries a timing information associated with the sampled waveform

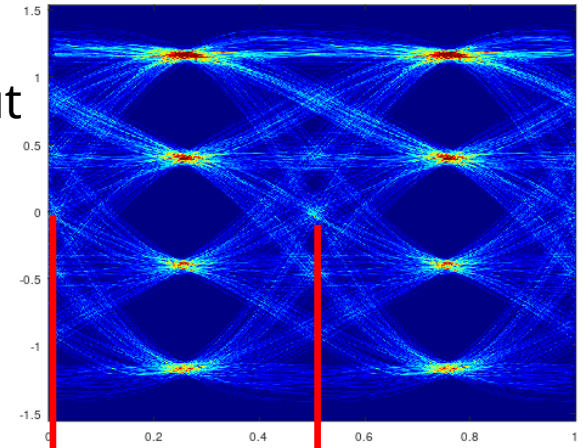
Interpretation of the pre-post equalizer coefficient quantity

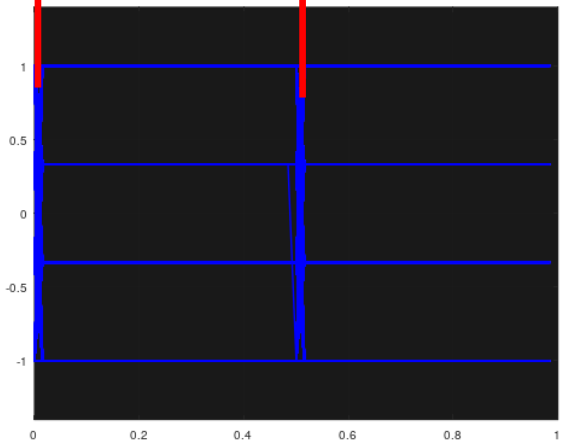
In order to associate a time stamp to a sampled waveform, one can correlate the received waveform with the ideal reference signal transmitted.



Ideal PAM4 ref

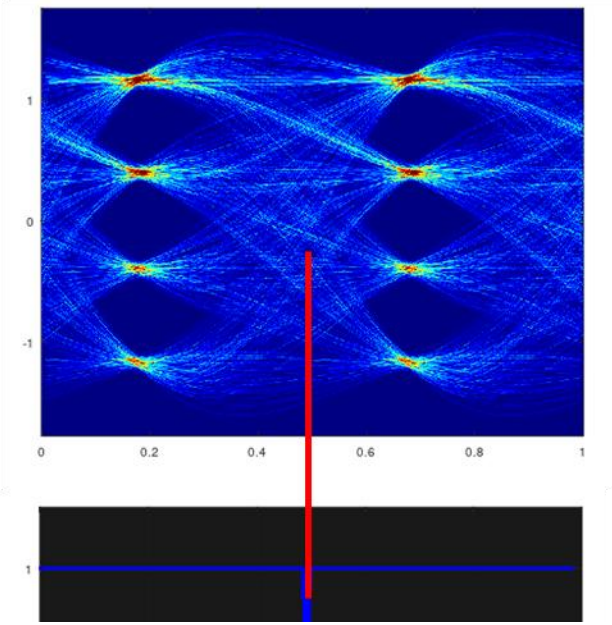
Ref. RX output

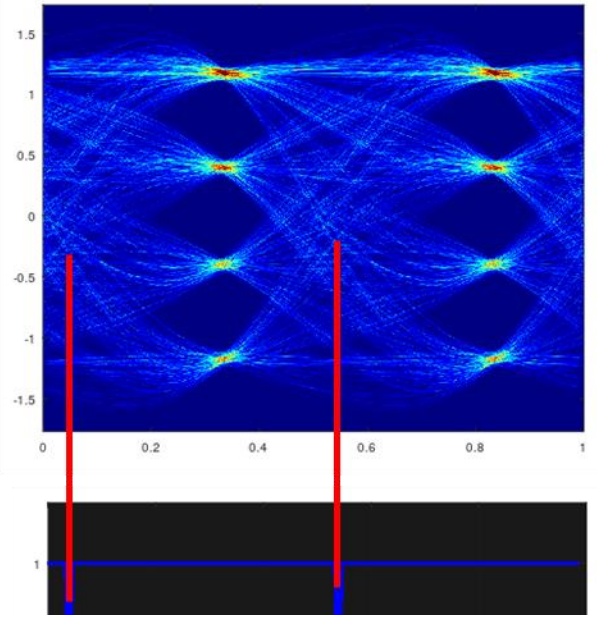




Oversampled rectangular reference pattern.

The correlation peak corresponds to a time stamp associated with an optimum time alignment of the two waveforms. A deviation from this reference time stamp, indicates that the waveforms are seen with a delay or an advance.





Interpretation of the pre-post equalizer coefficient quantity

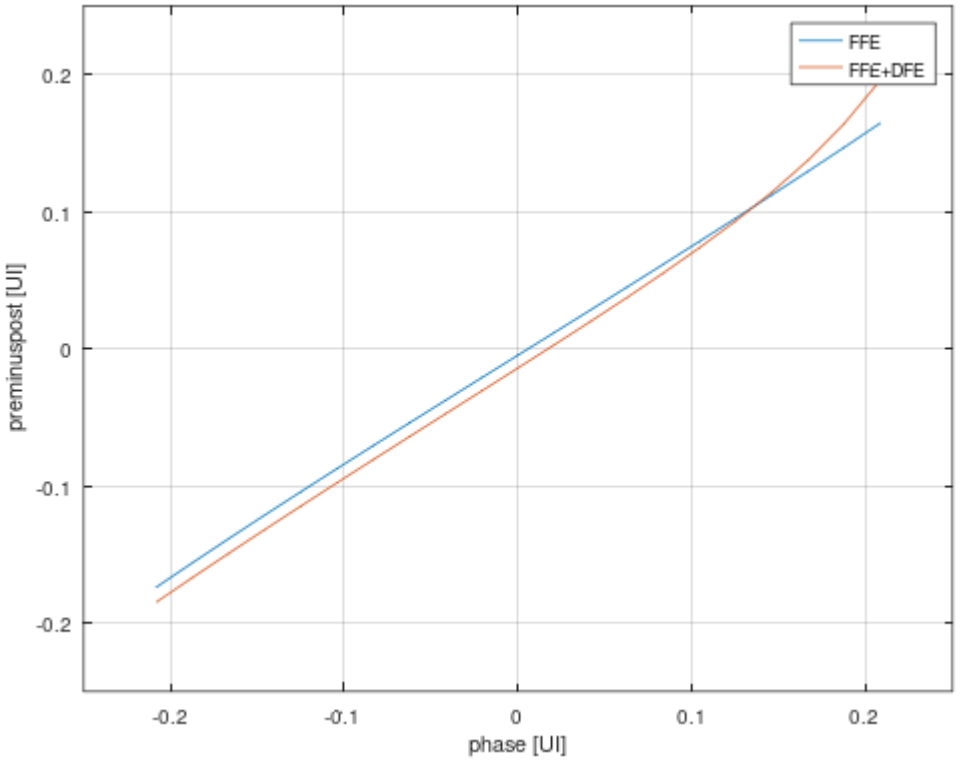
Similarly, the quantity t = w(1)/w(0) – b(1) – w(–1)/w(0) is nothing but a fraction of a Baud

When t = 0, the receive sampled waveform is centered. When t = 1, it is delayed by UI/2; when t = -1, it is advanced by UI/2

Shown here is the evolution of pre-post equalizer coefficient difference [in fraction of 1 UI] vs the deviation of the optimum time stamp derived by the correlation process [in fraction of 1 UI]

=> The equation is nothing but a measurement of the intrinsic delay of the sampled waveform

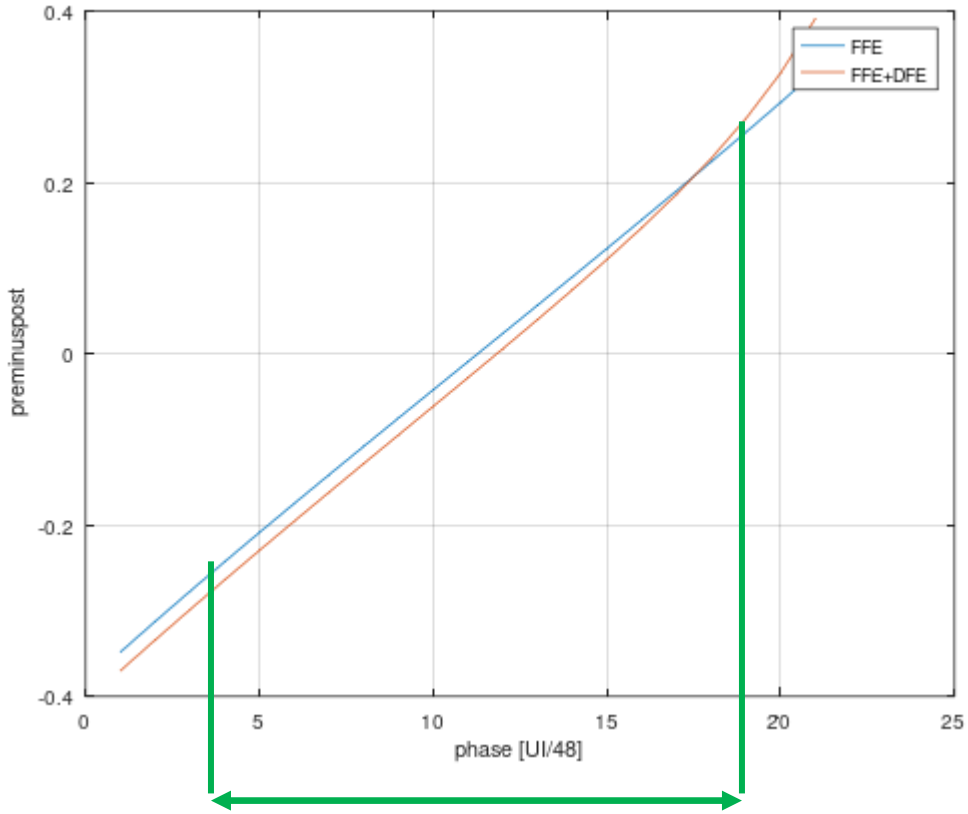
Note: for a large range, the results are identical after an FFE or an FFE+DFE receiver



Interpretation of the pre-post equalizer coefficient quantity

Imposing a maximum and minimum limit on the pre-post equalizer coefficient difference is nothing but restricting the allowed phase range for the TDECQ optimizer.

Note the measurement of the phase of waveform is intrinsic to the waveform and can be done with any of the following options:



Allowed phase range:
|prempost| < 0.25

1. Via a correlation process on the unequalized waveform
2. Via a Mueller- Muller PD on the unequalized waveform
3. Via the pre-post coeff limit using the reference DFE receiver
4. Via the pre-post coeff limit using any independent equalizer, even an FFE

Concern raised against D3.0 wrt. Coefficient limit equation

Cl **180** *SC* **180.9.6.3** *P* **480** *L* **17** # I-70

El-Chayeb, Ahmad — Keysight Technologies Inc

Comment Type **TR** *Comment Status* **X**

Including the DFE tap b1 in the limit: |w(1)/w(0)-b(1)-w(-1)/(w0)| <= .25 makes the implementation makes the limit non-linear limit, introduces complexity and increases the measurement time.

SuggestedRemedy

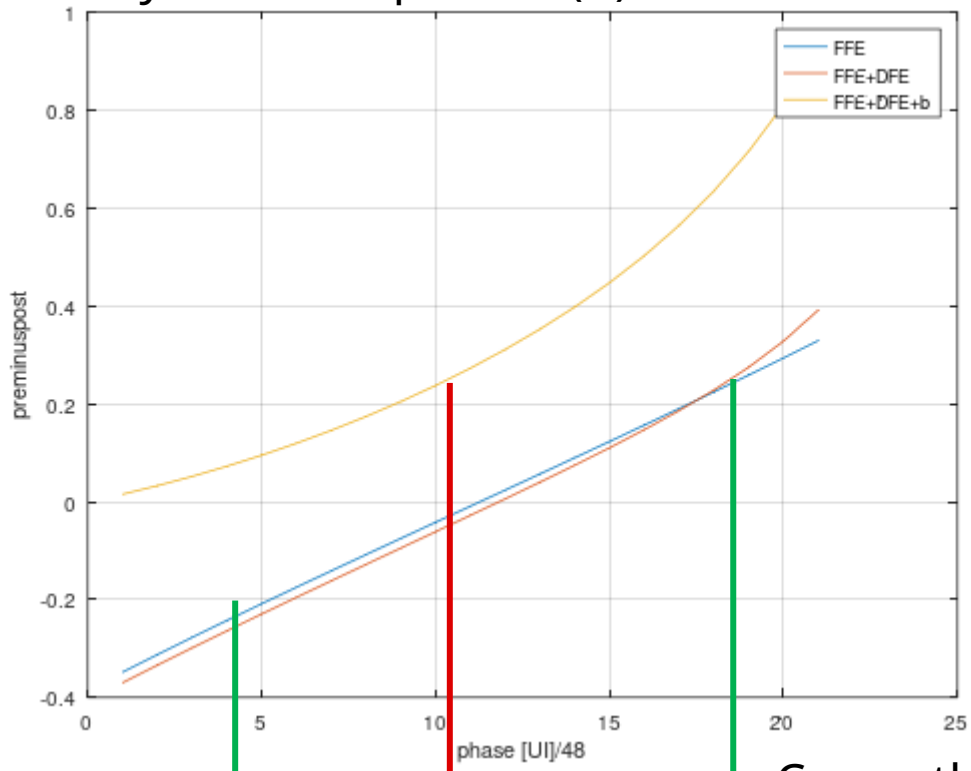
Suggested remedy: Remove b(1) from the equation

Proposed Response *Response Status* **O**

A comment was made against D3.0 to modify the pre-post equalizer coefficient limit equation from $|w(1)/w(0) - b(1) - w(-1)/w(0)| <= 0.25$ to $|w(1)/w(0) - w(-1)/w(0)| <= 0.25$

Results of pre-post coeff limit implementation

Altering the pre-post equalizer coefficient limit equation and omitting b from $|w(1)/w(0) - b(1) - w(-1)/w(0)|$ to $|w(1)/w(0) - w(-1)/w(0)|$ would shift the curve estimate with respect to the correct one by the dfe tap value (b).



New allowed phase range:
$|prempost| < 0.25$

Currently allowed phase range:
$|prempost| < 0.25$

The results would alter the phase range limit for the various modules depending on their DFE tap value
=> It produces an arbitrary constraint not anymore in line with the intent of the constraint.

Conclusion / Recommendation

We recommended in https://www.ieee802.org/3/dj/public/26_03/alloin_3dj_02a_2603.pdf to change the DFE normalization for the TDECQ computation.

With this DFE normalization, the Pre-post equalizer coefficient limit equation retains its meaning of that of a delay associated with the sampled waveform. The limits associated with this equation translates into a restricted range of phases over which the TDECQ search takes place.

There exists alternative schemes to derive the phase /delay information associated with the sampled waveform. If T&M manufacturers want to implement an alternate scheme that enables a faster TDECQ computation, they can, provided that the approach yields similar results as the specification. The specification should be mathematically correct and unambiguous.

We propose to retain the pre-post coefficient difference equation in its present form:
$|w(1)/w(0) - b(1) - w(-1)/w(0)| \quad <= 0.25$

Thank you