Addressing Clause 185 comments against D2.0 for 800GBASE-LR1

(Support contribution for Comment #625)

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Comment #625

Cl **185A** *SC* **185A.2.3** *P* **862** *L* **30** # 625

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Comment Type **TR** *Comment Status* **D** *(Optical) ETCC*

The offline digital signal processing described in this section and Fig 185A-4. is missing a post-equalizer after the "carrier phase recovery" block which is required to allow relaxation of the :IQ Quadrature skew (max)" spec to 0.75ps in Table 185-5. The relaxed skew specification is required to allow design of lower complexity 800GBASE-LR1 modules. Without this block the ETCC calculation will result in a large penalty if the skew gets close to the max allowed value.

SuggestedRemedy

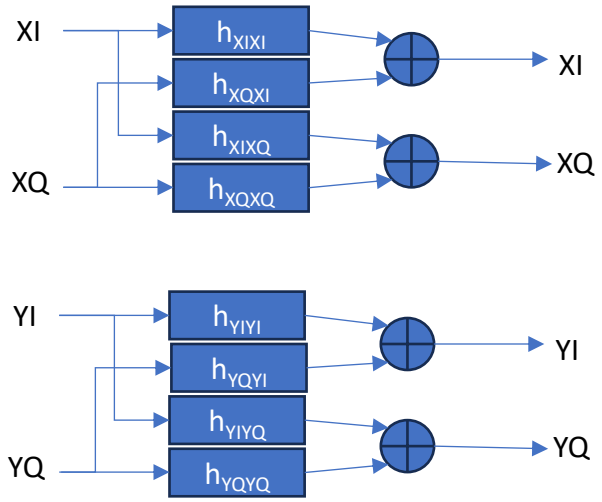
Add post-equalizer stage to the digital signal processing. Presentation to be provided.

Comment #625: Background

- Table 185-5 includes a “I-Q quadrature skew (max)” specification of 0.75ps
  - This specification corresponds to 0.093UI normalized to the symbol period of 800GBASE-LR1
  - Specifications from prior generation coherent interfaces such as the OIF 400ZR IA had a tighter requirement of 0.045UI.
  - The relaxation envisioned by this specification requires a post-equalizer after carrier recovery in the reference DSP processing described in Section 185A.2.3 and shown in Fig 185A-4. Without this filter, the ETCC calculation will result in a large penalty for implementations when the I-Q skew approaches the specification limit. See kota_3dj_02_2407 Slide 14 for examples of calculations with and without such a filter.
  - Same arguments also apply to 800GBASE-ER1 specifications.

Details of post-equalizer filter

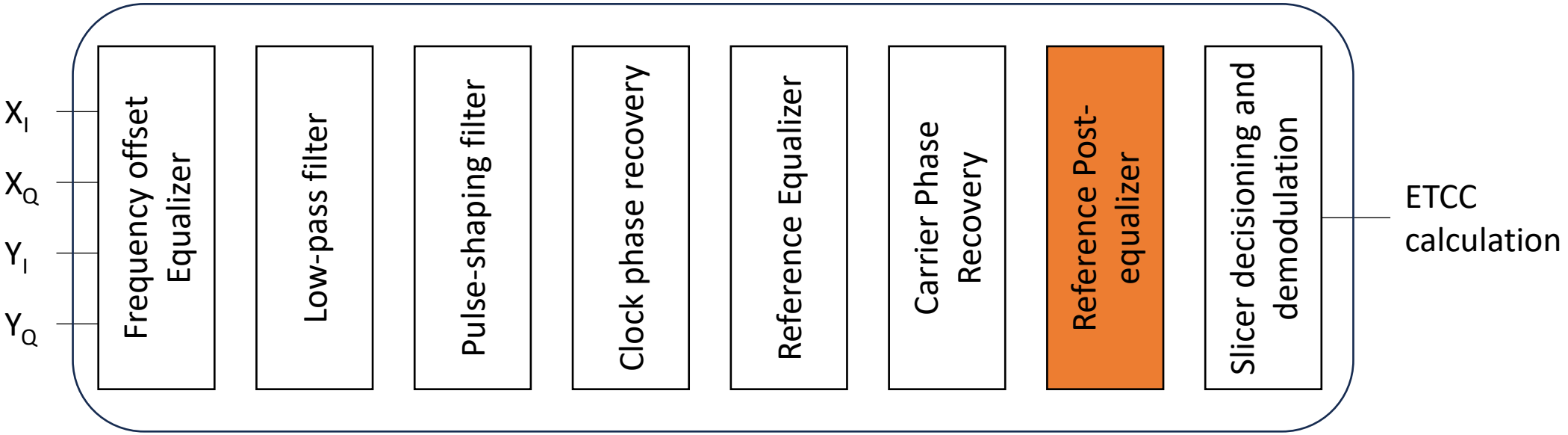
- The post-equalizer is placed **after** the carrier phase recovery to handle transmitter impairments such as TX I-Q skew and TX I-Q phase error.
- The recommended filter is a 2x2 real MIMO for each polarization
  - Each 2x2 MIMO consists of T-spaced FIR filters from each of the in-phase (I) and quadrature (Q) inputs (i.e. real and imaginary components of the complex signal) to each of the I and Q outputs. For e.g., each of h_{XIXI} etc in the figure represent FIR filters with real -valued coefficients operating on real-valued signals
  - The coefficients of these filters are adjusted as part of the ETCC calculation to minimize error
  - 3-taps for each filter is the simplest reference filter to provide significant performance improvement
- See the reference below for simulations demonstrating the benefits of such a filter.



‡C. R. S. Fludger and T. Kupfer, "Transmitter Impairment Mitigation and Monitoring for High Baud-Rate, High Order Modulation Systems," *ECOC 2016; 42nd European Conference on Optical Communication*, Dusseldorf, Germany, 2016, pp. 1-3.

Comment #625: Proposed Remedy (1/2)

- Add a post-equalizer stage to Fig 185A-4.



Comment #625: Proposed Remedy (2/2)

- Insert following text after section 185A.2.3.6 to describe the post-equalizer stage

- 185A.2.3.x Reference Post-Equalizer

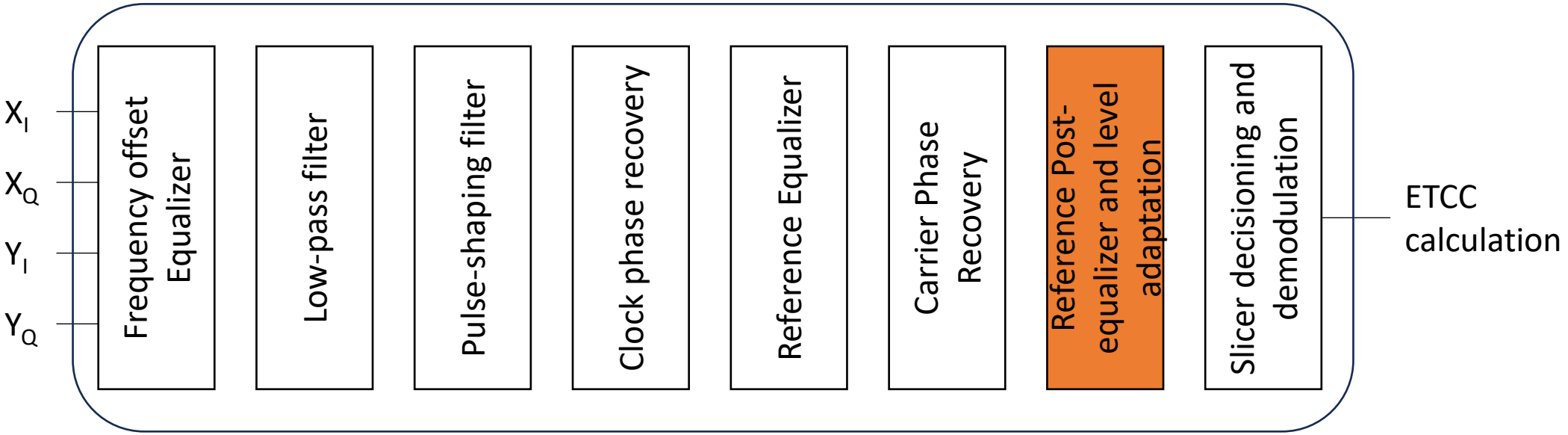
A reference post-equalizer consisting of 2x2 real multiple-in multiple-out (MIMO) filters for each polarization, placed after the carrier phase recovery, is used to compensate for transmit I-Q skew and transmit I-Q phase error impairments. Each 2x2 MIMO filter consists of adaptive T-spaced feed-forward filters from each of the in-phase (I) and quadrature-phase (Q) inputs and producing in-phase and quadrature outputs, where T is the symbol period.

Option 2: Include an additional Level Adaptation

- It is recommended to combine the post-equalizer with a level adaptation stage which can allow better handling of I-Q gain imbalances and imperfect transmit levels
- Level adaptation consists of logic to calculate the mean levels of the 4-level signals received in each of XI/XQ/YI/YQ signals
- Such logic presents minimal cost to a coherent receiver while providing significant benefits for transmitter design

Comment #625: Proposed Remedy – Option 2

- Add a post-equalizer and level adaptation stage to Fig 185A-4.



Comment #625: Proposed Remedy – Option 2 (2/2)

- Insert following text after section 185A.2.3.6 to describe the post-equalizer stage

- 185A.2.3.x Reference Post-Equalizer and Level Adaptation

A reference post-equalizer consisting of 2x2 real multiple-in multiple-out (MIMO) filters for each polarization, placed after the carrier phase recovery, is used to compensate for transmit I-Q skew and quadrature phase error impairments. Each 2x2 MIMO filter consists of adaptive T-spaced feed-forward filters from each of the in-phase (I) and quadrature-phase (Q) inputs and producing in-phase and quadrature outputs, where T is the symbol period. A level adaptation block for each of XI/XQ/YI/YQ follows the post-equalizer. The level adaptation block estimates the average levels received for each of the four levels and uses these levels to minimize the slicer error.

Parameters for Offline DSP in 185A.2.3

- Section 185A.2.3 describes the blocks for the offline digital signal processing as shown in Figure 185A-4. For consistent ETCC calculation it will be necessary to define the important parameters for this processing. For e.g. the reference equalizer is missing the number of taps
- It is recommended to add a table defining these parameters. The values of these parameters would be defined in the Physical Layer Specification that invokes this method.

Proposed remedy for missing Table (1/2)

- Update text on Page 862, lines 21-22 as follows with editorial discretion:
  - Replace “This processing is done in a series of steps described in 185A.2.3.1 through 185A.2.3.7.” with “This processing is done in a series of steps described in 185A.2.3.1 through 185A.2.3.<TBD>. The parameters for this processing are listed in Table 185A-<TBD>. The values assigned to these parameters are defined by the Physical Layer specification that invokes the method.”
- Add a table titled “Offline Digital Signal Processing parameters” to Section 185A.2.3 with editorial discretion:

Parameter	Unit
Reference equalizer number of taps	-
Post-equalizer number of taps	-

Proposed remedy for missing Table (2/2)

- Update Sections 185.9 and 187.9 which reference Annex 185A to define values for these parameters. Example changes for 185.9:
  - Update text “The ETCC is computed using the test setup and calculation defined in Annex 185A and the parameter values listed in Table 185-12, Table 185-13 and Table 185-<TBD>.”
  - Add Table 185-14 containing parameter values

Parameter	Value
Reference equalizer number of taps	TBD
Post-equalizer number of taps	3

Thank you!